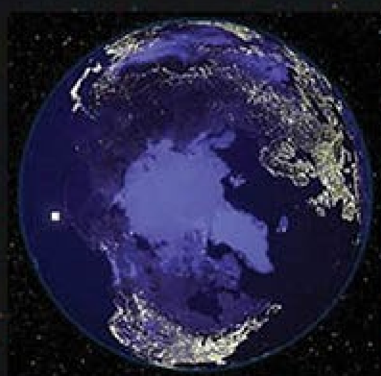
Redesigning the Planet



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Redesigning the Planet

A Challenge to You to Engage in Creating
Wild Designs for Wicked Problems—
To Transform the Human Share
Of the Planet for the Extended Present
Using Common Sense, Ecological Designs
Eutopian Strategies & Global Thought Experiments
Now!

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Michael W. Fox
Paolo Soleri
Alan R. Drengson
Arne Naess
Twila Jacobsen
Michael Barnes
Alan Wittbecker, Coordinator

You, *you* and ***you***!

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Planet Contents

Dedication

To Craig Dillard, for decades of wild conversations and good dinners. To Devorah Levy, Caroline Hagen, Linda Martin, Margaret Wittbecker, Hanna Metzger, James Luck, and Janet Wampler for reading and questioning portions of this work. To Marcella Crider, for her unquestioning support and suggestions to simplify biological and thermodynamic topics. To Garrett Hardin for his correspondence on topics related to global things, populations and commons (not to mention the incredibly ugly Darwinian postcards we used to exchange ideas). To Buckminster Fuller for rejecting my untenable ideas on technology and listening to my suggestions for him to pay more attention to ecological and political perspectives. To Paul Shepard for refining the ideas of cultural madness and for inviting me to help build his house. To Thomas Berry for sending me drafts of his work on approaching the earth and for reading my draft articles in exchange. To Eugene Odum for sharing thoughts and time on ecological science and perspectives. To Alan Drengson for helping me on the path to an ecoforestry approach to forest management and restoration. To Arne Naess for discussions on peace and deep ecology, between climbing and boxing practice. To John B. Cobb Jr for patiently leading me through the 'tangled bank' of my errors on process thinking and ecological economics. To Paolo Soleri for hosting me at Arcosanti to work on early portions of the book. To Michael W. Fox for suggesting new directions for and rewrites of material on animals and philosophy, and for his continuing conversations and support.

0.0. Introduction: Design for Sharing

This work is about physical, ecological and political designs for sharing the global resources and services of the planet to meet the needs of all living beings and their community patterns. It uses ecological design to create a simple method to implement and manage the sharing. First, we assess what the planet needs to develop in a stable flow, then we set aside a satisfactory area of the planet to ensure the continuing operation of evolution in wild systems. Next, we measure the ranges of productivities of wild ecosystems as well as agricultural and urban systems, and use those results to determine optimum human populations for local places, regions and the planet. Finally, within human systems, every culture would claim a share of local resources and global services not set aside for wild regeneration.

The equal apportionment of resources to all cooperating participants in the global commons is supported by the practice of recognizing and honoring the 'legacy' of the entire planet that hosts its legatees as tenants, and is supported by the 'rule' of all beings, although in the human legal system, humans represent the interests of all other beings, much as we are starting to do now. This reapportionment is enhanced by the wisdom of harmony and by the drawing and making of ecological zones, which emphasize ranges of separation of wild and artificial areas. This reapportionment of 'resources' that human communities have already claimed, as well as of resources that have been badly distributed as a result of theft or violence, may cause some degree of discomfort or suffering for wealthier people, but that is minimal compared to the suffering and death under the current industrial system, which encourages overconsumption and large, immoral differences in the distribution of wealth.

Ecological design would work on local and regional scales, as well as on the global scale. Like metaphysics, ecological design has a vision that exceeds its bounds and a reach that exceeds its grasp. And, we have to use it to explore possibilities of local and global harmony, without having complete knowledge or experience. Ecological design requires participation and cooperation to accomplish its ambitious goals. It has to be flexible and adapt to changing environments.

This means understanding challenges and problems, as well as natural and artificial ecosystems, histories and cycles, before using a variety of physical and conceptual tools to create ecological designs on local scales, but considering the regional and global implications. This means trying to design places, ecosystems and landscapes, as well as cycles and processes. It means redesigning flows of minerals and gases, wetlands and streams, domestic and wild forests, and animal paths and reserves. It means redesigning human patterns, from transportation corridors to traditional and modern cultures. It means redesigning agriculture, cities—traditional cities and proposed arcologies—buildings, neighborhoods, vehicles, industries, and medicine. It means trying to redesign social traps, cultural adaptations, corporate goals and responsibilities, formal commons, styles of conflict, economic frameworks, political forms and sizes, religious applications, and even advertising. And, the purpose of all this is to restore harmony to systems that support and encourage health and development, under *emergency conditions*.

0.1. *Preliminary Thoughts on a Framework for Redesign*

Redesigning the planet is a conscious effort to correct the massive 'unconscious redesign' of the planet, which is causing imbalance, disorder and terrible destruction. The 'unconscious redesign' is an unconsidered effect of the activities of convoluted economic and political structures devoted to self-growth and private profit. This unconscious reordering is rapidly changing the social and environmental orders that represent the natural capital of social and environmental evolution. This unconscious reordering is also constructing an accidental trap that leads to massive catastrophes that will destroy that capital as well as the basis for its renewal. Only an equally massive response of a conscious global ecological design framework can lead to some form of global balance.

Buckminster Fuller suggested that the appropriate tools, such as eutopian design frameworks or advanced technologies, might help human worlds to work, given the right emergency. We have been encountering the right emergencies for well over a hundred years, and we need to refine and try these tools, now. The emergencies that he considered were the human responses to a variety of catastrophes, such as fires or earthquakes. But, we are finding that not all catastrophes are fast, human-scale or visible. The effects of those large, slow, invisible, long-term changes make us uneasy, but not adrenaline-ready. The changes are reflected in starving children, hotter summers and stronger storms, failing food supplies, and collapsing infrastructures. We must learn to recognize and respond to these other catastrophes. And, we have to do it now, before they crest and become overwhelming. We can do it. We have the evidence that things are taking a downward turn, the original meaning of the word catastrophe. We need to respond with the best tools we have.

0.1.1. *What This Work is Not*

This work is not a list of global emergencies. It is not catalog of losses. Many comprehensive lists and catalogs already exist. It is not a linear analysis of sudden problems and surprises. It is not a larger, more data-rich, compartmentalized model of change. It is not an abstract discussion of possible shallow changes. It is not a plan to avoid or control catastrophes. This work does not propose simple, single solutions to stop changes or to stop emergencies. It does not offer a way to save the planet or our global, industrial, capitalistic, semi-democratic civilization. It is not about saving the world, or nature, or humanity. This work is not about preserving the status quos of industrial societies or formal democracies.

This work is not about greening our civilization with more efficient cars. It is not about the continuity of market force into private lives, or about breaking with tradition to counter market intrusion. It is not about profiting with green businesses, after certifying mild, small improvements. It is not about sustaining our current styles of living or levels of luxury by tweaking light bulbs, battery recycling, engine efficiency, or sod rooftops; it does not address sustainability. This work does not focus on the symptoms of a single small environmental crisis, or even several crises. This work is not about adapting to drier climates or finding immense forms of alternate energy.

This work is not about big institutions and big successes. It is not about creating spectacles or spectacular successes. It is not about creating virtual worlds in a utopian fantasy of voluntary good will to minimize exploitation and waste. It is not about the management of the planet or a detailed design for the planet. It is not about the stewardship of remaining resources or of other species, domestic or wild. It is not about a partnership or cooperation with nature—the planet is much too large, complex and dangerous for kind of pretense. It is not about the invention of global cooperation or a map to achieve it.

Many other works herald the smallness of nature, the end of nature or the death of wildness. Other books recount the themes of recent times, from the horrors of war to the triumphs of science and technology. Many authors have emphasized the urgency of responding to climate change, to extinctions, to trends of violence and victimization, and to growing inequity and financial dishonesty. Others have identified other emergencies, gender differences, border insecurities, travel dangers, and natural disasters such as hurricanes, tsunamis and earthquakes. Some have emphasized the importance of miscommunications, misinformation, violent attacks, terrorism, misuse of resources, epidemics, potential asteroid collisions, energy shortages, population growth, and desertification and ecosystem collapse. Others have recognized the momentum of short-term self-interest, self-deception, perceptual limits, overconsumption, polarization, and destabilization. And, they are all certainly right to do so—but these urgent problems are *interconnected*!

0.1.2. *What This Work Is*

The problems are interconnected, so this work has to address everything *simultaneously*, because solving one problem will only offer a temporary, limited solution as other problems affect the one in the center of our focus. This work is a recognition of the problems, as well as of relentless change and radical uncertainty, that now confront many species as well as human civilizations. It is a recognition that we do not have adequate understanding, knowledge or control to solve any problem once and for all.

This work is a way to adapt to ignorance, limits and chaos. It is a call for immediate action to recognize problems and try to balance the whole planet, rich nations and poor nations, methane and carbon dioxide levels, and bad designs and good designs. It is a call for large kind of public investments through the UN (or new global government) to avert global risks and to avoid some kinds of catastrophes. It is a global framework for simultaneous changes in consciousness and action, and a platform for people to self-organize and to create responses to challenges. It is a framework for personal, immediate action.

This work is a process of assembling ideas into a nonlinear narrative for the development of interacting patterns of design. It proposes creative alternatives to the business of business and the technological imperatives of progress. It is about reforming cities, and agriculture, and transportation for survival. It is about reordering economics, putting constraints on businesses, but removing taxes from desired ends. It is about radical strategies to confront disruptive environmental and climatic changes. This work is about preparation for the immediate future, using ways to survive and prosper that are exciting, adventurous, imaginative, and joyful, but that also may be hard, painful and demanding.

This work is about creating meaningful images and goals. It presents strategies to implement the images and goals. It attempts to create a framework for details, because we cannot know those details in advance or plan for them. It is about replacing the idea of sustainability with that of flexible creative fitness to a chaotic and uncertain future. It is about understanding the underlying causes and reactions to planetary stress. It is a sketch of possible directions for ecological and cultural development.

This work is a thought experiment for a design framework to contain the creative coevolution of wild nature and human culture. It is an experiment on how to invent a new approach, given the immense body of knowledge that humanity already has, from the present and the long-term past. It is about recreating civilization from the bottom, by reducing our impacts and reducing our vulnerability to catastrophes. It is about managing and constraining humanity at a global level.

This work asks neglected questions about big problems, about the long, deep, wet history of life, about how many wild ecosystems we need, as well as what humans really need—about our history with its images and goals. It asks questions about our cultures and our interference with natural systems and cycles. It is about acting heroically and exuberantly to live joyful, meaningful lives under stressful conditions. It asks for respect and engagement with the planet, so that we can accommodate changes. This work is a call to imagine, participate and then to act through a common global design project.

0.1.3. *What we Need & Why it Would Work*

There may only be a small window of opportunity, between 1 and 20 years, for changes to be effective. Otherwise, losses due to external changes might be unacceptable economically. Fast changes are needed, requiring fast investments, mobile capital and social capability.

Reindustrialization is necessary, with open platform ecosystems of scaled generators, producers, and developers. In an industrial ecosystem, processes need to be revised with energy efficiency, renewable energy and recyclable materials. Technologies need to be transformed to be applicable, then shared. Collaboration has to be emphasized. Problems have to be exposed and presented for design ideas and solutions.

Assumptions have to be made explicit. This is an emergency situation, requiring large-scale, multiple approaches, with new technologies, massive conservation, and micro-energy solutions (which require participation), but not using old, unconscious assumptions and design traditions. The costs of change may be relatively high, from 1 to 24 percent of the productivity of every culture. The entire framework has to be run on an emergency footing.

We need to ask what is required for dangerous times on the planet. We need a sense of common purpose. We need authoritative leaders, who can command. Courage and imagination, obviously. Intelligence and passion, rightly so. But, also we need faith in our abilities and in nature's process of regeneration. And, we need to accept failure and uncertainty. And, we have to have the willingness to proceed with realistic optimism, despite limits to knowledge or cooperation.

We have some experience; thousands of people have collaborated on computer operating systems or online encyclopedia. So society might benefit from a push to redesign society itself, as well as the environment and planet. We have the time: One billion people in affluent countries have 2-6 billion hours to spare every day. Six billion people might have 6 billion hours a day.

We need to act on a global scale. We have acted on a large-scale before, in times of world wars. We were able to treat war as an emergency and to encourage or enforce remarkable changes, such as rationing or redefining jobs. We were able to take these actions without destroying our citizens or our cultures (or most of the planet).

Although nature and our human nature are not enemies to be vanquished, the current situation has similarities to war. Massive changes threaten our lifestyles. Resources are removed from our reach by thoughtless or inefficient use. Growing insect and animal populations seem to be attacking our food supplies. Species are being forced to extinction. Habitats are collapsing. Dangerous chemical wastes are accumulating. Ozone holes are growing, extreme climates pressing, and the entire planet seems to be wobbling. Changes in climate and ocean balance, as well as renewed diseases and infiltrated toxic chemicals, threaten our lives. And, it is happening everywhere, at once.

Although we want to respond with a warlike approach, we have been fooled by the fact that we cannot see an enemy—fooled by thinking there *is* an enemy. We have been misled by the slowness and subtlety of the penetration of our defenses. We have been betrayed by our own desire to continue our industrial dreaming at any cost. Some people have noticed changes and have been crying alarms, but they have not been loud enough or persuasive enough. Everybody needs to be awakened; everybody needs to participate, everybody needs to sacrifice and work towards peaceful solutions. The big problems seem insurmountable, and simple actions will not save our civilization from catastrophes. Part-time participation will not be enough to reverse the degradation of ecosystems, and partial business greening will not stop the unraveling of global cycles.

What is needed is an immediate, peaceful, comprehensive approach to this situation—wise actions in a framework of intentional, reflective design. The proposed framework, ***global ecological design,*** is based on eutopian design, an ecological and cultural framework for making good places on local, regional and global levels. Eutopian design is a way to preserve what is good and useful in human cultures and sciences, and to reserve what is necessary for nature to keep regenerating itself, while addressing the cascading problems of the modern expansion and development with an emergency approach. Eutopian design is a practical framework for allowing the creative anarchy of traditional-size cultures to be able to implement appropriate technology to deal with their resources and with other cultures through a revitalized and empowered international body that has the power of protecting and taxing global resources and properties for its own support, as well as the power to disarm and neutralize the unhealthy influences of large nations and corporations. The framework limits human expansion to domestic and artificial areas, by specifying responsibilities and duties, while permitting the free operation of nature on the majority of the planet. It saves neopoetic areas and reserves wilderness. It encourages respect for natural and cultural capital. It recommends recognizing limits and planning for them using an ecological perspective and a metaphorical approach—it is the framework for global ecological design.

Why would global ecological design work? Because life has over three billion years experience with changing and adapting, because human life and cultures have over 50,0000 years of practical experience adapting and making changes, and because humans are immensely adaptable—if they can adjust to poverty and suffering, they can adjust to a few good changes. Perhaps it is already too late—limits may have been passed and the catastrophes cannot all be reversed. We do not know, and may never know, but we can still act as if we were wise, as if doing the right thing makes a difference. And, we will have worked together to help others, to improve things and to make good places. If we act ***now,*** this month, this week, this day, then the changes might be more effective.

0.1.4. *What Can You Do?*

Read this work. Correct it and supplement it. Extend it. Apply it. Is this work complete or original? No. Certainly hundreds of people have had ideas that are more original. Sometimes however, originality is aided by having many ready-made pieces to put together—for instance, Charles Darwin needed the works of Thomas Malthus and Adam Smith for his ideas. And, these were put into a new pattern. All our revolutions have to do with recombining ideas in new patterns rather than discovering a single, new, independent idea. This is a new global pattern.

Is this work an adequate response to the pressing emergencies? Why are they pressing? Because they are all concurrent. These emergencies are:

Ecosystem conversion, simplification, collapse, and destruction by agriculture.
Conversion of agriculture by cities and roads.
Animal and plant reductions and extinctions.
The creation of large quantities of waste.
The disruption of elemental cycles.
The misuse and overuse of resources,especially minerals and fossil fuels.
The narrowing if agricultural diversity and species.
The overuse of energy, pesticides and fertilizers.
The continued use of exotic and toxic materials and chemicals.
The fragmentation of wild systems by roads.
The narrowing of cultural capital and languages; the extinction of many.
The economic betrayal of trust.
The global homogenization of products and lifestyles.
The continuation of slavery, violence and war.
Gross inequities in wealth between people and nations.
The refusal to consider climate change or respond to it.

Unaddressed, these emergencies are converging into one gigantic emergency that is going to create one gigantic global catastrophe.

Can this work be effective? Maybe it could be, as a frame of ideas or as a matrix that could guide action. What's wrong with this work? It was written in a hurry. It is sloppy and unfinished. Why should you read it? Because it has many good ideas and it attempts to put them into a very large synthesis. People sometimes object to one person delivering finished material and ideas to a larger number of readers. That cannot be the case here. That is why this work is a crude outline. It is constructed as a frame that others, like you, can add to. In fact, think of this as a workbook to which anyone can contribute, as a sketchbook where you can fill the sketches, or as a dynamic corrective exercise that can be improved and expanded.

The attempt at global design means accepting the opinions of everyone, regardless of their motives or level of understanding. The attempt therefore becomes the beginning of reeducation of humanity, which may be a long process, longer than single human lifetimes. This work should aim to be an extensive community of cocreation, like the Grameen bank or Wikipedia. This work is an open framework that addresses and limits the global, but allows local and regional designs within that scope. The work is a participatory process. That may be the only way it is useful. So, please think about it, but then become part of it and contribute to it. Otherwise, it will just be another poor, unread book, with a snazzy title.

0.2. *Redesigning the Planet?*

Redesigning the planet? With global design? What is global design? How can it defined, much less applied to the planet? The title and subject of this book refer to the intentional design of the emergent global aspects of the planetary system, especially living forms and more especially human forms, who are becoming a global influence. Is global design even possible? Why are there not a lot of books on it? Why is no one talking about it? This section outlines the goals of the book.

What does the word 'global' mean? In the Old English Dictionary, it meant 'spherical' referring to the earth. By 1945, the word was used by the United Nations to describe political action, referring to actions to commonize costs. The United Nations used it thus. Marshall McLuhan and others used it in reference to a global village. Then, it began to mean ubiquitous, or everywhere. Garrett Hardin contrasts the ubiquity of potholes around the world with the specific meaning of a property of the planet earth, such as the atmosphere. What are global things? Certainly the whole of the planet, as well as the atmosphere and ocean, are global; perhaps life is a global phenomenon. Global things are quite different than things that appear globally. The global system, for instance, has unique characteristics that emerge from local interactions. What does it mean to be global or local? These terms are terms of scale, used to describe a field.

The word global refers to the unique features of the whole system; it is not used to mean things that are ubiquitous, such as potholes or soft drinks, or large, such as human trade and business exchanges between nations on separate continents. The word design refers to the entire range of human intentional behavior to improve its situation, as it is applied to the entire planet, from benign neglect of some systems to complete control of other systems.

We have not designed patterns or structures for the planet, so far, possibly because of the challenges of scale and complexity, or possibly because we have trouble thinking about large, slow, long-term, partly-invisible processes. The planetary or global system has a unique set of ecosystems with interactive histories. The global system has unique properties and limits that have to be addressed in any design. It exhibits very-long term trends, which will be called gigatrends.

0.2.1. *Starting with Global Design*

The vernacular designs of many cultures are superb adaptations to their local environments. Many early cities were planned and built as a response to adapt to difficult conditions. Many of our modern buildings are models of beauty and efficiency. However, our modern cities are generally examples of wild, stochastic growth. Very few people, other than Paolo Soleri, are designing cities. Our habitations, fields and transportation seem completely haphazard. Instead of placing cities on mountains or barren ground, we are filling fertile grasslands and swamps. Instead of placing roads around vital breeding grounds, we are bisecting and fragmenting ecosystems. Instead of integrating our food areas with wilderness, we are simply converting productive ecosystems to temporarily subsidized monocrops, which we then convert to roads, city squares, or wastelands, without regard to place.

One way to play with design is through ecological thought experiments. The design itself must be considered as an ecological design on a global scale. Many global factors must be considered, including the biogeochemical spheres of the planet, cycles, forests, and animals. Other factors, such as wilderness and the extent of human cultures, must be an integral part of any design. Wilderness areas, of many kinds from autopoetic to neopoetic, have to have appropriate sizes and shapes to thrive and provide environmental opportunities, or 'services,' to all living beings.

Human cultures have adapted to different environmental conditions over tens of thousands of years. These cultures sometimes operated within local and global processes, as well as within human structures. Cultures become critical design factors since their adaptive patterns, such as agriculture and technology, create opportunities and problems on regional and global levels. Human populations have a significant impact on the planet, especially through conversion of ecosystems and the addition of exotic elements.

In fact culture and nature are converging in a new pattern that can be referred to as 'domiture.' Domiture is the object of regional and global designs that have to begin with a foundation of wild species in wild systems and continue to the common and artificial places that human cultures create and maintain. This new pattern is supported by ecological design and ecosystem medicine. Design operates on many levels and works upwards and downwards, as well as inwards and outwards. It has to incorporate numerous other factors relating to religion and urban shapes, as well as to economic and political forms. Corporations and the growth of inequality must be addressed in any designs, due to their negative characteristics, which can distort productive actions.

Creating designs for the planet has to be done in a large political framework, complete with new global political structures and corporate trusts. Cultural solutions to regional problems have to be applied, but global problems resulting from conflict and inequity have to be addressed in every culture and especially through a larger framework. Global designs have to fit global patterns and limits. Redesigning the planet has to be a coordinated, constrained series of actions that build local good places and adjusts them to good patterns in a global system.

We have had designs on large scales before, often presented as imaginary utopias, but most of these were rejected as impossible ideals. These rejected utopian designs can be replaced by realistic and achievable ones, that are based on a new image of the earth and humanity, that use an ecological perspective to ease human societies into partnership models, to restore wilderness and common places we have destroyed, and to change international relationships into a poetic framework capable of limiting war and permitting the unique human expansion of cultural expressions.

Global ecological design rests on a foundation of ecological knowledge, as well as on an appreciation of historical problems and philosophical ideals, and it employs an ecological perspective. This work outlines how to create global designs consciously, using our knowledge of how things work, but being aware of our ignorance, and by being careful and respectful. A global design process would address many problems, from problems of scale to political inappropriateness.

0.2.2. *A Snapshot of Global Design*

Global design can create appropriate images for the planet to replace the harmful image of the machine. We can build on archaic cultures, with the image of a Turtle, or expand a mythic image scientifically, as with the Greek Goddess of the earth, Gaia, as James Lovelock did. We must create an image of a whole living planet. Lewis Thomas suggested that the planet was like a living cell, and the atmosphere was its outer membrane that could edit the sun to promote life.

Global design can formulate specific goals to be associated with a common image. These might begin with working towards a civilized human existence on a dynamic planet, characterized by interhuman and interspecies equities. They might include the reservation of the wild, to keep the minimum conditions and processes of the planet in motion. They might include the definition of optimum human populations based on normal ecosystem productivities and the limits of geochemical cycles. They might include a plan for the independence and relative isolation of independent cultures. They might include new kinds of cities and immense areas of common lands for domestication.

Global design could also develop strategies to discuss, refine and work towards these and other popular goals. The first strategy would be to create a eutopian structure for human societies that emphasizes self-reliance and international cooperation on global resources and cycles. Eutopias would be less vulnerable to downward drift or collapses. Through the UN, the framework would allow for global coordination and planning. Archaic societies have experience adapting to local catastrophes. The variety of cultures, each adapted to different environments, would provide resiliency and functional redundancy to human survival.

The eutopian structure would create new goals and images that would be applied to priority approaches, starting with survivability and protection of the wild. Some of these goals would increase our ability to anticipate and respond to these new catastrophes. Others would work towards equity of human societies, within important ecological limits. And, still others would reduce our impacts and disruptions on wild ecosystems and cycles. Eutopias would encourage compartmentalization and self-reliance of cultures as regards food and shelter. Eutopias would offer redesigns of our cultural and economic systems so that they would become smaller and more independent and flexible, in order to respond better and faster to new environmental uncertainties and changes. Eutopias would provide a repository for the diversity of human knowledge, cultural knowledge, as well as the diversity of crops and animals—and of course the genetics of wild beings. It would catalog cultural legacies from archaic cultures, like the *Foxfire* books to record and preserve Appalachian folk knowledge from being lost from the transition to cities. UNESCO could coordinate that.

Other strategies could be coordinated to accomplish further common goals. A few of these would include:

- Empower the UN (Or a new global government) to support itself by coordinating and charging for the use of commons.
- Encourage the UN to accept independent cultures as nations.
- Create a steady state (in Herman Daly's term) framework of local economies, that is, a homeorhetic state constantly changing with ups and downs, but without large massive disruptions or differences, a state limited by optimum numbers, sizes and processes.
- Limit the use of fossil fuels to strategic uses, not cars, burning or fertilizers. Limit human use of everything to within ecosystem limits. Conserve 80 percent of remaining energy and resources by limiting heating/cooling, driving, and other uses.
- Manage the human end and impacts to avoid the global technological fixes that require constant monitoring and control.
- Preserve small scales of everything, from cities and farms, to roadways and air

transport. Deindustrialize agriculture. Make it more labor intensive.
- Monitor possible catastrophes, from asteroids to earthquakes and tsunamis. Insure readiness for dealing with them.
- Keep options open. Keep flexibility high. Flexibility is crucial for dealing with changes. Equally important is creative co-constraint.
- Compartmentalize systems more by following an ecological model, reducing connections and overintegration. Increase diversity and redundancy at multiple levels.
- Require a diversity of sources of materials and services for all kinds of manufacturing, with always at least one local or regional one.
- Restructure financial institutions from interest and profits to fees and community donations. The times and reasons for profits are gone; that age and those needs no longer exist. At this point the concern is not exploration or new trade, it is enoughness, support and equity.
- Create massive stores and vaults. Create long-term seed vaults, like the Norwegian doomsday vault. Create seven-year food banks of cereals. In fact, create long-term banks of needed technologies, tools, and physical materials. Keep reserves of everything needed for catastrophes. Make sure supermarkets have more canned goods. Pharmacies, medical supply companies and hospitals need more warehouse supplies for catastrophes. Keep oil reserves. This are pressing needs for any Homeland Security.
- Accept all of the effects of living on a dynamic planet: extinctions, death, suffering, destruction, life, accomplishment, beauty, and joy. It has always been a wild ride and it will continue to be. The music is wild, the dance is wild.

These and other strategies will be expanded throughout the work. Some of the strategies will be constant and permanent, while others will be temporary suggestions for transiting to desired states.

0.2.3. How Can We Feel About Global Design?

We can do this now! But, what would it be like? It might feel similar to some times during World War II for some people in some nations. People could react in days. The economy could shift in months. Some things would be limited or rationed. Morale should be high because people would sharing the losses and risks, the challenges and stresses—and they would be doing it for the common good, to avoid catastrophes that could affect everyone and to save their part of civilization. The world would not suddenly become peaceful and utopian; there would still be conflict and crime, cheating and violence. But, these problems would occur within a smaller scale, within the context of redesigning human structures to be in tune with the natural processes of the planet.

The thing is, we do not want a uniform—and likely boring—world culture. What we want is a framework to insure the development of local cultures. An analogy might be the atmosphere of the earth, which is essentially the same, but allows many kinds of life to develop. Designing the planet is a process of assembling ideas, a narrative for the development of interacting patterns. It is not a comprehensive model, but a sketch of possible directions and developments. It is, in John Thackera's words, an incomplete score, because the composer, player, audience, site, all vary with every performance. What is important is the framework for action, with its clearly understood constraints. The work is coadaptive with the participants.

0.3. *Global Design Science as Poetic Production (R. B. Fuller's Suggestions)*

Buckminster Fuller dedicated his life to solving problems. The problems were big then, as they are now. And, what daunting problems they are now: Humans deaths on an unimaginable scale, perhaps over 200 million people in the last 100 years, from shortages and distribution failures to wars and diseases, as well as the conversion of vast areas of vital ecosystems to agricultural fields and deserts, resulting in the deaths of animals, species, habitats, and ecosystems. All of these problems interact, so that it becomes difficult to isolate separate problems. Some of these long-standing problems result from long-standing challenges to human health and happiness: Violence, stupidity, greed, forgetfulness—not just personal forgetfulness but larger forms of cultural amnesia—old diseases and new, lust for power, and the lust to consume. Some of these problems are the result of detachment. Corporations, a trademark form of our industrial civilization, contribute to this detachment. Fuller invented an imaginary corporation, Obnoxico, as a foil for his ideas on addressing these problems. Fuller dismissed the flatscapes that resulted from uninformed design and recommended a form of eutopian design—Eutopias is from the Greek word meaning 'good places.' This word, with Outopias meaning 'no places,' was the source of Thomas More's pun 'Utopias,' which was also the title of his fictional account of human development to the beginning of the industrial era. This work is an extension of eutopian design to deal with long-standing problems.

We tend to think of problems as unwanted 'side-effects' of the wanted main-effects, but all effects are equal, as Fuller noted, and must be addressed as equal. A problem (from the Greek words 'to throw forward,' which is what we tend to do with them) can be considered as a question proposed for solution. Most things identified as problems are embedded in a network. Nothing is simple; there is not one problem, there is not one solution. Problems could be considered also as challenges that we must respond to continuously, in the process of living, not as puzzles that have to be solved once for all time. A challenge is a calling into question or a demanding task (a challenge is defined as 'a call to take part in'). It is about consciously choosing to see what can be done, rather than dismissing a conflict as terrible and unsolvable. When challenged by some situation, we react by habit, although this may be disconnected from other habits. Habits protect us from many problems. Addressing a problem often has to do with a power struggle, which becomes part of the problem. If problems are regarded as challenges that require a social response, then much of the conflict can be avoided.

The problems of cultures, of natural ecosystems, and of modern, industrial, corporate, urban civilization, have been documented quite thoroughly. We have identified most of the problems in the problematique, from erosion, pests, and fertility loss, to population migration and diseases, and we have addressed them separately, using technological innovations or political adjustments. But, we have not dealt with them in a whole pattern. We have not understood them as equal parts of complex large dynamic systems.

Sometimes we forget, moreover, that the decisions of our ancestors saddled us with losses, just as our losses will encumber our heirs with deforested landscapes on depleted soils, despoiled by exotic chemicals and hazardous wastes, in a network of impoverished habitats with an unstable climate, and of course, compounded by large intergenerational financial debts. This network of problems can be grouped under large categories, each of which contains a multitude of related problems. Each category also extends numerous threads to the other categories. The loss of nature and the wild, that is, the loss of the whole and the pieces, ecosystems, habitat, species, and individuals, may be devastating to all self-renewing systems. The remaining losses, such as the loss of place and the loss of design, are fundamentally human losses.

0.3.1. *Allowing Flatscapes & Killing the Planet*

Our habitations, fields and transportation seem completely haphazard. Instead of placing cities on mountains or barren ground, we are filling fertile grasslands and swamps. Instead of placing roads around vital breeding grounds, we are bisecting and fragmenting ecosystems. Instead of integrating our food areas with wilderness, we are simply converting productive ecosystems to temporarily subsidized monocrops that we then convert later to grazing areas, roads and city zones, without regard to place or appropriate use—and then let them degrade to deserts, ruined landscapes or placeless flatscapes.

Placelessness begins with adoption of an attitude, an abstract, geometric view. With this inauthentic technique, places can be treated as interchangeable and unremarkable, where nothing is significant. Cutting historical roots and eroding symbols contribute to an awful placelessness, an alienation to place, and an inability, finally, to have a home and to live there. This becomes the fate of a billion, and it increases.

After shaping ourselves with technology and necessity, we have lost the knowledge of how to care. We have learned to be dispassionate (uncaring), objective (uninvolved), and unattached (placeless). Other animals have used languages and tools, so it is not those things alone that account for our lost knowledge. We 'not-care' because we are confused. Our confusion results from being out of place and not having an identity.

People use to identify with place, but the gain of a global monoplace has led to a loss of identity for many. The commonness of industrial culture, at a low common denominator, has led to fewer identities to choose from. The mass production of homes, as well as of music and art, has led to fewer creations.

A number of scholars have noticed that we are creating flatscapes, devoid of depth and providing only mediocre possibilities. Flatscapes, C. Norberg-Schulz's appropriate term, have allowed landscapes and places to become monotonous and dull, displaying fewer unique qualities and fostering weaker attachments. Edward Relph outlined the disappearance of variety that results in placelessness. Places become homogenous and interchangeable, as people everywhere share limited ideas and limited ways of relating to others.

David Brower urges us to revive the human sense of place. Places cannot be preserved, however, without cutting their vital connections and making them lifeless. Places cannot be restored to some Arcadian fantasy, without severely limiting their movement and development. Places cannot be created using a machine metaphor that boasts the substitution of anything for anything.

There have been attempts to define and design places. Christopher Alexander decomposed environmental objects and activities into their constitutive elements, to be reconstructed into designs that could fit local places. These formal solutions can improve strategies for design and can provide a matrix for the making of places. But, they should not assume that human variables can be manipulated to achieve a predicted response. And, they cannot ignore specific psychological or cultural patterns.

There must be a way to define places, using an ecological approach, and considering cultural modifications and adaptations to places. The approach has to be tradition-based and partially self-conscious. It has to be responsive to the genius of place, as well as to human meaning derived from the existential and phenomenological significance of a place. The concept of place incorporates physical, biological, and cultural dimensions. The solutions cannot, and do not, need to be precise; they can be unfinished and ambiguous. They can be fuzzy. The design does not need to guarantee rootedness or workability, but it can identify limits. It can provide possibilities through a matrix that allows tradition and richness. It can provide direction from the understanding of the parts. It can understand how to make a fertile kind of soil, as a metaphor, where things can live and develop. Living beings synthesize the parts and find meaning in living there, and in doing so revitalize a place.

Other human losses are equally important. The loss of culture leads to the inability of humans to adapt to unique environments due to unstable social environments. The loss of health results in weakness and sickness, the inability to maintain the self or to produce necessities. The loss of fitness leads to the inability to function under normal environmental conditions and to reproduce; this loss may also result in personal and cultural insanity. Paul Shepard went so far as to state that the losses that resulted from the Neolithic revolution trapped people in behaviors that ended with insanity. The feedback sequence was inevitable due to a number of agricultural and urban characteristics, including simplification, territorialization, and distribution; for instance, concentration led to intensification, stress, disease, decline, and finally madness (See section 5.6.4).

The loss of equity results from the massive breakdown of the distribution of goods and luxuries. The loss of renewal reflects the inability of social systems to renew themselves or to provide security and resources for their constituents. The loss of accord happens when people or cultures are unable to work together or to control conflict. Finally, the loss of design is the inability to imagine, shape and build things that enhance life and safety; it is the inability to respond to changing circumstances with adaptive physical and cultural patterns.

Too many losses may be killing the planet. Although the planet is immense and complex, we do not know when critical thresholds may have been or may be crossed. James Lovelock once suggested that human actions were damaging the planet but could not kill it. Recently, however, he has noted that too much damage to ecosystems and biomes might disrupt systems such that bacteria and a lower diversity could not drive global cycles. In any case, industrial culture is still working to consume every resource and to convert every wild ecosystem to an artificial system. This is a challenge for ecological design.

0.3.2. *Designing Real Living Places: Eutopias*

Perhaps the root problem lies in our images; we use old images of frontiers or simple, inadequate images, like the ‘machine’ metaphor for nature. Perhaps the problem is really a failure of imagination. Ideal images of the world have been offered as ideal schemes for social and political development, but are dismissed as being unrealistic and flighty. On the other hand, many of these images would require too much change—rejecting the past or refusing the cultural present, then creating new institutions from nothing. Some of them are thoughtful and imaginative, yet most of them are rejected as irrelevant dreams or self-indulgent imaginings. Yet, as Pierre Dansereau has said, the failures of pollution, poverty, and urban decay are failures of imagination. Rejecting the solutions of imagination, therefore, can only make the suite of crises worse. Dreams and imagination are needed to describe desirable futures, to support plans, and to outline goals.

These rejected utopian designs can be replaced by realistic and achievable ones, that are based on a new image of the earth and humanity, that use an ecological perspective, to ease human societies into partnership models, to restore wilderness and common places we have destroyed, and to change international relationships into a poetic framework capable of limiting war and permitting the unique human expansion of cultural expressions.

This work outlines how to create places consciously, using our knowledge of how things work, but being aware of our ignorance and limits, and by being careful and respectful. Certainly this seems less radical than continuing to surround ourselves with nuclear weapons and habitat destruction in the name of a perverse political reality. A eutopian process, quite different from the utopian, would solve many problems, from problems of scale to political inappropriateness. A Eutopian framework would allow many new nations, but alliances and networks would form and reform, as they do now. Fuller once suggested that the United States was a collection of nations, much like Leopold Kohr argued in the early 1940s; see *The Breakdown of Nations*. Several sections on global design are drawn from an earlier book, *Eutopias: Making Good Places Ecologically and Culturally* (1970).

Buckminster Fuller was one of the first to consider this other meaning of utopias, as good places. In the 1920s, Fuller began work on a Dymaxion Air-Ocean World Map, as an alternative eutopia that sought to define civic and ecological order through maps of known areas (Dymaxion is a word formed from the words dynamic, maximum and ion—an ion is an atom or molecule that has lost or gained one or more electrons). On this map, the North Pole is the neutral center around which land mass and ocean unfold; this deemphasizes Europe, China or America as centers. In the dymaxion series of maps, Fuller superimposed a spherical icosahedron grid onto the earth's surface to limit the distortion of the relative size and shape of its components. The projection represents all areas with equal weight.

Later, he sketched the World Town Plan, a map that preceded and directly influenced his subsequent maps. The town plan map, in its projection method and form, highlights the connectivity of the "one world island." Fuller saw his map as an operational tool to be used by the members of the global citizenry. He intended to establish a map that does not prioritize cardinal direction, political entities, or hemispheric organization. Instead, the Dymaxion map provides a base for presenting larger global themes such as human migration, natural resources, and population distribution. Temperature replaces politics as an organizing feature. World climate is shown in a range of coloration from warm reds to cool greens and blues. Even with these specific theme, Fuller's map emphasizes wholeness across the global surface.

A single utopia would not work for the whole globe. Many, as Eutopias, are necessary. Most utopias expect a perfectly rational humanity in a stable, ordered nature. Eutopias accepts the imperfect nature of humanity and the changing ambiguity of nature. Most utopias present a finished, closed, completely planned society. Eutopias would encourage building an open, progressive, partially planned global society. Utopias are the dreams of reason. Eutopias are dreams of small traditions and cultures, reasonable or not. Where an imagined utopia offers revelations promising a desired future, eutopias offers references from selves and cultures for producing good places on earth now.

There is no mechanical prescription for designing and making good places, no blueprint or timetable. The current institutions cannot create good places; the market has not been able to create health and equity; even scientists have not been able to create a way—Eutopias is a fourth way. It is not an institution that benefits only the rich; nor is it a schedule of temporary handouts. It is a plan for a framework for local self-reliance and global exchange, that is respectful of traditional cultures and ecological networks.

Eutopias has a low—but not too low—political feasibility. The benefits must be worthwhile to justify the costs. Benefits cannot be vague and unsatisfying when the costs are immediate and painful. Poetry and education must prove the benefits, so that the eutopian alternative can begin. This code emphasizes its flexibility, to avoid the eventual hardening of choices. But it must be instituted at once. The crisis caused by exponential growth and destruction cannot be solved after some final limit is passed and some great catastrophe has begun. The crisis of ignorance cannot be solved by hurrying and creating more problems.

Eutopias exists in the extended present, incorporating past traditions and future values. It would concentrate earthward (down) and inward. Eutopias is a new comprehensive philosophy to make sense of the world. Eutopias is comprehensive and global. A broader frame of reference is assumed. It is concerned with unfolding and producing new emergent forms, not just static structures. Eutopias is grounded in environmental concerns. Its values must be the most useful cultural and natural values. It must develop from existing social and political forces.

Eutopias can reduce the losses of nature and culture by creating a framework to protect them. Eutopias can reduce the losses of health, fitness and accord, by emphasizing them and creating circumstances for their continuity. Eutopias can reduce the losses of equity, renewal and design by offering new designs that allow for a normalization of equity and for the normal processes of renewal. Losses from accidents and diseases can be reduced by preparedness. Losses from earth and climate changes can be reduced, also, with preparedness for 'normal' regular events, such as hurricanes, earthquakes, and droughts.

Eutopias is a framework in which to base global ecological design. Design can be used to reduce impacts from these events; for instance, by denying building permits on floodplains. The losses from some events, such as droughts resulting from El Nino, can be ameliorated by having surplus food and supplies stockpiled.

Eutopias can integrate tools and designs. Tools and designs are important extensions of the human mind. Their purpose is to foster and assist survival, not to make it more difficult. Tools and designs can be made appropriate to environmental limits and cultural preferences, both of which are often ignored by industrial approaches.

Eutopias can suspend the designing of noplaces by promoting the understanding of the inadequacies of bad characteristics and bad designs; it can stop the plague of uniformity and paucity. Through an understanding of the consequences of human ambitions and actions, eutopias can avoid many of the evils that result from a civilization on autopilot.

Eutopias can show how to preserve and restore, design and plan whole patterns that envelop fields and cities as well as wilderness,roads as well as animal trails. Eutopias can provide an ecological planning process that offers a structure of limits and divisions for the planetary system that would permit the preservation and restoration of natural cycles and places. An ecological design process would be applied to ecosystems as well as to cities and fields.

0.3.3. *How Can We Redesign the Experiment?*

For his commitment to a design science revolution, Fuller made "Ten Proposals" (from *Earth Inc.*) that would address the problems of our civilization. One of the most important is to learn the mathematical coordinate system of the universe. In fact, an educational revolution, based on synergy, would be the highest priority. It would start with an inventory of all known principles, using Fuller's world game for theoretical exploration. To inventory the resources of the planet, we would convert general accounting systems to a planetary ecological accounting system, intergenerational and cosmic rather than annual and agricultural. Wealth would be refined from a scarcity model to an energy model. By making ownership onerous, excess property would be eliminated, and we would be liberated from our slavery to 'thingness.' World sovereignties, with their suite of barriers, would be modified. Humans would apply their unique skills as problem solvers by realizing our competence at design science.

Fuller made many brilliant suggestions, and applied many ideas in brilliant inventions. His technical focus, however, allowed him to overlook many of the needs of people and cultures. One sovereignty, replacing many hundreds, for instance, would make things worse. As Leopold Kohr noted, bigness is the source of most problems, such as misery and conflict, and smallness is the simplest and most elegant solution.

For Fuller, the discipline of design science proceeds from a subjective search through experimentation and feedback to generalization, then development, including practice and regeneration, to evaluation and back to the subjective search in a loop. Fuller notes than humans have evolved from the local 'rejuvenation' of agrarian farming to a collective nonlocal rejuvenation of industrialization. However, industrialization has proved to be nonrejuvenating, stuck too long in a flow-through pattern of production, where everything is treated as commodity. Something that is capable of self-renewal is needed.

Fuller also argued that we have displaced ourselves as specialists and must again become generalists and 'comprehensivists.' We need greater degrees of freedom to increase the probability of cross-fertilization to solve design problems. We need new skills in design that can come from considering the global context. We need to try new approaches and correct the inevitable mistakes. And, we need to ask questions about the global systems, before we can try to answer them.

Fuller emphasized the importance of global communications, through radio signals, and global transport, complete with a computerized global transport system and traveling cartridges that would be assembled at local stations or loaded onto planes or ships. Fuller also proposed a global energy grid (the Global Energy Network International), which would connect all areas, although we would have to be careful not to create connections that are too rigid. The dymaxion house was to be a global dwelling service, which would optimize performance and efficiency for builders and families.

A design science revolution, using a comprehensive anticipatory design science, would reform the environment. But, Fuller thought—erroneously—we could reform the environment without reforming people. Therefore, design cannot be limited to simple mechanics, but has to extend to cultures and behaviors, to ecology, economics and politics.

Fuller does suggest that a design scientist has to take the initiative rather than being retained by a client to carry out a limited design. The design scientist has to perform the fundamental invention, underwriting, development, and experimental proof of a project.

Design science has to provide effective anticipatory strategies for formulating and managing the regeneration of industrial organisms in the same way that the medical profession deals with human metabolic regeneration, according to Fuller (WDSD No. 5, 1962). Design has to be holistic. Fuller states "the design scientist would not be concerned exclusively with the seat of a tractor but with the whole concept and distribution of food." For the field of global ecological design, this means siting industry within the context of the global system.

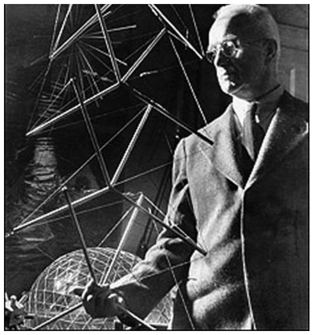

Figure 033-1. R. Buckminster Fuller

0.3.4. *Poetic Production*

Fuller pushed his scientific and technological program passionately, aware of the limits of the planet, but he neglected other necessary dimensions in design. In his technological utopia, knowledge was considered enough to inspire changes. His technology was quite anthropocentric, ignoring the continuity of technology from termites and fungus to wolves, monkeys and humans. His technology was based on the current industrial system, which allowed him to ignore the increasing resource use, energy use and waste from the reduction in size—what he called 'emphemeralization'—of machines. He also suggested that information, production and human population could increase indefinitely, although the growth of the last two contradicted his insights on limits. That and his other insights can be combined in a more holistic approach.

There are three kinds of intellectual activity, according to Aristotle (Metaphysics, E.1.1025b25). The first two are theoretical knowledge and practical knowledge. These two activities, or sciences, involve different ends. The theoretical sciences involve necessary propositions and have knowledge as their end; the practical sciences subordinate knowledge to action. Philosophy, mathematics, physics, and theology are each a form of theoretical knowledge. The practical sciences, such as agriculture and forestry, derived many propositions from the theoretical sciences. The sciences become less exact as they involve more elements, and thus the practical becomes more dependent on the theoretical.

There is a third kind of knowledge, according to Aristotle; it is productive knowledge. The productive sciences have a product as their end, not knowledge or action. Productive, or poetic, science derives many propositions from both other sciences, and because it involves more elements, poetic science is the least exact of all. Yet, in a sense, poetic science is more basic than the others, since all sciences produce an end.

Poetic knowledge is inseparable from the power to make. Poetic knowledge is a kind of knowledgeable activity with a product for an end. Aristotle defined poetic art at various times as: having to do with creation; "principles of change in another thing;" and being concerned with the same thing as "chance." Poetic science is a making, a fashioning of random data into a significant statement of universal relevance. The whole is structurally unified into a complex thing. This unity is based on organic themes, for Aristotle. Art is a mimesis of nature, but it does not copy nature's products. It presents unified wholes, in the manner of nature. Works of art are structured like unified living things; when things exhibit unity, then they have order, and when things have a definite size and order, then they are beautiful, in art and in nature. Fuller once said: "When I am working on a problem I never think about beauty. I only think about how to solve the problem. But, when I have finished, if the solution is not beautiful, I know it is wrong." In fact, only by being organically structured can art be mimetic; and only by being mimetic to life can art works be organisms. Poetry imitates, not fragmentary reality, but the essential whole.

Our designs of ecosystems, of wildernesses, of cultural forms need to be poetic productions. By following the principles of ecology and applying them to the characteristics of good places, we can make global designs. According to David Orr, certain design principles work with ecosystems and nations: Small units dispersed in space, redundancy, short linkages between modules, simplicity, diversity of components, self-reliance, decentralized control, large margins, and immediate feedback. A megaframe like Eutopias incorporates and expands these principles and would allow the scaling of design from the local to the global.

Ecological design, for instance, is the design of whole communities. We can design places as organic wholes to promote the well being of individuals and the common good. But, we can only really do so as participants of ecosystems (and this takes us back to the fundamental lessons of physics: That we cannot *not* be part of an experiment, that disorder creates order which creates disorder, and so on). Humans need to recognize that they automatically participate in everything. Furthermore, due to the uncertainty in dealing with large, long-lived systems, we have to learn to accept that the system needs most of its own productivity and to limit our use of the systems to well below critical limits, that is, within the flexibility of the system.

Global design is the design of the entire human impact on the unique global characteristics of the planet. It may require patterns of constraint more than specific technological applications for a global level. It will require the participation of everyone, dealing with small actions and very large cycles. But, the designs and actions, and certainly our awareness, should extend beyond the planet.

0.4. *Humanity's Cosmic Role in Protecting and Restoring the Planet?*

By Arne Naess

I am practically overwhelmed by this reception and I don't understand why so many people would come to listen to something that seems to be one of the last questions you would ask, namely, does humanity have a cosmic role in protecting and, maybe to some extent, restoring the planet. I'll say that we might have a cosmic role. And that means it is more than a planetary role. Let me explain what I mean.

We are on a planet that is a tiny, tiny speck in an enormous galaxy we call the Milky Way. It is nearly impossible to think that with so many planets and stars, there are not other planets resembling the planet we have the honor to inhabit. So I think we are not alone. But there are such distances that we are, practically speaking, completely alone, so far as I can see. It might take 50,000 years to get an answer to a Christmas card, and while I feel sure there are some bodies out there who would like to get a Christmas card, we will never get in touch with these people if relativity theory is correct.

If we have on this planet a role that could be called cosmic, I think it is because we are the only creatures within enormous distances, creatures that can consciously feel and understand life, what's going on, what it has cost, and how long a time it has taken to have people here. Three thousand million years, this miracle of evolution has taken! When creatures moved out of the water and onto the land, they were demonstrating what the French have called an "élan vitale." This means breaking the limitations, getting into new worlds and new ways of living, transcending any kind of goal you have so far, any kind of style. So you crawl up out of the water: I think there are still possibilities that humanity could crawl up to somewhat more dignified behavior. It sounds unlikely but it could happen that within a very short time, say five hundred years, we could reach a level of consciousness about where we are and what we are able to do, such that we would say "We cannot treat this planet as we do." And in a manner that is completely ethically justifiable, we will try to be fewer instead of being more and more. Wherever you are, you should live on the land in a way that does not destroy it.

This seems very unlikely, but so many unlikely things have happened this century. There have been some very bad things, such as wars, but there were other, more cheerful things that were absolutely unpredictable. So, I am an optimist, for the 22nd Century, that we will be on the way to achieving more ecological sustainability. But in the 21st Century, I think we will have a much worse time before we have the courage and enough motivation to change our behavior to enjoy the planet without destroying it. In the long run, we will manage, but we need to have a long-term perspective. The Earth has fantastic resources, and if we can just reduce the number of our bad habits, things will go all right.

But then what about restoration? Many people think that we have destroyed, or standardized (which is a much better word for it) the landscapes. Not only have we reduced biodiversity but we have reduced differences of every kind. Restoration is very difficult, and I do not think we can restore very much. Rather, we can limit what we do of the bad things in areas still not dominated by humans. Instead of wilderness, I use the term "free nature." One great goal is that every little child should have access to free nature, because it will help them understand very easily that other living beings, like themselves, like to live, they are wonderful to look at, and to be together with.

I started being together with certain small animals in the water when I was about four. When I was walking in the water, tiny fish and crustaceans would run away, then circle back under my foot; because they like to have places to hide, they hid from me under my foot. I felt this tremendous power that we have as human beings compared to those tiny crabs, but also I felt the nearness of these creatures at the same time. Most children don't have this opportunity any longer and that is bad. So we have to go back again and give every small child the opportunity to experience nonhuman dominated areas. That is the great goal, I think. It makes me optimistic to hear about offering teenage criminals in big cities opportunities to get into the national parks to experience, often for the first time, free nature. After a couple of weeks, they see the same as I see, even though I have had all these opportunities already early in my life.

On the other hand, we know that we have a system of economic growth with a tendency to say "yes" to bigger and bigger markets. In this way, countries such as Japan, the United States, and Europe can agree to collaborate, so that we get ten times as much trade, ten times as much transport, and so on into the future. At the same time that the ecology movement, especially the more radical deep ecology movement, is getting stronger, the opponents are also gaining in strength. These are not people who lack sensitivity, but people who are just part of the system. The so-called green backlash, the forces against taking ecology seriously, are rapidly gaining in power. This will limit efforts to restore and the possibility for political forces to implement new policies. In Norway, as in many other countries, we talk about politicians in a rather negative way, but then we vote for exactly the same kind of people next year. My reaction is that we should not talk this way because we are the ones who vote for these people. If somebody is really courageous, saying that we must reduce our material standard of living and retain our quality of life, then we are mostly silent. We criticize when they say something we don't like, but we don't say much when we like what they say. It is my impression that it is still the "ordinary people," those who feel they have no power, who do have the power to change.

In terms of the cosmic role, I think it means that we should try to internalize the feeling of the millions of years behind us. You cannot neglect who you really are and where you are. It is so important for us sometimes to truly feel what fantastic creatures we are, to recognize that the difference between Einstein and Leonardo de Vinci and you is small compared with the difference between you and any other creature on this planet. We are such fantastic beings in our capacities. It is inconceivable that we could neglect who we are, neglect thinking how great we are compared with anything else within any distance. We are able to think and to imagine an immense number of kinds of words and worlds, which nobody else on this planet can do. Couldn't we, more often, do things and teach things that are relevant to the deepest knowledge and deepest feelings we have on this planet?

This is my answer, and it is only formulated as a question because what I am saying here, and what I am hoping (and what I am hoping not), is that nobody is competent in these questions, nobody. We should better reflect on who we are, and feel that the choices we have as humans are not the same choices as for a pig, although a pig is a wonderful creature. We have the feeling, I think correctly, that the variety of choices open to a pig compared with us is tiny. The choices we have are large because of our brains, which we use mostly for no good. One of my speeches, which has been repeated many times over the radio, asks, "How can you undirect yourself, as you seem to do, when you have so much creativity?" Our needs are so immensely fewer in number than we seem to believe, looking at how much we consume. I think it has to do with a fundamental uncertainty inside; if you are a little uncertain of yourself, it is easier to follow the system, to follow what others do.

Not all people are content doing the same as others, listening the same, looking the same, and telling the same stories. Sometimes people want to go in a different or uncommon direction. In my life, I have had a certain amount of independence. I listen to what others have written and said, and I am glad to get the instruction, but in matters outside mathematics, I also can identify things I like or don't like.

I will end with a proposal: Think of yourself as having a cosmic role, and then contribute to perfecting that role. And if I come back next year, I would ask how people are doing with their cosmic role. How conspicuous consumption might be less and yet businesses are still thriving. The changes will not lower quality of life. And I end with that term "quality of life;" if it is measured according to how you feel about your world and your existence and not by how much you have, then you will feel greater, not bigger, but greater in your cosmic role.

Figure 04-1. Arne Naess at the ski lift
with M.L. Woulfe & Kit-Fai Naess in Oslo, 2002

1.0. Preparing for the Challenges to Design

1.1. *The History and Development of the Planet*

The planet and its living ecosystems have a long, complex history embedded in the entire history of the universe. The universe may be an empty field or a field of quantum foam. In its development from a single event, many things emerged in the first three minutes: gravity split off, the weak interaction and electromagnetism separated, the strong nuclear force started operating (the four basic forces of nature); quarks formed particles, the nuclei of light atoms formed. After 500,000 years, complex atoms formed. Before a billion years were over, clouds condensed into protogalaxies.

There may be 100 billion galaxies in the universe, each with perhaps 100 billion stars. Galaxies have a catalog of shapes. Our galaxy, named the Milky Way as the result of several myths, is a spiral galaxy. The galaxy is composed of light and dark matter and energy that develop in regular ways. The evolution of matter, for instance, proceeds through a spiral process, as exemplified in the carbon cycle in stars, where a carbon nucleus captures four protons and emits them as an alpha particle at the end of the process.

Physical processes in stars build more complex atoms; on cooler stars and in gas clouds, molecules are formed. Molecules condense to crystals on planets and cold stars. These increases in order are a function of temperature and form. At some time during the development of the earth, natural processes created a pattern that guaranteed the maintenance and reproduction of a system of processes. These were considered living.

Our solar system is located in one of the spiral arms of the galaxy. The system has one star, a G4 star, with eight planets and numerous other bodies. The spinning of the sun caused a disk of aggregates in the plane of rotation. The Sun is a large sphere, maintained by a balance of fusion reactions and gravitational attraction that is slowly increasing its output.

With the moon, the earth forms a double planet. The earth has a metallic core under a gaseous atmosphere. The atmosphere of the Earth is composed of nitrogen, oxygen and argon. Carbon dioxide is only 0.03%. By contrast, Venus has an atmosphere that is 95% CO_2, but it is also 95 times denser than the earth. The temperature of its atmosphere is 450 degrees. CO_2 traps solar energy. The atmosphere of Mars is also about 95% CO_2, but it is only 1% as dense as Earth, and the temperature is about –80C at night.

The environment of the earth is interplanetary space, which is affected by solar wind, dust, meteorites, and energy in the form of photons and rays. The Earth has changed dramatically over four long periods. In the first (Hadean: 4.6-3.7 Billion Years Before Present), volcanoes kicked out magma and carbon dioxide (to make up 30% of the atmosphere); rock and water produced free hydrogen. In the Archean (3.7-2.5 billion YBP), life developed and further pushed changes. Bacterial life produced nitrogen, carbon dioxide, and methane (0.1 to 1%). Oxygen was a trace gas. In the Proterozoic (2.5-0.7 billion YBP), bacteria and then eukaryotic cells caused oxygen to rises over 10%; CO_2 declined to 10%. Finally, in the Phanerozoic (0.7 billion YBP to Present), plants and animals let oxygen rise to 21%. CO_2 was pumped down to 0.03% or 180 parts per million in glacial times and 280 in the interglacial.

1.1.1. *Short Deep History of the Current System*

The entire current system rose during the Cambrian explosion, about 600 million years ago; less than 10% of the history of the planet. The evolution of eukaryotic cell allowed explosive radiation. Life has been relatively quiet since then, as it was before. The Cambrian explosion could have been predictable outcome of a process set in motion far earlier. Much life rose during the initial rapid diversification, but died out during stable times. The one burst must have filled up the oceans. Since then evolution has basically recycled the basic designs. S.J. Gould claims that the mystery of the Permian extinction can be solved by an ecological theory relating organic diversity to habitable area. In short, the Pangaea coalescence caused the area of shallow seas to shrink and deepen drastically, causing extinctions.

By 400 million years ago, in the early Devonian period, primitive plants covered much of the surface of land; in order to compete better for light some plants developed strong stems and vessels to support their leaves above other plants. These plants quickly, in an evolutionary timeframe anyway, attained heights of 5-6 centimeters (or several inches). Partly as a result of competition and of predation by early terrestrial arthropods—scorpions, spiders, and centipedes—these primitive plants competed and diversified into club mosses, horsetails, and ferns. They also grew taller, which challenged insects to climb to get to the nutritious tissues, and eventually to glide or fly between leaves.

These first forests were composed of such trees in dense jungles over swampy ground. The tree crowns were formed by spreading branches covered with green spiny leaves; limbs and trunk were coated with brown scales. Although insects—beetles, flies, lice, dragonflies, and cockroaches—and amphibians were evolving throughout this period, there were no: flowers, fruits, nuts, pollen, seeds, nectar, frogs, reptiles, birds, or mammals. The jungle was relatively noiseless and monotone. For over 100 million years (345-225 million years YBP—years before present), while dinosaurs and winged insects were evolving, these seed ferns covered vast expanses of land. As the continents broke up further from one large plate, Pangaea, these forests formed the basis for most coal fields found around the earth. This break-up caused a massive drying of the land.

About the time glaciers started appearing on several of the continents, 225 million years ago, cone-bearing plants, conifers similar to modern pines and spruces, supplanted (no pun intended) the seed ferns. Conifers could colonize dry ground, especially because of the innovations of pollen and seed, whereas ferns had to live near water and mate with their immediate neighbors. Pollen in clouds can travel hundreds of miles, offering greater variety for mating. The seed ferns had naked seeds not enclosed in fruit and were, according to Lynn Margulis, sensitive to cold. The conifers had a greater tolerance to cold, even subzero temperatures, because the seeds were wrapped, even though they are labeled gymnosperms, 'naked seeds'). The fungal root networks allowed them to ingest phosphorus and nitrogen and to expand into higher elevations and colder latitudes. The first conifers were the main diet of vegetarian dinosaurs.

After roughly another 100 million years, plants with flowers descended from the same plants that produced the seed ferns. Within nine million years, flowering plants had colonized most of the land areas, coevolving with the first mammals, warm-blooded egg-layers and small marsupials. Coevolution of life forms is far more important than previously thought. Mammalian interest in these plants as food probably led to their rapid dissemination. Flowering plants (or angiosperms, 'clothed seeds') had fruits and seeds to protect the embryos from being made into animal flesh. Margulis suggests that plants have been seducing animals for millions of years, tricking us into helping them to move and forcing us into more complex *patterns* of behavior. Angiosperms developed concurrently with mountain building, such as the Alps and Himalayas, in the Miocene. Coniferous forests began to diminish in the Miocene as grasslands spread and deciduous trees appeared. Poplar and plane trees were established by the early Cretaceous. Deciduous trees had evolved with many more plant, insect, and animal partners.

1.1.2. *Recent History*

The current era, the holocene, is characterized by a long-term warming trend that has shifted life zones north and south towards the poles and has resulted in many extinctions (See Table 112-1). Several writers have suggested that several hundred years ago, we humans created a new era, the 'anthropocene,' as a direct result of our landscape transformations and industrial pollution. Within the current geological epoch, the Holocene, there is no doubt that a 'human-dominated period' has contributed to the interglacial warming, but we have not controlled it or kicked it out of bounds. There is no doubt that we are affecting natural processes, cycles, and habitats dramatically. There is no doubt either that we need to begin planning, designing, and applying our efforts with an ecological perspective and sensitivity.

Table 112-1. Major Events in Global History & Ecology

Event	*Dates*	*Effects*
Moon formation	4 billion BP	Energy pulses, axial tilt; tides, variations, adaptations
Change to oxidizing atmosphere	2.5 billion BP	Opens new opportunities to organisms.
Plate tectonics	On-going	Climate change, ocean circulation, ecosystem disturbance
Human use of fire	40,000 BP on	Selection of fire adapted species
Glacial maximum and warming	18,000-8400 BP	Squeeze or eliminate species
Indian colonization of Americas	14,000	Fire and hunting
Climate change Hunting stress	12,000 BP	Megafauna extinctions in N. America
Farming domestication of animals and plants	9300 BP	Shifts in wild species
Forest clearance	6000 BP on	Europe, Middle east, Mediterranean
Climate change	5500 BP	Desiccation of Africa and Middle East
Polynesians colonize Pacific islands	2100 BP	Extinctions of endemic species
Tropical forest clearance	1750 AD on	Desiccation of tropical areas
Fossil fuel use	1800 AD on	Additions to atmosphere and energy system
Extinction spasms	1940 AD on	Interference with habitats and other species
Exotic chemical use	1940 AD on	Nonadapted forms and unformed cycles

The glacial-interglacial alternation during the last million years has a periodicity of about 100,00 years, with interglacial durations of 10,000-12,500 years. The current interglacial time began about 10,000 years ago. Glaciers have covered vast areas of the northern hemisphere. The advance and retreat of ice sheets and climactic changes have spurred large migrations of plants and animals, and more recently peoples. During the last glacial stage in the Pleistocene, both coniferous and deciduous woodlands were forced southward, often to isolated refuges. The return of the forests by the Holocene, our current geological epoch, is one of the great stories of natural history, according to Neil Roberts. Even in the past 10,000 years forests have expanded and contracted with environmental change, for instance, the vast dawn redwood forests north of the present Arctic circle died out in the Eocene; long thought extinct, fragments remained in China, preserved on monastery grounds, to be discovered again a few decades ago. The shape of forests depends on a suite of physical conditions that vary from continent to continent. Weather patterns on North America, for instance, have created in Paul Colinvaux's term, "nation states" of trees that surprised the first European naturalists because they were so different. The "Little Ice Age," which lasted from about 1000 to 1850, caused misery, starvation, war, and plague in Europe. The switch to a glacial climate now would drastically reduce food and compress humanity.

1.1.3. *Limits*

A limit is a very important characteristic of a system. Limits appear again and again in different levels of design.

1.1.3.1. *Physical & Ecological Limits*

Our modern cosmology, based on machine metaphors and the principles of plenitude, gets in trouble because it does not understand how basic the concept of limits is to the physical universe, to life, to ecosystems, and to human constructs, such as cities and economics. Limits are important at all levels, starting with the physical.

We have learned that there are physical limits to many physical phenomena. We cannot measure light going faster than a maximum speed. We cannot reach, even in theory, a lowest temperature of absolute zero. We see that certain masses of hydrogen cannot exist without exhibiting qualitative changes in form or temperature.

When it comes to biological phenomena, we notice that groupings of individuals cannot exceed a certain number before the group fissions. With human beings, we almost never have a permanent family group of over 150 individuals.

These limits have to do with the characteristics of patterns that make up individual things and entities. The limits can be described in terms of the number and strengths of connections, as well as of perceived limits of freedom.

Life involves a vast number of interacting structures. Living consists of complex behaviors whose limits are defined by rules of order that can be empirically described. Biological order is built on physical and chemical orders. That is why life is limited to such a narrow range of conditions, as regards temperature, pressure and the composition of air or water. And, that is why the most complex orders are vulnerable to changes in their substrates; energetic radiation can alter and destroy an individual, a small change in climate can destroy crops and human civilizations. Complex orders always depend on simple orders. Where a planet entirely of algae is conceivable, one inhabited by only rats and humans is not.

The earth is suitable for life because of three kinds of limits: the solar radiation that has stayed within certain limits for four billion years; the biogeochemical cycles of oxygen, carbon, nitrogen, phosphorus, sulfur, water that have stayed within certain limits; and, the constancy of the environment, constant enough for organic evolution, but variable enough for natural selection to be challenged.

1.1.3.2. *System Limits: Carrying Capacity*

The system itself has limits. It has a maximum biological load that can be carried indefinitely; this is the biological carrying capacity. This carrying capacity is usually considered to be the maximum population sustainable on a long-term basis of renewable and nonrenewable resources.

Calculating a carrying capacity for many mammals is relatively simple. For instance, the number of caribou that could be supported on the North Slope of Alaska is basically determined by a long-term average of primary productivity, that is, food for browse, according to David Klein. Calculating an optimum population for human beings, based on caribou as a food source, is also relatively simple. Based on current caribou populations, 180,000 and using maximal ratios—1/30—to simplify the calculation, the North Slope Region could support a optimum of 1,338 Inuit people, or an maximum of 6,000 people. Garrett Hardin reminds us that carrying capacity is never an unchanging number, because the environment is variable through time.

Carrying capacity can be defined basically in terms of energy. For instance, an adult human requires 2300 kilocalories just in food. For heat and clothing, more calories would be required; for transportation and shelter still more; and, for luxuries, many more. By 1990 the average American was using 2,300,000 kilocalories per day, almost 1000 times the minimum. For humans, this carrying capacity must include domesticates, as human equivalents, since many domesticates compete for protein consumption. Carrying capacity calculations often just consider food energy, but all needs—clothing, shelter, transportation, information generation, aesthetic satisfaction—must be included. This introduces cultural elements into consideration, so the capacity must be considered as cultural carrying capacity.

Cultural carrying capacity involves many more variables, such as luxuries, aesthetic space, the use of technology, the implications of images of place, and the idea of an optimum. Since an optimum is always less than a maximum, according to Eugene Odum, the carrying capacity would be reduced by as much as half. Many mammals adjust their numbers below a maximum capacity, especially when the variability of the system is considered. Wolves underutilize their resources, as do most mammalian predators, perhaps since the same level of resources are not always available every year. Because people use culture to adapt to the earth, a figure for carrying capacity has to be variable or inconstant, to reflect the annual changes in productivity.

Furthermore, the optimum carrying capacity decreases as the per capita use of energy and resources increases. Technology could expand the carrying capacity to some extent, with more efficient use and resource substitution, but it could reduce the capacity with unforeseen effects, from the use of pesticides, for example. The optimum could be reduced more to reflect the possibilities of catastrophes; perhaps it has to be the lowest possible number to meet the worst conditions in a satisfactory way.

1.2. *Fields & Levels of Patterns*

The universe at large, with its clusters of galaxies, clouds, stars, and planets, extends itself through space and time. Parmenides held that space was a plenum. On the other hand, Leukippus conceived of space as emptiness. The physicist David Bohm combines both ideas in the concept of a field. He describes the universe as a field with waves of infinite size. The universe is permeated by septillions of waves at all times. A wave is an integral pattern of the physical continuity of a particle. Waves shape the field, that is, they excite the field. The field is an invisible, nondetectible source from which elementary particles draw order and energy. There is no place for both field and matter, "field being the only reality," according to Einstein. The field here and now depends on the field in the immediate neighborhood at a time just past. Excitement is generated with a temporal dimension. Humans generate their own waves that are added to the infinite variety coursing the universe.

The field concept was originally introduced by Michael Faraday into studies of electricity and magnetism, and was expanded by J. Clifford. The field concept is central to the unification of theories of light, electricity, and magnetism. Einstein extended Clifford's ideas of the field in his theories of relativity. In large systems, time acquires a new meaning associated with irreversibility. The classical mechanical concept of time results from simplifications. Einstein induced that time is relative to the frame of reference. Space-time is an ensemble of occasions and places, held together by duration. The future and past are tied together by duration. To the largest duration—the universe—all time is present. Time is not empty or abstract. According to Einstein, every change of coordinate systems mixes space and time in a mathematically defined way.

In his *Special Theory of Relativity*, Einstein included gravity in the picture, making space-time curved. But as massive bodies have greater gravities and mass can be converted to energy, all four perspectives form a field that can alter each component. Through the principle of equivalence of gravitation and acceleration and through the use of a symbol that mathematically described the local rate of 'turning' of the curvilinear coordinates, Einstein was able to relate curvilinear order and measure to the gravitational field. Both the electromagnetic field and the gravitational field can be understood as aspects of curvature. Einstein's 1907 principle of the local equivalence of gravitational and propulsive accelerations (geometrodynamic law) linked the two currents of thought from Riemann ("geometry is part of physics") and Mach ("inertia is influenced by mass elsewhere").

The physicist John Wheeler regards curved geometry itself as the building material of the universe. Gravity can be regarded as slow curvature; the electromagnetic field is rippled with different curvatures, and the particle is a knotted up region. Wheeler hypothesizes that a pregeometry is necessary because geometry fails to explain some events such as gravitational collapse. If one regards geometry as an abstraction from a moving Space-Time-Energy-Mass field (STEM), the pregeometry is the STEM field, the ground of being. The STEM matrix is a cosmic, transformable field. The STEM field is primary. Time and space are secondary to the field that contains them. No one component is ontologically subordinate to another. The fundament is an immense multidimensional ground, from which orders are projected into a unified field. The STEM field is a meso-field in the universe; it vanishes at both ends as a knot dissolves into the identity of rope after being analyzed. Particles dissolve into identity with the universe. The field is a paradox; localities are part of it but do not communicate instantaneously, by light. The speed of light is still a limit for most communication, but not for the behavior of the field as a whole. Space is filled with local relationships. The limits of the array are nondefinable. The STEM field has general properties, such as motion and autopoesis (self-making).

1.2.1. *Properties of the Field*

A property is an attribute proper to a thing or characteristic quality common to all members of a class; by comparison, characteristics are qualities that distinguish unique individuals, systems, or patterns. Gregory Bateson calls them differences that make a difference. The properties of a field are shaped by the historical operation of the field itself. This means that these properties are reflected in different levels of organization.

Mario Bunge distinguishes three kinds of collective properties: aggregate, structural, and global. Aggregate properties are often statistical, as in the average age of the wolf pack is 3.9 years. Structural properties can be possessed by individuals or groups on the basis of their relations to others, e.g., high-tail is the daughter of nick-ear. And global (or emergent) properties are possessed by wholes, regardless of components, as in "the territory of the wolf pack is eighty thousand hectares." This property emerges with the system and submerges if the system breaks down. It is an emergent property if no component of the system has it individually. History, structure and stability are emergent properties of an ecosystem. Role and scarcity are not. The basic properties of a field, any field, are: Motion (process), autopoesis (self-making), differentiation, integration, constancy, and development.

The properties of the field are modified by the operation of the field. Different properties emerge at different levels. For instance, stability at the ecosystem level is replaced by loyalty at the social and psychological level. It is possible to trace the changes in characteristics from the field to the ecosystem and then to place and society. The properties have unique names at different levels, but can be compared (as in Table 121-1). These properties will be used to support designs at different levels.

Table 121-1. Contrasted Properties of Different Levels of Patterns

— Nature —		— Culture —		— Domiture —	
Field	*Ecosystems*	*Place*	*Culture*	*Good Places*	*Good Society*
Process	Course	Dynamicism	Conduct	Action	Method
Autopoesis	Self-making	Identity	Wholeness	Individuality	Extension
Differentiation	Diversity	Uniqueness	Flexibility	Richness	Variety
Integration	Construction	Investment	Adaptation	Conviviality	Cooperation
Constancy	Stability	Regularity	Endurance	Consistency	Loyalty
Development	Productivity	Renewal	Vitality	Health	Harmony

Animation and ecological value changes the differentiation of the field to the openness of the ecosystem. The addition of communication and cultural values to that characteristic of the ecosystem results in the richness of place. And, the addition of social values and awareness of a place leads to variety in that society. These six properties of a field can be related to equivalent properties in different aspects of the field, from ecosystems to human societies.

1.2.2. *Living Fields*

Field theories in physics provide for continuity in space-time, for instance. Later, Charles Sherrington developed a field theory of subjective space. He distinguished between exteroceptive, interoceptive and proprioceptive fields; the exteroceptive receptive field was coextensive with the body surface and richer in receptors. These elements comprise a biological explanation of subjectivity. The subjective field is characterized by a broadening of lived time. This extension includes the lengthening of responses.

The subjective field of self is parallel to Kurt Lewin's concept. The self is a creature committed to a specific association, a genome plus place; the fitting of self to setting is partially definitive of both. Place/person/act are as indivisible as the physical STEM field. Lewin thought that the psychological fields joining the personality to its life-space, the immediate environment, and life-space to a larger environment, were strong enough to alter objective facts, that is, to make them normative.

Lewin was willing to study the objective factors that were potential determinants of life-space. The organism's own world is usually left out of consideration by Psychology. Ludwig Binswanger broke the life-world into three interrelated modes for human beings: *umwelt, mitwelt* and *eigenwelt*. The first refers to world of natural objects (environment); it is approximately equal to von Uexkull's idea of *umwelt*. The second to the human alone, the interrelationships of humans; the third is one's self-world, which equals a thought world. The same division could be made for animals, but would be more difficult to describe.

Lewin's life space combines the *umwelt* and life-world (of Edmund Husserl). Topology provides the mathematical model for Lewin's representation of psychological processes. Topology is a geometry in which spatial relationships are represented in a strictly nonmetrical manner. Since topology had no directional concepts, Lewin invented a qualitative geometry called hodological space, represented by vectors. He used two-dimensional planar maps to represent life spaces; recent researchers use a linear graph, on which an indefinite number of points can be mutually interconnected; and asymmetrical relationships.

Lived space requires a three-dimensional representation. It may be horizontal or vertical. A vertical aspect could include the high of a mountain climber; but, it could mean the loss of horizon and the horizontal. The horizontal dimension requires reciprocity; it is an intersubjective domain. Older cosmologies balanced the horizontal and vertical, but unbalanced cosmologies exhibit problems. New mathematical treatments of fields tend to be three-dimensional. Rene Thom's catastrophe theory and Conrad Waddington's epigenetic landscape are two such theories. The epigenetic landscape field can be used to explain why chickens rarely walk around a fence to get food. The chicken's need chreod is deeper than the path of a cognitive chreod around the fence. So the chicken can only go toward the food. If the need chreod is too deep, it cannot explore first with its cognitive chreod, where a less hungry chicken could. In humans, this explains why necessity cannot be the mother of invention; the broader landscape of leisure is needed.

1.2.3. *At Play in the Field of Limits*

Humans are actors in a tremendous presentation. This metaphor once formed the basis of a worldview where nature was a theater of violent competition. The frame of the metaphor carried the conceptual baggage of the culture in which it originated. So, over time the play supported the idea of superiority of "favoured" races in the struggle for existence and emphasized the role of competition in biological and cultural situations, at the expense of other 'softer, weaker' interactions, like altruism or love.

Alas, the metaphor needs to be expanded. All species play a temporary role in the local stage in the ecological theater. All the actors and acts are essential. We are foolish to think some species as more important than others—that is ignorance or wishful thinking. All species and things contribute to the functioning of the whole, including rocks and gaseous elements. But, some are invisible to us because of their size or longevity. Some play their roles in a clump of soil, others in continental landscapes. Some acts last less than a second; others take millions of years. Even if actors seem to leave the stage or the act seems over, they influence the play with their corpses and elements.

There are many stages playing simultaneously in the theater, and it is not a one-act play. The human play has converted some of the stages, subverted and converted others. The human actors are ridiculously egotistical and ignorant, pretending that the stages and theater is for them only, and that others are support characters. They pretend that the less important people are in the audience, but the only audience is other stages with partial perspectives.

And, some plays are embedded in others. One play is the evolutionary play, where autopoetic beings drift through filters in the morphogenetic landscape. Another play is the human conversion of ecosystems and the urbanization of human communities, with some companions and pests.

We have trouble understanding the theater or the plays because of our physical, temporal, psychological and cultural limits. We see species and ecosystems as individuals, when most of them are in fact communities. We see walls and barriers, and not permeable filters. We see philosophical constructs of classes in isolated locales. We have problems dealing with motion, indeterminacy, ambiguity, and vagueness. We are seduced by logic and fallacies to believe that we can understand and control the play.

Although the scales involved in a planetary theater are linked by processes, in fact, the scale of the planet and its evolving life forms is significantly larger and longer. As important as human changes are to us, and to the ecosystems from which we emerged and on which we depend, for the planet those changes may only bump the global system to another stable state, well within the range of those from the past 2 billion years, but possibly not to our liking. We are the stewards only of ourselves and companion forms, not of the planet.

On the other hand, Francis Bacon noted that we faced four major obstacles in understanding nature: The idols of the tribe, cave, marketplace, and theater. The perspective of the tribe is our inherent tendency to interpret and measure nature through our human senses, with their limits and scale. The idols of the cave refer to our personal and local peculiarities of worship and beliefs. Those of the marketplace refer to errors from language and culture. Most of the errors of the theater have to do with the limits and fallacies of our world views, even those based on good metaphors. Those obstacles can be overcome with a broader ecological perspective and a deeper understanding of nature.

We can feel joy that things are always new and different, that there is enough change to continue to provide for and to inspire us. We are actors in a process, but we are genealogical actors in ecological roles in the evolutionary play in the global theater. As long as we realize that we are not everything or the center of existence, we can continue to feel joy.

Of course, play has a less formal meaning than the theater. Play is the method of learning for most juvenile animals and a means of enjoyment for many adult animals. For humans, play is imaginative experience, entered into freely. Much human activity is play, in place in a community. Even science and philosophy are forms of play, attempts to solve the puzzles of existence. Although early ethological definitions of play emphasized its activity as an outlet of surplus energy, later definitions enlarged its importance in learning and information gathering. For example, play is also defined as: An activity with 'no immediate objective;' an experimental dialogue with the environment; a rehearsal, performed in a nonfunctional context, of the serious activities of searching, hunting, fighting, or mating; and, it is behavior that functions to develop, practice, or maintain physical or cognitive abilities and social relationships by repeating or recombining sequences of behavior outside their primary context.

Play is activity for its own sake, where the drives of emotion and reason are harmonized. The state of play is whole and simultaneous. It unifies permanence and transition, chaos and order, and duty and selfishness. The object of the senses is life, the object of reason is form, and the object of play is living form—beauty in the widest sense. Aesthetic play, like physical play, requires order and control. The rich flowering of human nature is possible only when the constraints of need are replaced by leisure and abundance.

The natural object of play is the aesthetic state, according to F. Schiller. Neither reason nor the state can achieve further transformation, however; that can be done only by the instrument of art. Using a mimetic faculty, people imitate one another. Life imitates art, which is an expression of values. By means of art, people can ascend to a moral state. We need to play to cope with the complexity of life, so we do not end up just simplifying life.

We need to play to learn. We need to play with technology to cope with the rapid changes in technology. *Think about it. Culture became too fast for biological evolution, and now technology is too fast for culture.* What will happen? We might have to trust art and especially design to control technology.

We could learn to play to design the planet. David Ehrenfeld suggests we learn to distinguish, in play at least, good pretending from harmful pretending. But, high-tech civilization has let us ignore the limits of safe pretending. We are convinced to pretend without limit by technology, especially by genetic engineering, scientific models, and research. This kind of pretending might damage our lives and civilization, by squandering our wealth on expensive long-term projects like 'star wars' and by losing the real wealth of wild ecosystems. It keeps us from pursuing real solutions. We need to play to avoid the uncritical belief in our economic and political systems. Play could let us have fun with those things that can threaten our health and accomplishments. We could play as if we knew what we were doing. And, take joy in that.

1.3. *Identifying Large & Long-term Trends—Gigatrends*

Things change, sometimes rapidly, sometimes slowly. We often refer to rapid change as a revolution or as a catastrophe; we sometimes refer to slower changes as trends or fate. Trends are directional changes. Some trends are readily evident in the human present; other processes or cycles take many human generations to complete. Many trends in economics and politics can be fit into the megatrends identified by John Naisbitt over a decade ago. The things that are most popular to society, such as money, real estate, insurance, and politics, are the things that are treated as the most important. Italian Foreign Minister Gianni De Michelis identified the most important megatrend of the century as the availability of free time; he claims the US economy will remain the most important economy in the world because its GNP is increasingly geared to entertainment, communications, education, and health care, all of which are about individuals 'feeling well.' The things that will ultimately be most important, such as directing the course of civilization, limiting human activities, or preserving wild ecosystems, are ignored or relegated to a sideshow. This section presents some of those gigatrends for consideration by large-scale or global design.

The real long trends in ecosystems, forests, human history, and earth history occupy the entire human calendar and long before. They are sometimes invisible in the present. Often the changes are very slow, taking more than one lifetime to notice; slow change is rarely noticed until too late. We might call them gigatrends, since they are larger and more involving than megatrends. Gigatrends ("giga" from the Greek for very large or giant) are long or very-long-term trends, usually ignored by science and economics, such as atmospheric temperature increases or global deforestation (and perhaps cosmic trends, lasting millions or billions of years, should be called teratrends, although for the sake of comparison, they will be included as gigatrends). Some gigatrends may only cover a span of fifteen years, but some of them have continued for thousands of years. In general, the larger the unit of study, the longer the trend; for example, changes in the physiology of a tree occur in days and months, while changes in the forest ecosystem can take decades or centuries. Some gigatrends are beneficial, although most of them seem to be detrimental to human well-being as well as to the health and stability of ecosystems.

Because of their length and scale, most of these trends can be represented graphically with simple lines, which show gradual or rapid (exponential) changes. Horizontal lines indicate constancy or stagnation. Straight lines indicate linear growth or decrease. Curved lines show accelerated growth or decline, as well as stabilization around equilibrium, rhythmic regulation, growth to a limit (asymptote), and oscillation and fluctuation.

Several trends seem contradictory or inconclusive in the short-term, but are evident with long-term study. For instance, atmospheric carbon dioxide increases and decreases with seasonal change in vegetation, but has been rising slowly and steadily for at least 35 years, according to Keeling and Whorg. Ecosystem succession is also misleading in the early stages, as pioneer species take advantage of a disturbance—here the short-term abundance of intolerant nitrogen-fixers prepares the site for a mature forest. Other trends are actually complex. For example, wood use as fuel decreased from the 1800s until 1970, when it started to increase again, due to the fashion for stoves in industrial countries and the rising prices of petroleum and coal.

Many of the negative trends have been noticeable for thousands of years, but nothing has been done to halt them. Environmental factors have shaped the course of human history to a greater extent than has been realized. The decline of Rome demonstrates that ignorance of forest ecology can have important consequences. There have been other environmental catastrophes in the Tigris and Euphrates valley, Greece, Khmer, Maya, Cahokia, and other places. These civilizations were very successful before they failed. Failure from success is tragic. For the Greeks, the operation of tragedy resulted from success taken to great lengths, that is, where successful behavior in one context is applied to all contexts, with the result that the opposite effect occurs from the one desired. For example, humans in moderate numbers were able to take what they needed, such as wood, from natural ecosystems without interfering with the processes. When human cultures adapted to ecosystems over long periods of time, the ecosystems also adapted to human cultures; when the human impact has been rapid and intense, as it has been in North America recently, the ecosystems collapsed or stabilized at a simpler state.

It has been argued that humanity is not adapted to live everywhere. Since the human species emerged in a subtropical climate, where it acquired certain biological characteristics, it may lack some degree of fitness to survive in the tropics, the arctic regions, or even temperate forests. The species may remain genetically best adapted to a certain type of subtropical savanna. Rene Dubos presents this development as explaining some of our present behavior patterns: Subconscious fear of forested wilderness (where good vision was little use for avoiding danger); the commonness of design features in landscape architecture; the preference for a narrow range of temperature; and the biochemical similarity of nutritional requirements. Perhaps this may explain why people modify their surroundings the way that they do, as well as why forests are less valued than lawns and gardens.

Although many gigatrends are interrelated, they can be discussed in categories, such as general human populations or ecosystems and forest ecosystems. Positive trends, often smaller and more recent, are discussed after negative ones. This list is not meant to be complete or detailed.

1.3.1. *Cosmic & Global Gigatrends*

The universe seems to have been expanding and cooling for well over 14 billion years. This process also seems to be creating more complex chemicals and patterns. This sun, solar system, and planet are developing (or aging) according to physical laws. The planet is cooling. The atmosphere of the planet has been changing from a reducing atmosphere to an oxygenating atmosphere for the past 3 billion years, apparently due to the waste products from living beings. The diversity of living forms has been increasing for almost a billion years. There have been long term changes in continental shapes as well as the heating or cooling of the surface.

1.3.2. *Global Ecosystem Gigatrends*

Ecosystems build up information. There are three different channels of information in an ecosystem: The genetic, in replicable individuals; an ecological based on interaction between cohabiting species, expressed in changes in their numbers; and the cultural, transmitted through individual learning based on experience. Feedback within the interaction of species is expensive memory with little storage capacity. When succession starts again, after a volcanic eruption for instance, old information in the form of interactions has not been saved. Genetic memory has a much larger capacity and is long-term—but may be limited by environmental conditions. In higher vertebrates, such as wolves or humans, cultural memory is enlarged, but may be lost after population collapses. The unconsidered use of information results in still more long-term trends.

Forest destruction was first associated with hunting, when fire was used as a technique to drive animals into the open. Grasslands maintained by burning allowed safer hunting. The technique is still used today by a few small groups of people. Centuries of burning in Africa reduced forest cover to less than 40 percent of its original cover by 1948, according to E. Eckholm. With a shift to agriculture, forest destruction increased dramatically.

Agriculture and forestry have been related in many civilizations. The expansion of agriculture is directly related to the shrinkage of forests; other trends in agriculture, such as opening southern lands, have resulted in forests reclaiming some of their northern territory. Nevertheless, the overall global trends have not been affected.

Global diversity is decreasing. The diversity of use narrows with agriculture, although early agroecosystems were more diverse. There are roughly 250,000 described higher plants. Of those, 7000 have been used as food by foragers and horticulturists. Only 150 have been used as important agricultural crops. But, only 15 are used as crops supplying over 90 percent of agricultural foods. Three cereal crops—wheat, rice and corn—provide over 50 percent of protein. Some modern approaches, such as permaculture and perennial agriculture, could restore some diversity.

Global ecosystems are being simplified and degraded; deforestation, desertification, and exotic take-overs occur on a large scale. Humans simplify ecosystems and keep them at early seral stages to harvest the increased productivity. Much vegetation becomes a social artifact. In Scotland, for instance, forest cover was reduced from 55% of the total area to 5% by primitive stock-keeping and agriculture; the moors decreased by half, but meads increased eight-fold. New forestry projects in Scotland and elsewhere could reverse those trends.

Global forest cover has been reduced, possibly since the first use of fire for hunting 70,000 BCE, or since the first clearances for hunting or farming 10,000 years ago. But, it has been constantly reduced since the 1500s, and drastically reduced since the 1950s. No one knows the exact rates of reduction. Overall the world forest cover has been reduced over 35 percent. The actual amount also is very uncertain, since inventories are rare or crude—half the land reported as forest land in many countries is also labeled "unstocked," according to Eckholm and the World Forest Inventory, with the result that grasslands, scrublands, and wastelands are labeled as potential regeneration areas. Forest health is rarely measured or addressed. Forests still are cut at rates greater than the net primary productivity.

1.3.3. *General Gigatrends for Human Populations*

With the success of the human species has come human domination of many ecosystems. Human beings have modified animal and plant associations, simplifying patterns of energy and chemical exchange, and solidifying ourselves at the end of many food chains as a dominant species. Our domination is related to our large biomass, our large annual increase (over 2 percent annually), our high energy use, and our high structural organization (information and matter). These very large-scale effects relate to basic gigatrends having to do with population size and dominance. Human populations are increasing exponentially—at 2 percent per year the doubling time of the entire population is 35 years. The growth of human populations for 500,000 years was minuscule; the agricultural revolution (10,000 years ago), which increased food supplies, and the industrial revolution (in the 1800s), which decreased the death rate, led to dramatic increases in population numbers and the rates of growth. Humanity is taking over the habitats of other animals and plants, regardless of the loss of function of ecosystems, limits to carrying capacity, or deficits. Kenneth Boulding suggests that eventually humans may have to perform the functions of other species.

1.3.4. *Positive Trends*

None of these gigatrends can be reversed until the remoteness is transformed into participation and attentiveness. There are already a few trends flowing against the tide. Some positive gigatrends include the mutual adaptation of human cultures and ecosystems over time in Asia, Europe, and parts of Africa, resulting in diverse, domesticated landscapes, and the setting aside of areas, such as preservation of ecosystem processes, reservation of archaic cultures, and conservation lands, from industrial interference (including the restoration of forests from abandoned fields, anthropogenic deserts, and ruined ecosystems). There has been an increase in the scope of ethics, from family, tribe, nation, humanity, to include reverence for all living beings, as identified by Schweitzer, and an increase in the scope of ethics to include land and forests, as identified by Aldo Leopold. There is an increase in the scope of law to include legal rights for forests and ecosystems, identified by Christopher Stone. Increasing localization seems to be countering the threats of globalization to destroy local identities and homogenize cultural lifestyles. It can lead to knowledgeable governance and can respond faster to environmental destruction. Considering other new trends in housing, such as arcologies (Paolo Soleri), ocean arks and bioshelters (the Todds), and in agriculture, including agroforestry, permaculture (Bill Mollison), and tree crops (Russell Smith), positive trends seem to be expanding. Large-scale ecological designs should be able to increase the number of positive trends.

1.3.5. *Summary: How Will Gigatrends End?*

None of the negative gigatrends can be modified until our remoteness is re-educated into participation and attentiveness. By making long-term trends visible and immediate, we can understand how they shape our use of nature. The intent of describing large-scale patterns is to have human patterns fit with observed patterns in nature; patterns have a form, sometimes repetition, and sometimes regularity, but each of these is caused by some limiting factor. Fitting the pattern can lead to both continuity and predictability, and both of these are needed to adapt human activities to natural limits.

With most of these gigatrends possibly ending in tragedy for humanity, it is critical to ask questions about them. What kind of ecosystems and do we want? Wild or domestic or both? Small or large? Managed or unmanaged or preserved? How shall we use those ecosystems? For resources like wood products? To protect watersheds and maintain global biogeochemical processes? As a home for other beings? Recreation? As some kind of balance for domestic landscapes? How many ecosystems do we (or other cultures or the earth) need? What kinds, in what forms? How many should be wild? These questions lead to new strategies for living on the planet, strategies that we can test with thought experiments.

Linear thinking leads to great short-term successes, but also to long-term problems, since nature produces many beautiful nonlinear curves and explosions. What these trends show together is that humanity is using more ecosystems, and more of each ecosystem, to produce more goods that cost more for more of us. These trends are not fated to continue. Some of them can be slowed, redirected, changed, or reversed. Rather than be converted to plantation forests, remaining old-growth forests could be preserved or harvested at very low numbers and very low rates.

We have spent most of our cultural infancy fighting nature. Up until the seventeenth century Europeans regarded untamed nature as a vast, hostile desert. Wild nature still remains unwelcome in our cities and gardens. We might understand the historical failure of cities and walls to lock out the forest or nature with a Mesopotamian example. After the Sumerian king Gilgamesh killed the great spirit of the forest, Humbaba, he became possessed with the fear of death and tried to lock out nature with the great wall of Uruk. It did not work. Like any ecosystem, the forest must be wooed. The forest will haunt us until we give it a new life in the heart of modern culture.

Thinking we have conquered nature and are omnipotent, we have quit thinking. Satisfied with our comforts, we do not ask enough of ourselves. We seem to be confused between luxuries and necessities. There may be enough ecosystems for necessities, but not for luxuries. We also act confused by the distinction between temporary goods and durable goods (nothing is permanent); temporary goods are things like cars, entertainment, guns, and drugs (any kind), while durable goods are things like reforested areas, organic farms, well-designed roads, and healthy buildings.

Garrett Hardin used to say that the essence of ecology was found in the question, “and then what?” meaning that everything you did had primary effects—there were no side-effects—on the system, every action produced a reaction, or as it has been rephrased by Barry Commoner and others, “you cannot do just one thing.” We have to consider the consequences of our actions as much as we can. Even good actions, taken in isolation, can have tragic consequences. For instance, what if, in setting aside forests in North America and reducing the load on them, we put more pressure on forests in Malaysia, causing them to be cut faster and more disastrously? What is the solution then? Social equity with other cultures or peoples? Voluntary simplicity? Global laws? These questions lead to one reason why design has to be global—to coordinate the consequences of good actions used to direct trends.

1.4. *Performing Global Thought Experiments*

Humanity is engaged in a great experiment with the planet. We are converting wild ecosystems to managed, simplified economic systems, that is, we are replacing large, old, complex ecosystems with young, simple fragments, in which fires are suppressed, large predators are removed, large herbivore populations are encouraged, exotic species are introduced, soil is compacted, and excessive biomass is removed—all for the purposes of increasing the amount that can be harvested for human use. Our radical cultural experiment to dominate the planet comes from our strengths that allowed us to survive rapid climactic changes during and after the ice ages. The ideas that are guiding us, the strategies we are using now, however, are obsolete; they worked under less complex conditions, at lower population levels, but not at high populations on a global scale, where domination leads to ecosystem interference. This is the making of tragedy—applying strength in a different, inappropriate context.

We are also burning massive quantities of fossil fuels; this is a one-time, large-scale geophysical experiment that could not have happened in the past and can never be reproduced in the future, according to R. Revelle and H.E. Suess (1957). Other unintentional experiments are also accidental and expected to have dramatic effects. Massive pollution from industrial processes is altering regions with acid rain or dark dust. Massive use of biocides, as well as chemical additives, hormones, and antibiotics and medicines, is selecting unwanted 'pest' species, as well as altering human and domestic and wild animal immune systems. Pervasive artificial lighting, at any time or place, is altering human behavior, as well as many insect, animal and plant behaviors. And, not finally by any count, electronic devices, including color televisions, microwave ovens, laptop computers, and cell phones are being tested in use, on us, and on our companion animals and plants.

Our actions are experiments, whether we want them to be or not. Unfortunately the experiment is not only bad science—there is no control planet—it is ill-considered. This experimental course, which may be global and irreversible, cannot be unmade, not by planning or science, much less by our standard methods of ignorance, cupidity, or denial. Some kinds of thought experiments might guide large-scale, long-term designs, which could alter the direction of the great experiment.

There must be a way to refine the experiments, to minimize our impacts, to be less reckless, and to anticipate the outcome of our experiments before we finish performing them. Not all experiments must be physically implemented. Albert Einstein and Leopold Infield suggest that knowledge of laws can be gained through the contemplation of idealized experiments created by thought, Gedanke-Experiment. For example, to address the equality of inertial and gravitational masses, that is, how the problem of general relativity is connected with gravitation, Einstein imagined an elevator at the top of an incredibly high building, and then imagined what research could be done in this local environment. Such experiments might seem "fantastic" in his words, but they might help us understand what we are trying to understand.

Although ecosystems and political orders are orders of magnitude more complex than physical systems, perhaps we could imagine and use such experiments to help us understand what is happening with our complex planet that is composed of many interlocking ecological systems. One of the more comprehensive thought experiments conducted is "Daisy World" by James Lovelock, to show how the evolution of species would lead to the self-regulation of climate on an earth-like world. This was the basis of the Gaia Theory, which was expanded from the Gaia Hypothesis.

Freeman Dyson offers another example of a thought experiment from Isaac Asimov: Saturn's satellite Enceladus could be used to provide water and warmth to Mars; a rocket could be sent to the satellite, carrying self-reproducing automatons, which could make miniature solar sailboats to carry small blocks of ice from it—there would be enough ice to keep the Martian climate warm and wet for about 10,000 years.

A recent computer simulation, popularized by Carl Sagan, of the medical, ecological and political economic consequences of nuclear war asked and attempted to answer the question: 'and then what?' Nuclear war casualty estimates made by military experts were shown to be gross underestimates when scientists considered all possible human casualties. The smoke and dust from nuclear weapons explosions and the resulting firestorms—previously considered trivial effects—have been mathematically modeled, and the computer results indicated a Nuclear Winter Scenario, in which more people are expected to die of starvation generated by the long range climatic effects than by the immediate consequences of radiation sickness and burns. Studies in 2004 and 2008 indicate that even a limited, regional nuclear exchange could produce a large number of fatalities (exceeding those from WWII), create a massive ozone hole, and disrupt global climate for a decade or more.

Thought experiments can give us clues about what can happen and what is the likelihood of that happening. "And then what?" asks Garrett Hardin again. Unlike medical doctors or scientists, we cannot either wait or directly experiment within a realistic time frame or scale. We cannot experiment at all in a traditional sense, where we hold most variables fixed, while changing one or two variables in experimental runs. Ecosystems operate over very long time spans; furthermore, their historical nature means that they cannot be restarted for tests. These limits are more obvious on the scale of the planet.

1.4.1. *Sample Thought Experiments*

Let us imagine that forestry and conservation both have failed, and *the earth is a planet without forests* and without trees in general—except for a few artifacts kept in arboretums (as in the movie *Silent Running* with Bruce Dern). For the first time in over a billion years, the planet is not sheltered, the climate is not moderated, and plants, animals, fungi, and bacteria are not protected. Humans have made shelters for themselves, but they do not want to share it with mosquitoes or grizzlies. Have the ice caps melted? What is the shape of the global system? Are all human crops grown inside? Is the reduction of biodiversity causing unalterable (and yet unknown) changes? Can forests ever be replanted? What kind of forests could live without fungi or centipedes? The Buddha, as related by E. F. Schumacher, taught that every good Buddhist has the obligation to plant and establish at least one tree every five years. Would planting trees be required by law in our treeless world?

We can outline another thought experiments. This experiment calculates the services and the number of arcologies needed to house the entire human population. It is incomplete, but suggestive of the kinds that we could be creating and manipulating to guide our plans and models.

What If All Urban Concentrations were Arcologies? At present over three billion people live in cities, about half of the total world population of 6.3014 billion (revised and estimated for 1 September 2003). What if essentially all people lived in arcologies, except for some small traditional communities living in wild ecosystems?

Historically, human hunting altered ecosystems, then human gathering and planting converted forest, grassland, and wetland ecosystems to agroecosystems that had to be managed. Now, the expansion of urban areas with roads, power grids, and other infrastructure, is interfering with the basic functioning of many ecosystems. Modification, conversion and destruction of ecosystems disrupts the complex interactions within and between ecosystems, the hydrology, soil structure, topography, and the predominant vegetation; it changes the complement of species, and it causes a loss of diversity. The new replacement systems are simpler, less mature, and less diverse.

We have achieved great horizontal growth, much like a gigantic fungus. However, if we want to be like a smarter fungus, slime molds for instance, we need to learn to cooperate to grow up and be more dense and vertical. The larger metropolitan regions are covering wild ecosystems and agricultural fields with single-family houses, malls, building, recreational areas, and roads—all of which are car-centric or auto-morphic. This means that energy and goods are also spread thin. Such systems of things are hard to control, hard to keep safe, and hard to remain interesting. In fact, it might be worthwhile to compare human systems to mature ecosystems; we are creating pioneer individuals that do not live well in concentrations. We are creating edge individuals and not those who can live in interiors and share resources, or can develop new resources with cleverness and intelligence. City designs do exist, however, which incorporate the properties of mature systems, as well as the characteristics of ecological thinking.

An arcology, as defined by Paolo Soleri, is a city which embodies the fusion of architecture with ecology. The arcology concept proposes a highly integrated and compact three-dimensional urban form that enables radical conservation of land, energy and resources. Arcology eliminates the automobile from within the city, and with it, the fifty percent of land devoted to automotive needs. The multi-use nature of arcology design would put living, working and public spaces within easy reach of each other and walking, supplemented by elevators and airport things, would become the main form of transportation within the city. An arcology would use passive solar architectural techniques such as the apse effect, greenhouse architecture and garment architecture to reduce the energy usage of the city, especially in terms of heating, lighting and cooling.

The small footprint of an arcology, combined with many built-in gardens, would allow rural space and agricultural fields to be closer to the city, and a part of the immediate urban environment. Wilderness, also, would be much closer to population centers in arcologies. Psychologically, the intelligent design would be more conducive to inspired living, the kind found in traditional culturally-significant cities at certain times. The proximity of agriculture and wilderness would allow people to participate more in them, with the full range of benefits that comes from growing and cultivating plants, as well as being able to immerse in the otherness of wild ecosystems.

The sizes of arcologies range from 25,000 to almost a million people, although smaller or larger ones are possible. For the sake of argument, assume that the average arcology is the size of Soleri's proposed Novanoah, at 400,000 people. At that size, it would take 15,734 arcologies to house the planetary population; this number is less than the number of cities in the United States in 2004, at 19,354. Assuming that the area under the arcology is about 5 square kilometers (almost two square miles), the surface area taken up by arcologies would only be 78,768 square kilometers, which is only 0.00054 percent of the land area of the planet—that is half of one thousandth of one percent (149.45 billion square kilometers, or roughly 0.0167 percent of the land area currently under concrete and asphalt now, which is 4.71 million square kilometers or 3.15 percent) of the land area of the planet.

The number of roads would be significantly reduced, from 676,750 square kilometers (roughly half of one percent of the total land surface in every country, according to the International Road Transport Union) to 230,000 km^2 (a generous number to be sure, but it could be as little as 50,000 km^2). Over 2 percent of the land is under road surfaces in the United States, with a smaller percentage in Europe, by comparison. Land under agricultural production would also be reduced, from 33 billion square kilometers (22 percent of the land area of the planet), partly due to improved practices, partly due to the integration of many kinds of agriculture into the city, and partly due to the carefully limited use of wild populations, without domestication or containment.

The shapes of arcologies would be as diverse as any. Many of Soleri's shapes are geometric. They could be large pyramids, filled with living and working spaces, connected by transits and illuminated by light wells. The traditional ziggurat modernized would offer a good ratio of sunlight and truck gardens to size. Arcologies could be empty tubular pyramids with modular dymaxion attachments that could be moved between arcologies or new sites. They could fit the shape of the landscape, as does the mostly-underground Palouse Arcology (Wittbecker 1992). Arcologies could be built around small mountains, in bridges crossing canyons, or threading through coastal seas. What would such a change mean to most people? Probably, few people would have the need for private cars. A typical day, for most workers, whether administrating, grading papers, policing, or making steel, would start with a walk to work, past local stores and businesses, playgrounds, and microfactories. Work would involve fewer layers of hierarchy; the pay range would only be from 1 to 7 times the minimum salary.

Since Soleri's heroic designs, arcologies have been confined to computer games and have become elements in science fiction and cyberpunk films. With more prototypes being designed, one may be built in the next twenty to thirty years. A proposed project for Tokyo Bay, the Shimizu TRY 2004 Mega-City Pyramid, if constructed, would become the largest artificial structure on the planet; it would be over 2000 meters tall and house 750,000 people. The external structure of the pyramid will be an open network of megatrusses, supporting struts made from carbon nanotubes to allow the pyramid to stand against high winds, earthquakes, and tsunamis. The trusses will be coated with photovoltaic film to convert sunlight into electricity and help power the city. The building will be zoned into residential, commercial and leisure areas. Separate buildings for housing and offices would be suspended from the supporting structure with nanotube cables. Transportation would be provided by accelerating walkways, inclined elevators, and a Personal Rapid Transit system inside the trusses with individual driverless pods.

It seems that arcologies would be part of a whole package of changes, brought about by ecological planning on a global scale. The experiment would not require that arcologies replace archaic populations living in human-modified ecosystems, or even all low-density habitations or traditional cities. But, they could be new cities situated in infertile areas.

Many cultures could live in optimum configurations in their territories, as part of wild and domestic landscapes. But, we also need heroic architecture. Heroic design and extravagance in life is needed in general. It is not contradictory or antithetical to frugal lifestyles or to restoring a healthy environment. Life is exuberant; energy is used, lives are lived and used, not wasted or saved. Life is the accumulation of individual experiences that cannot be saved, stored, or owned. The heroic things in life are often those most admired or remembered by subsequent generations.

1.4.2. *Conclusions: Working Experiments*

Thought experiments can give us clues about what can happen ("And then what?" as Garrett Hardin always asks) and what is the likelihood of it happening. Unlike medical doctors or scientists, we cannot either wait or directly experiment within a realistic time frame or scale. We cannot experiment at all in a traditional scientific sense. Ecosystems operate over very long time spans; furthermore, their historical nature means that they cannot be restarted.

Large-scale, long-term experiments are expensive and relatively few. Most experiments are short-range, small-scale, isolated, and detail dense. They do not present the hypotheses required for the management of ecosystems. Ecosystem management, because of uncertainties, lack of controls, age, and uniqueness, is an uncontrolled, large-scale experiment. Thought experiments can refine the design of our larger experiments by suggesting better hypotheses.

Thought experiments can help us avoid being overwhelmed by details. Thought experiments can help formulate goals and interpret information appropriate to scale. The idea of science is to manage our experiences with generalities. Once the thought experiments are started they can be refined with conceptual or mathematical models, which can simulate the changes and evolution of changes. Computer-based models can permit complex explorations, as well as suggest new patterns and further hypotheses. Through thought experiments and models, many of the dangers and expenses of our activities can be avoided.

Thought experiments are vital to understanding the complexity of ecosystems and global cycles. In practice, erring on the side of preservation—the prudent and conservative course—means minimizing the influence of human activities on the land. It means experimenting cautiously with new approaches to resource-taking and being properly skeptical about claims for sustainability. It means drastically reducing our demand for natural products, through conservation, reuse, recycling, and human population control, so that the greatest possible number of ecosystems can be left wild and degraded lands have time to be restored to health.

Thought experiments can also be used to examine possible scenarios of the future based on our actions. For example, if we continue the current trend of disequity, how might things play out? For example if the rich keep getting richer, how will they have to protect their wealth from the poor? Will laws be enough? Will they need ever-larger armies of security personnel? With already four times the number of civic police, will they need even more? Will corporate police protect the wealth of their stockholders after the civic police give up? Will the poor collapse leaving rich enclaves that have to grow their own food? At what point will the gap be wide enough that the poor have to harvest the wealth of the rich by force? At what number of poor? Will the poor prey on each other first? At what point will the environment be used entirely for a few more years of life for rich or poor humans? At what point might the environment collapse?

Will regional groups, such as the northern hemisphere, form alliances to keep going, after writing off other regions or the southern hemisphere? Will this block be able to defend its resources? Will that extend the time to any collapse? Or accelerate it? Will the United Nations be able to coordinate some kind of peaceful reorganization? Can a revitalized UN guarantee a rational economic and political strategy for all nations? Should a China or a Germany dominate this UN, so that it may operate without as much discussion? Is it utopian to think of such reorganization or redistribution for equity? Is this less naïve than allowing the market to sort out entire cultures and regions and consign them to poverty and violence?

Thought experiments will be suggested throughout this work. Some of the chapters on wilderness, population and design are, in fact, thought experiments. Most of the suggestions for designs are thought experiments. The best response to a question about what would happen as a result of some actions under some circumstances may be a thought experiment. Through that, you can create explanations and discover answers in a dialogue with others.

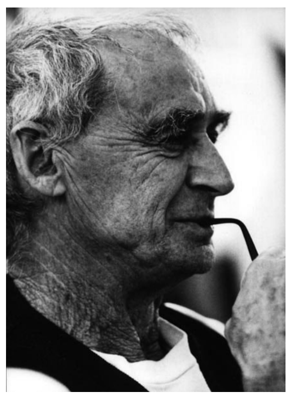

Figure 142-1. Paolo Soleri

1.5. *Having Fun with Words Numbers Links & Images*

An effective education need not be bound by the conceptual and economic limits assumed by most institutions. A minimum education may train students for an economic role in society, but a good education teaches them how to enjoy living among other human beings in an ultrahuman nature and to perpetuate a good society. Poets like Wordsworth and Auden recommended that broad training in science and technology was necessary for, poetic knowledge, which is part of a good education. Novalis considered that the study of the external world, through science, was only the first, half-way, step to full human consciousness. The second step was introspection, the contemplation of the self. Subject areas in traditional institutions concentrate on one step or the other. Any student can achieve both steps, leading to a complete education, with time and inclination. A complete education requires intense effort, discipline, patience, and a tolerance for failure. An ecological education could offer greater benefits, with a teacher "leading" a pupil to an education (which is derived from the Latin word meaning 'to lead'). In his educational theory, Plotinus went still further and laid down a triple organization of education, requiring a social education, a personal and self-revealing education, and a synergetic one that would permit a perspective of the whole of human existence. Only institutions that integrate education within a balanced society can achieve this triple objective. By encouraging students who are already working outside academic walls, ecological institutions can foster this necessary kind of synergetic education.

Garret Hardin points out that education is not just literacy, and that literacy, the ability to understand what words really mean, is not enough anyway. It needs to be supplemented by 'numeracy,' the ability to quantify information and interpret it intelligently— computers, remember, use numbers for everything—and, on another level, by 'ecolacy,' the ability to take into account the effects of complex interactions of systems over time, for understanding of the complexity of the world, that things are interconnected and affect one another. Together, these are three major 'filters against folly' that citizens can use against the blindness, short sightedness, and sheer idiocy that experts disguise as expertise.

1.5.1. *Literacy* (Words)

Literacy is the quality of being literate. Specifically, it is the ability to read a short passage and answer questions about what was read. The word comes from the Latin word meaning letter or later 'writing.' Being literate is being characterized by learning, cultured, educated. A person who is educated has been "lead" from ignorance, out of the self in other words, by fostering the growth and expansion of knowledge through a course of formal study. knowledge is a condition of knowing, an acquaintance with theoretical or practical understanding. There are no limits on what can be known. But, most knowledge is concerned with survival first. It is important to know what plants to eat, where to find shelter, how to make clothing. This was, and still is, the most basic level of literacy.

But, literacy occurs on more than one level. Gandhi put literacy in a similar perspective, "Literacy is not the end of education, not even the beginning, it is only one of the means." Certainly, computers can be valuable for certain aspects of education, but we must not forget what function the computer is assisting. In other words, computer use should not displace the skills themselves. Education should include a core of mathematics as a liberal education always has. And poetry and narratives should still be memorized, as well as written or examined on a computer.

Literacy, as the skill in the written and spoken language, enables readers to draw on the wisdom (and foolishness) of human beings distant in space and time. Hardin notes, in a discussion of the sins of the literate, that language has two functions beyond communication: "To promote thought and to prevent it." The second function is why literacy has to be accompanied by the ability to think critically.

1.5.2. *Numeracy* (Numbers)

Numeracy involves the ability to measure and to interpret quantities, proportions and rates. Hardin warns that human beings have learned how to use literacy to hide numbers and the need for numerate analysis. He draws attention to the problems created by always thinking solely in terms of dichotomies, e.g., safe vs. unsafe or pure vs. impure, rather than in terms of relative risks and benefits. James Lovelock has also noted our inability to assess risks mathematically. The quantitative analysis that is so important in science, technology, business, and government is dismissed with indifference. In a complex, rapidly changing society, understanding quantities, ratios, rates and duration of time is crucial. Numeracy has limitations, also—the conclusions of an accurate analysis are only as good as its premises.

There are many interesting numbers that play a part in the design of the planet. For example, Earth it is part of double planet system with the moon. Its elliptical orbit is off 8 degrees from a circular orbit of sun. It tilts on its axis about 22 degrees, but the moon stabilizes the tilt and keeps it from rolling over.

The changes in human density have been dramatic: About 100,000 YBP, there was 1 person/12,500 km^2 or 0.00001 person per square kilometer. In the Upper Paleolithic, the numbers were 0.08 person per km^2. At 10,000 YBP 0.04/km^2, and at 5,000 YBP 0.32/km^2, and at 2,000 YBP 42.1/km^2, and 300 years ago 160/km^2, and now 1013 people per km^2.

By now we are using much of the productivity of the entire planet. In 1986 Peter Vitousek calculated 40% of all plant energy was used or wasted or destroyed. Around 1980, human demands for plant materials was equal to the regenerative capacity of the earth. In 1999, it exceeded it by 20 percent. Also, for the first time in human history, in the year 2000, as many people lived in large communities (over 20,000) or cities as in small communities (under 20,000). By 2001, the number of people living in cities reached 56 percent.

The econosphere may be as big as the biosphere, according to K. Kelly. In 1998 dollars he estimated the global infrastructure is worth 4 quadrillion dollars—perhaps an overestimate. Mary Daily estimated ecosystem services of the earth at 33 trillion. This is undoubtedly an underestimate. If you include the worth of the capital that is producing those services, at some nominal interest, such as 5 percent, then the value of the living earth is over 3 quadrillion dollars, which still might be an underestimate

1.5.3. *Ecolacy* (Links)
Ecolacy was once achieved by studying natural history, the plants and animals that surrounded every human group. Scientists have been extremely successful using reductionistic methodology on every problem, breaking problems down into their components and studying the properties of these components and their interactions. This has led to the ascendancy of mechanical science—thinking that one can do just one thing. Garrett Hardin stated the important ecological understanding of ecolacy as: 'We can never do merely one thing." This statement is now known as Hardin's Law, and it means that there are always wanted and unwanted effects, products and wastes.

Reality is composed of causal chains of events rather than single effects. Events are embedded in causal networks and are produced by multiple causes and have multiple effects, each of which triggers a causal chain of future events. Hardin contends that since we cannot do just one thing we must always ask and answer that question: "And then what?" This would allow the effects of the interactions of systems over time can be taken into account. We have to try to ascertain the benefits and costs of proposed courses of action on both the individual, social, and ecological levels. The ecological systems way of thinking employs scientific theories and knowledge to study the interlocking processes characterized by many reciprocal cause effect pathways. The ecological systems way of thinking must become an integral part of the thinking of the well educated person if we are to adequately balance technology and human actions.

1.5.4. *Discussion of Filters*
David Hargreaves judges that our current educational institutions resemble a curious mix of a factory, an asylum and a prison. This command and control model creates pressure on overloaded people. Ivan Illich's proposal to deschool society means creating learning webs by using existing technologies and spaces, such as town halls. Learners would connect with their peers in new contexts to learn. Learning would not be funneled through one teacher.

The world is too complex for our minds, suggested G. P. Marsh and many later thinkers. So, our minds have to filter out what is less important. We filter data, arguments, emotions, and information. The filter allows a total picture of the whole with relatively little information. Of course that picture might be wrong. But, it is clear, as a result of filtering and thinking. Other human activities act as filters, also, especially culture.

The industrial system developed like a jigsaw puzzle with an unknown design. With only a few pieces the pattern is unknown, notes Charles Taylor. Partly, however, that is because we are making the pattern, generating it as we go along as a sort of bricolage. Our efforts at aggregation and filtering result in a form. As we generate it, more of the pieces fill in and a pattern emerges. But, if the pattern does not fit the environment, it has to change.

Garrett Hardin contends that most of the major controversies of our time can be understood as the result of the participants relying too much on any single one of these three filters. No one filter by itself is adequate for understanding reality and predicting the consequences of our actions. There is, however, a filter that has gone unmentioned, in its ability to concentrate or distort human perception (although we started to discuss it, Personal Communication 1988). That filter is the image.

1.5.5. *Imagacy* (Images)

In general, revolution is discontinuous and synchronous, whereas evolution first appears to be continuous and diachronous. In the synchronic mode, form is complete as soon as it appears; in the diachronic, the form is slowly elaborated. It would appear that complex processes, like evolution, actually use both modes.

An image is an imitation or representation of something. It can also be a symbol or type, a metaphor or concept. An image can stand for something else, for instance the image of a dove is often used as a symbol for peace. In the etymological sense a symbol is something 'thrown together,' as a problem is something 'thrown forward.' Unlike an image, a symbol often represents some other thing, process or quality. Symbols can be processed by computers. These machines have been used for metaphors of the brain, which also processes symbols, that is, the operation of both parts of the metaphor, 'brain equals computer,' can be described in terms of algorithms, or mathematical rules for manipulating symbols.

An image of course can be used in a variety of ways. It can reference similarity, correlation or a formal linkage. Understanding the logic of images, as well as their power, is important to their use in communicating and design.

An image, especially a cosmology or an image of the world, models the system in miniature. From the image, which can be a paradigm or mind-set, a whole system can arise, with unique goals, rules, parameters, and structures. A cosmology includes a mythology constructed as a poetic system. Joseph Campbell states "Mythology—and therefore civilization—is an poetic, supernormal image." Mythologies and religions can be understood as great poems. When recognized as such, they point through individual things and events to the ubiquity of a presence that is whole in each. Poets generate images for the future, and these images can be articulated into goals to influence our actions. Bad images, from indifferent poets, can relate to severe cultural problems, as when popular Italian poets romanticized the violence and hatred of Fascism.

The mechanistic images of science, from Shelley to the Fascists, determined much of the violent conquest of nature. Kenneth Bounding notes that the image as a cognitive construct of the world has several aspects: Spatial, temporal, personal, relational, value, and affection (emotional) for each individual. The total sum of individual images is a world of interrelated constructs. This parallels the experiences of other living beings. Using its senses, each participant creates an image of nature, or world—umwelt, life-world, is the term used by Jakob von Uexkull)—from the sensations that are meaningful to it, and which limit it. Simple beings, such as bacteria, make a relatively simple image, whereas more complex beings, such as apes and humans, forge more complex images.

In fact, human beings design complex images for a variety of purposes, including to make a profit or to persuade others to join a group. In this, design reflects the economic and political bents of humans. In a hyperactive marketplace, design responds with sophisticated images and crass intentions. In the city, design responds with an architectural icon, the skyscraper, for expressing power, status, success, and victory over limits and the environment—however temporarily.

In the discussions of design, the importances and weaknesses of images will be explored. Images will be added to the complex ecology of people, projects, tools, and social structures in an open living system. William Thackera wondered if such an ecology could be designed. Perhaps it can.

2.0. Approaching the Planet with Design

How can we approach the planet as a whole? Scientifically? Technologically? Aesthetically? The planet is relatively old and large, with a unique history and dynamic ecosystems. To examine something that is larger than our logic or perception, than our techniques and science, we might need a different approach. There are ways of dealing with the planet that are not scientific or technological; they are aesthetic or ethical. To examine nature in general, we must shift to a taoistic approach, asking rather than telling, and observing rather than manipulating. We need to be receptive and passive, rather than active and forceful, and nonintruding and noncontrolling, instead of pushy and manipulative. A taoistic approach stresses noninterfering observation rather than controlling manipulation; it is receptive rather than forceful. This is part of the paradox of duality; it is detached yet concerned, free yet committed, and independent yet responsible. Perhaps the Taoist is another path to objectivity with greater perception.

We are skilled at iconic perception and aesthetic perception, but seem unable to use a double perception. Aesthetic perception offers a reassuring vision, which interprets or identifies nature—we need a naive vision, which surprises, shocks, fascinates or seduces the senses, which awakens desire and stirs the imagination, and which furnishes a feeling of the invisible. Iconic perception offers a cognitive view of the planet that reduces the planet to the limits of logic—we need a holistic view, compounded with the unconscious and feeling.

Nature is an extremely sensitive nexus of means and ends. Nature is a feeling system. We need a new animism to approach nature, the understanding that perception is part of feeling. This animism would allow us to behave "as if" nature was intelligent and sensitive, and as if we were loving and wise. Loving perception provides kinds of knowledge not available to nonlovers; this is especially true in ethological literature. Abraham Maslow cites his own work with monkeys. K. Lorenz, N. Tinbergen, G. Schaller, J. Van Lowick-Goodall, and M. W. Fox have found it to be true. This is the way a good psychotherapist, teacher, scientist, parent, or friend functions. And that has to define our approach to the planet.

We can apply designs to the planet, on many levels. We are doing so accidentally now. But, new designs have to consider the limits of the planet, as well as limits to the human enterprises. We might start by designing ecosystems, artificial ones on a small scale, for the express response to problems caused by inappropriate scale, interference and waste disposal.

2.1. ***The Planet & Human Design***

Humans have designed many things, from tools to trade routes. And, we have changed many different ecosystems to be more productive for us. But, we have not attempted to design humanity, or regional patterns, or global patterns.

2.1.1. *Why Design?*

Why should we need to design the planet? It is self-making, self-managing, and self-renewing. What can human design add to that? As a young, exploring innovative species, we have added diversity and interest to other living forms. We became hosts for many new parasites and types of bacteria. Our feeding patterns encouraged other species, which did not taste as good to us, to compete successfully. Other animals and plants found us useful to live near. As an older, confident, successful species, we started to convert ecosystems to what we wanted. Now that we are self-satisfied and arrogant, we find that we are influencing every natural system, taking what we need from some ecosystems, enhancing a few, misusing others, and interfering with the rest; we are creating patterns that we cannot control. So, what can we do? We can control ourselves, we can control our influences, and we can abstain from trying to control every variable in a system and every system on the planet. That may be the concern of the design of human limits.

There is no guarantee that nature can provide humans with everything they want. Recognizing the lack of guarantee is simply recognizing that nature is wild and we must come to terms with nonhuman beings and processes. It is not enough to arrange trees in rows to maximize future harvests; it is not enough to preserve small areas of old-growth without natural disturbances. We must pay attention to the processes that make up the habitat, for example, the role of herbivores on trimming vegetation (and diversifying it by predation). The design of an ecosystem and its management must ensure that the processes operate to maintain a dynamic state. Furthermore, the context must be conserved. The ecosystem, however, cannot be considered outside of the context of the entire landscape, including human images and institutions.

We need good ecological designs to restore the balance between human needs and natural processes. Ecological designs focus on whole communities that work in the same self-sustaining and self-limiting ways as nature. By consciously creating meaningful order, we can develop ways of producing widespread community wealth while positioning the community for a long, sustainable future in a healthy environment.

What are we considering when we talk about the design of a planet? Should we move the continents? Build new islands? Add aluminum sunscreens to the atmosphere? People are often discussing solutions to global problems, or perceived global problems, such as global climatic chaos (a more fitting phrase than the comforting ‘global warming’), that would entail massive changes, whether ocean-doping or orbiting mirrors. These technical aspects may also be the concern of a design of physical alterations.

2.1.2. *What is the Global?*

What does the word ‘global’ mean? In the Old English Dictionary, it meant ‘spherical’ referring to the earth. By 1945, the word was used by the United Nations to describe political action, referring to actions to commonize costs. The United Nations used it thus. Marshall McLuhan and other used it in reference to a global village. Then, it began to mean ubiquitous, or everywhere. Garrett Hardin contrasts the ubiquity of potholes around the world with the specific meaning of a property of the planet earth, such as the atmosphere. What are global things? Certainly the whole of the planet, as well as the atmosphere and ocean, perhaps life, perhaps other things as well. Global things are quite different than things that appear globally. The global system, for instance, has unique characteristics that emerge from local interactions. What does it mean to be global or local? These terms are terms of scale, used to describe a field.

2.1.2.1. The Global Field

The concept of the field allows many things to be related internally and connected by scale. These operations of the field scaling to other aspects of the field need to be addressed by designs on various levels. These properties of the field are important to design because they must be considered if the design is to be stable and useful. Global design has to address these properties to be successful as design. Global design has to consider the emergence of new characteristics and the qualities of patterns, especially related to connectedness and scale.

Global systems properties are a set of constant constraints on local systems. These differences will have important affects on global ecological design, especially at the level of the planet. Cultural systems develop patterns (especially as related to design): Paths, Nodes, Networks (hierarchy), Fractals (Explosions Implosions, traps), Spirals, and Cycles. These can create problems with feedback to global design (not enough feedback or none).

2.1.2.2. Global & Local Scales

Differences in scale are often called local or global differences. Concepts of scale apply to physical and biological fields. Local fields or events are those separated from other fields or events and exert minimal influence on the others. That is, the internal connections inside a local field are stronger than the connections between local fields. Both quantum theory and relativity consider that local fields are generally noncausally and nonlocally connected—that is, no communication is instantaneous—through higher dimensional realities.

Local systems create a global system, at the same time local systems emerge from a global system, which has characteristics that emerge from the interplay of local systems. Global systems have properties that no local systems have, such as an overall atmospheric temperature or global biogeochemical cycles. James Lovelock suggests that the interaction between hardwood forests and softwood forests may act as a global regulator of oxygen for the planet. Many things, such as human poverty and species extinctions, only seem global because they are happening in many local systems at the same time.

Local fields have characteristics that distinguish them from the global fields. Local fields can be characterized by: Separation, limited influence, disjunctiveness (the future is not like the past), reflection of local conditions, contribution to the global, and territoriality. Separation refers to location in the global field (space-time), as well as having different make-up and different environment. The local is independent of other local fields. Local properties may not determine the variables in other local fields. Having a limited influence means that there is often a weak connection with other local systems, and sometimes little affect on the global. A local field has an immediate effect on only a small fraction of the totality of parts of a global field. Ross Ashby uses the example of a chemical reaction of silver nitrate and sodium chloride, producing AgCl, but not influencing the global system. A local system reflects local conditions. Of course, local systems can create global ones, as well as affect them. They develop historically.

Table 2122-1. Local and Global Properties

Local	*Global*
Separation	Connection
Limited influence on other locals	Affect on all locals
Reflection of global influence	Constraint on local
Disjunctiveness (future different)	Internal temporal organization
Contribution to global	Independent of any local
Limited by global	Emergent properties from local

Global fields can be described as: Emergent, with new properties; internally organized; constraining the local, affecting all locals, and independent from any local. In general, global systems emerge from local systems; they have unique properties that local systems do not have. The properties are not repeated independently in local systems. Often the properties are too interconnected to be independent. R. Ashby uses the example of chemical and biological reactions that form protoplasm. Properties are emergent if they are not predictable from the analysis of local systems. For example, hydrogen and oxygen are gases; under certain circumstances, they combine to form a fluid, water. For another example, the tasteless gases hydrogen and oxygen can combine with carbon, in certain biological processes, and form a sweet, solid sugar. In a third example, amino acids, which can form as a result of volcanism in an early atmosphere of the earth, can be combined in living processes to make protoplasm, which is self-making; this new property is a surprise. The new emergent properties are protected from factors that could reverse or destroy them. Furthermore, they are not reversible due to their historical development. The global can organize local systems in internal relations (and have relations with an external environment). The global puts constraints on the local; that is, it limits the action of local systems. The global has connections to all local systems, even those that have no connections to other local systems. Global change affects all local systems. But, a global system is independent of any one local system; the local may have minimal influence. Global systems develop historically. As global systems become larger, when the range of size of part to the whole is larger, the properties of the whole are more likely to be very different than the local.

The global level has many more kinds of feedback, as it consists of many more subsystems. Furthermore, the rate of feedback is expected to be much slower. This means longer times and longer lag times or delays. Laws defining constraints on the whole cannot be derived from the laws of parts. Global systems properties are a set of constant constraints on local systems. These differences will have important affects on global ecological design, especially at the level of the planet.

Switching our attention from a focus to the larger frame usually involves a change in scale. Scale has several meanings. Basically, as it is used here, it has to do with the level of measurement in a space/time energy/mass context. For instance, in forestry the measurements of leaf litter by foresters can be made at several scales: Single tree, stand, annual measurements, or stand life measurements. Processes that are unimportant at a small scale might be vital at a large scale. Too much litter by one tree might be unimportant, but too much litter in one stand in one year, for instance, might suppress a soil cycle; too little litter over a century might interfere with several regional or global atmospheric cycles (for more forestry examples of scale in design, and delays of feedback, see Chapter 3.3).

2.1.3. *Why Start with the Global?*

Because the planet is a whole, global design has to address the uniqueness of the emergent properties of the whole. For example, it makes no sense to discuss the amount of CO_2 in the atmosphere without paying attention to the carbon, oxygen and water cycles—or in fact, any cycles, ecosystems, or organisms that impinge on carbon dioxide—or in fact the deep history of the atmosphere and planet, as well as the structure and function of the atmosphere.

All the layers and processes within the whole are subject to restraints and limits on the whole. The whole is not equal to its levels; it is more than the sum of the levels, to sharpen an old saw, so to speak. The planet moves and develops as a whole. The whole system maintains its identity through continuous self-making, or through autopoesis in the words of F. Varela. The system develops through a continuous dance of autonomy and control, according to Varela. By reducing the study of the planet to the chemistry and physics of a subwhole, or holon, science can lose sight of larger emergent patterns.

The framework of our thought has to be concerned with the whole idea of the planet, bound up in living patterns. A coherent, flexible framework can provide the context for the problems of atmospheric warming or extinction pulses. The organization of our thought requires the vision of the whole. Our efforts have to be directed to the good of the planet.

Perhaps we need to approach the wholeness of the planet in a mythical context: The planet is alive as Gaia, suggested James Lovelock. Joseph Campbell noted that when the tribe was the relevant social unit, it was possible for mythology to represent all those outside its bounds as inferior. The young were trained to respond positively to love fellow tribal members and their home and to project hatred outward. The concept of tribe and nation is being placed in an ecumene, an inhabited planet. Today, there is no outward anymore on the planet. Our mythology has to grow now, to include the whole planet. There is no practical elsewhere anymore. A global mythology cannot afford to teach of elsewheres—it has to teach a multiplicity of cosmologies on a whole planet.

2.2. *What is Natural Design?*

Poets and biologists often look at patterns and events in nature and express appreciation at how well nature designs things, from eyes to sunsets. But, we have to ask, is it design? Does nature design? Does life design living beings? What about self-designing systems? Does nature really design forests or streams? Perhaps we should say that nature is self-organized. The self is a scaled phenomenon. The small self is organism-centered. The larger self is part of a self-organizing web. But, self-organization is not self-design. Are living beings designed? Nature obviously produces complex beings over long periods of time, and it does so in a way that has been referred to as design by people for several hundred years at least. It seems possible that motion, over time, at various scales, results in greater complexity of elements and arrangements, automatically resulting in living beings. This process takes place in a changing biophysical environment, as a form of ecological play, complete with system economies and with living values. The process of nature is described in those four categories.

More complex kinds of patterns, such as the circular pattern, suggested by the myth of eternal recurrence, depends on regular repetition, as with the seasons. It allowed disintegration to be replaced by regeneration. The helical pattern is innovatively cyclic, and the cycle is additive and seems to reach a higher stage with each repetition. Finally, there are nonlinear patterns. These seem to have more surprises due to the display of complex nonequilibrium systems. They may evolve in a definite direction, but can do so by leaps and turns.

Of course perception is a large part of patterns. And, we perceive the direction as being towards more complexity and more integration, until we have a global society, coordinated on several levels, within a more complex biosphere.

2.2.1. *Natural Design?*

The patterns of nature form due to the characteristics of nature. These characteristics can be grouped according to their human use, from the surrounding biophysical environment to valuing. Biophysical properties include self-making, self-patterning, form creation, wholeness, systemic, pattern processing, development, place generating, place responsiveness, dynamic equilibrating, and interaction limiting. At the ecological level, natural 'design' is nature-based, aggregating, trial and error processing, trial generating, novelty generating, reciprocally interacting, bottom-up organizing, physically restraining, process, and actually existing. At the level of economizing it is productive, interrelational, nested, interdependent, solar-driven, aesthetic, waste generating, free playing, and forming gigatrends. Finally, at the level of valuing it is living, fitting, harmony building, existence valuing, learnable, adjusting, forming, and chaotic.

2.2.2. *Principles of Nature?*

Are there principles of nature? Can we say that explosiveness is a principle? Or intensity? We often describe design principles as being based on basic principles of nature, such as the principle of change. It might be more accurate to consider change a property of nature, that can then become a design principle or scientific principle. Nature is in flux, culture is in flux, everything is. The climate will change, the shorelines will change. Human understanding and behavior is changing. But, nature is also self-regulating—this is the principle of self-regulation. Nature has evolved to maintain its stability in the face of many kinds of disturbances from planetesimal impacts to changes in atmospheric composition. Nature will continue to regulate itself even as human beings make dramatic changes. The danger is not so much that nature will collapse, as that humanity will lose those things that it values the most, from cool air to wilderness.

Nature seems to flow, which is necessary to the functioning of organisms as well as to the biosphere. Flow can only be realized through structure, however, a cell or an ecosystem. It is the problem of free flow or division by membranes. At each level of a natural system, from cell to biosphere, the units involved do more exchanging internally than externally with other units at the same level. Flow and division must be in balance.

Individuals in nature exist through separation, by walls, barriers or membranes, which means nonflow or limited flow. Barriers are necessary to maintain form and integrity of individuals as well as of ecosystems. By removing some barriers, such as releasing carbon that has been locked up for eons, we unbalance natural cycles. Even though ecosystems exist within large ecoregions, which exist within the biosphere, they need closure to maintain their integrity. At the level of local ecosystems, there need to be fewer closures, so that there is a flow of genetic information within a species as well as between species. Human activities have the effect of blocking the flow at local ecosystems, with asphalt and wires, yet increasing the flow between large regions with ships and airplanes—mostly the flow of pests and domestic species.

Nature exhibits error, or play, which permits diversity. So many things are thrown at the flow of life. There is not just a little error. Half of everything seems to be error: Billions of pollen grains, billions of eggs, millions of species. Transmission is not flawless or efficient, but it is generative of difference and diversity. The diversity of the current ecological world evolved through the breakup of Pangaea, which provided the distances and barriers to isolate species. Many other properties of nature, such as least action or complexification, can become the basis of principles.

2.2.3. *Summary: Natural Patterning*

Nature produces many complex patterns. Living beings create further complex patterns, but this is done without conscious design, without plans. Natural ordering of the world makes places from spaces. A place changes qualitatively; it becomes structured. Some change, such as growth or decay, is quantitative. Other change is qualitative, resulting in breakdown or formation of the entire system. Life is also a property immanent in an organization of molecules; and language emerges in a higher level of organization. New qualities that emerge at every step are unpredictable on the basis of the past; natural reality is creative. Nature is more like an artist than an engineer in this sense, that is, nature provides novel patterns that can be duplicated or reformed by living beings within nature.

The scale of nature is fundamentally different than the scope of any design. The time scale of evolution is measured in billions of years. The size scale of evolution is measured in trillions of living individuals. These scales permit any speed of operation of selection through reproduction and genetic mutation. Nature does not design at all in the human sense, limited by a single lifetime or even group longevity. Nature makes patterns that change, on many levels, over an immense scale.

2.3. *What is Traditional Human Design?*

Human beings have an ability, shared with many species, to alter their environments. They are able to reform natural forms and flows with their hands or with tools that have been made for that purpose. They are able to design the tools, as well as other larger objects and patterns, such as landscapes.

2.3.1. *What is Traditional Design?*

The word 'design' comes from the Latin word for "to mark" and means 'marking off a pattern.' Tracing lines can be inclusive or exclusive, but if the line is more like a membrane then it permits certain sizes and shapes of intrusion. The verb form of the word 'design' means to make a pattern or plan, or to intend for a purpose. A design is a purposive plan, which itself is a diagram in two dimensions. Design is a human project in which, as Oliver Lucas says, "visual and physical parts are assembled in order to achieve a specific end result." A design can also be an orderly arrangement of parts in an overall pattern. Designers make visible creations from plans, using the resources available.

Most design is concerned with products, from magazines, clothing and toys to houses and buildings. Our designs are often shaped by the impulses of technological feasibility, assembled randomly in neighborhoods and cities. Of course, cities are the results of complex adaptive behaviors in response to environmental conditions. Cities are not designed as whole systems, with a few possible exceptions, such as Paolo Soleri. Landscapes around houses and buildings are often designed. But, large landscapes are not considered or designed. They are made up of individual patterns, such as farming and manufacturing. Sometimes the landscape is charming; other times it is not. The landscape is a common property that can be understood and integrated by perception. The loss of design is the inability to imagine, shape and build things that enhance life and safety; it is the inability to respond to changing circumstances. Too much of a world is overdesigned by professionals, according to Victor Papanek, with the result that design simultaneously ignores things that need to be design and creates further dangers with many designs.

2.3.2. *What is the Difference between Natural & Human Design?*

Life is experience that continues by reproduction. Design is creation for reproduction. Life is experiencing and reproducing forms to continue experiencing. Design is the production of forms for experiencing and reproducing.

2.3.3. *The Principles of Traditional Design*

In addition to the basic elements, structure and variations, design can be presented through a number of principles. Principles are fundamental rules or laws, based on the characteristics of objects or systems, that we can use to create images or models to meet stated objectives, that is, the goals towards which our actions are directed, such as a functional beautiful bicycle or a comfortable inspiring city park. Principles unify our images. Select principles are introduced briefly to show the depth and breadth of design.

The principles presented are derived from the typical characteristics of design objects. Characteristics are qualities that distinguish unique individuals, systems, or patterns—

Gregory Bateson refers to characteristics as differences that make a difference. From these principles, standards for design activities can be established. Standards are models or examples of quality or value, established by authority or mutual consent, which can be repeated as procedures.

The principles identified form the basic axiomatic truths of design. They represent the basic assumptions of the human world that guide the practice of design. These principles affect the arrangement of objects, elements or components within a composition. These principles, not exhaustive by any measure, state that any composition has to display: Proportion, Rhythm, Emphasis, Balance, and Unity.

2.3.4. *Applied Design Stages*

Traditional design proceeds in four stages. The first is to review the function or goal, asking what the composition is supposed to do or inspire, or whether it is to be a public or private composition. The second stage is to find appropriate materials. Some materials are better than others for certain purposes. Understanding the purpose, as well as the potential materials that can be used, insures a better design. The third stage is to create an outline or plan of the design, using elements and principles to guide the design. And, the fourth stage is to build the object. If a single object, it is given or sold. If it can be reproduced or mass-produced, it usually is.

2.3.5. *Levels of Traditional Design*

The traditional design process considers three levels: Components, products, and the community. Many cultures have found, released and used materials for tools and designs. The materials themselves were often the thing itself. Often, materials were melted, woven, or combined into specific objects or products, such as tools or chairs. The objects that were made were usually integrated into an order described by a culture, based on knowledge and techniques handed down through generations. These things acquired social value even when their utilitarian value diminished. Chairs, for instance, beyond being useful for sitting, can grant authority to the person sitting in it.

2.3.6. *Summary: Design as Human Action*

As a profession, design is a special self-consciously separate, economic discipline that adds value to human artifacts, and in fact distinguishes its objects from other, lower-quality goods. It is the separation of specialists from the vernacular design of self-sufficient people. Design is a historical process of the development of a profession. Of course, it can be regarded as more. Victor Papanek characterizes design as the "primary underlying matrix of life" and states, "All men are designers."

The basic elements and variations apply to all kinds of design. But, as traditional design expands to ecological design and to global design, the number of groups and principles has to increase to reflect the larger scales and increasing connections. Heroic design and extravagance in life is needed. It is not contradictory or antithetical to frugal lifestyles or to restoring a healthy environment. Life is exuberant; energy is used, lives are lived and used, not saved. Life is the accumulation of individual experiences that cannot be saved, stored, or owned. Design is a way of expressing conscious life.

2.4. *What is Ecological Design?*

What is ecological design? Benign design? How is it different from traditional design? Is it different enough to justify more words about it? This is an academic question. Ecological design is, in Nancy Jack Todd's words: "design for human settlements and infrastructures that incorporates principles inherent in the natural world …" David Orr defines ecological design as: "the careful meshing of human purposes with the larger patterns and flows of the natural world and the study of those patterns and flows to inform human actions." Let us take these ideas as a working definition and expand on them, by comparing ecological design to traditional design and 'natural' creations.

2.4.1. *Definition of Ecological Design*

The word 'design' comes from the Latin word for "to mark" and means 'marking off a pattern.' Marking creates a line or boundary that is inclusive or exclusive, but, if the line is more like a membrane, then it can permit certain sizes, shapes and regularities of intrusions. In ecological design boundaries must be designed as membranes.

Traditional design is a human project in which, as Oliver Lucas says, "visual and physical parts are assembled in order to achieve a specific end result." But, the end result has to be placed in its social and environmental context. As Lewis Mumford pointed out: All thinking must now be ecological. Ecological design has to consider the context and the long-term implications of any designed object. Van der Ryn has qualified design as ecological by stating that it "is any form of design that minimizes environmentally destructive inputs by integrating itself in living processes."

Ecological design has two meanings in this discussion. The first regards the connection of design to its ecological context, while the second refers to the design of ecosystems. In its large sense, ecological design is the creative modification of ecosystems to repair or enhance their ability at self-organization and maintenance of their complexity and diversity. Diversity, as in biological diversity, means species richness, different age and size classes in a population, and genetic differences in a species, as well as kinds of habitats present in an ecosystem and the kinds of communities occupying the habitats; and the kinds of ecological processes that maintain habitats; and the variety and richness of the planet's genetic heritage. Ecosystems that are designed so will become healthy. A definition of health is the condition of being sound in body or well-being.

2.4.2. *Differences between Traditional Design & Ecological Design*

The four topics from the design matrix— Biophysical systems, ecocultural play, economies, and values —are expanded to highlight the differences between traditional design and ecological design. The characteristics of natural systems are also repeated with both kinds of human design.

2.4.3. *Ecological Design Components, Elements & Variations*

Ecological Design builds on the basic geometric elements of traditional design, and it shares the same variations—number, position, direction, size, shape, interval, texture, color—as traditional design, but there are many more occasions: Sand blowout and a forested tertiary dune, the diagonal lines of hills, the path of a corridor, the framing of a skyline by the shape of hills, a talus slope on the side of a mountain, the volumes in and around an Oregon creek, the shape of an agricultural field squared by a road, the texture of an old-growth forest compared to a young tree plantation, or the palettes of a coral reef.

However, time in ecological design is ecological time, which ranges from the lifetimes of bacteria to the development of landscapes over tens of thousands of years or the lifetimes of species in millions of years. Trees in the temperate northern hemisphere tend to grow in stands. Nearness for ecological design can range from the interpenetration of endophytes to a general community grouping in a desert mesquite landscape. Blades of grass in a prairie may be perceived as dense from a low perspective. With fewer elements, a Japanese garden of the same area as a Dutch Tulip garden may look smaller.

2.4.3.1. Organization into Patterns

Ecological design shares the same organization into patterns—structures, rhythm, tension, balance—as traditional design. The structure may be more complex for ecosystems, as when a tropical forest ecosystem has a typical structure (of interrelated parts) of six levels, from the herbal layer to rising emergent trees. Rhythm in ecological design has units of time that may range from milliseconds to thousands of years, although most will seem to be daily, seasonal, or long (in 2-25 years). A large clearcut area could create tension in a mature forest landscape because it would rarely develop under natural conditions. In forest design, a larger meadow could balance a dense woods, due to differences in perceived masses (especially if it reflected differences in soils or topography).

2.4.3.2. Concluding Thought: Ecosystem Complexity & Wicked Problems

There are not many examples that give the interests of ecosystems independence or priority, perhaps because the project would be too large or complex, or perhaps because there is no funding for it. Eric Higgs thinks that this may be a wicked problem for ecological design. Rittel Horst, in 1960s, defined a wicked problem as a kind of social problem that is formulated with confusing information, too many clients, and confusing values. Imagine how wicked ecological problems are when they include all those nonhuman perspectives and values. Problem definition is subjective based on a point of view (or two or three). The solution is participatory design, which can reduce domination by one point of view. Design is political also; there is no way of envisioning other approaches.

Complexity is not the only variable that can make a problem wicked. The scale is a problem if we think we can destroy the planet by burning fossil fuels. And, it is a problem if we think that nothing we can do will affect the planet.

Orientation is another variable that can influence the wickedness of problems. Design can be object oriented, like a building, and not seem wicked. But, design can be pattern-oriented, like planning for minimized polarized light surfaces on buildings in sensitive ecosystems, and then it pulls in scale and complexity—we are finding that we cannot avoid the things that make design problems wicked—denying them does not make a design good.

But, design can work things out in an artistic way. There are ways in which design can be subversive; *Adbusters* is an example. Perhaps that might solve the wicked problem situation of design. Being subversive may turn over and expose wicked design problems. That artistic way is a wild way of thinking and meshes or can mesh with restoration design better than a simple technical approach. Ecological design requires an ecological perspective, systems understanding, participation, and standards of knowledge. However, it does not require a degree or certificate, which means that more people, educated or self-educated, could be ecological designers.

2.4.4. *Characteristics of Ecological Design*

The characteristics of ecological design have to address the properties of ecosystems and places. The courses of the design have to imitate the processes of systems and places. The wholeness of the design has to address the ideas of spirit of place and sensory force.

After the processes are identified, they have to be related to the patterns. Design may have to try shortcuts, unless it can afford to take ecosystem time, which is often many human lifetimes. These six characteristics—imitating courses, extending identity, enhancing diversity, participating in coconstruction, investing in stability and constancy, stimulating productivity and health—have to be related to other levels by ecological design (Table 244-1).

Table 244-1. Properties at Different Levels.

— Nature —		**— Culture —**		**— Domiture —**	
Field	*Ecosystems*	*Place*	*Culture*	*Good Places*	*Good Society*
Motion Process	Course	Dynamic Change	Conduct	Action	Method
Autopoesis	Identity	Self-making	Wholeness	Individuality	Self-extension
Differentiation	Diversity	Uniqueness	Flexibility	Richness	Variety
Integration	Coconstruction	Integration Investment	Adaptation	Conviviality	Cooperation
Constancy	Stability	Regularity	Endurance	Consistency	Loyalty
Development	Productivity	Renewal	Vitality	Health	Harmony

For instance productivity of the ecosystem level promotes vitality in cultures and harmony in good societies, which are embedded in human places, which are embedded in ecosystems. And, diversity at the ecosystem level promotes flexibility at the cultural level and variety in good societies.

2.4.5. *Principles of Ecological Design*

Principles reflect the differences between local and global systems. Principles cannot be reduced to other principles, because they emerge from earlier ones and they expand into new forms. This expansion is why we cannot fit them into the old can of old principles. These design principles are based on basic principles of nature, such as the principle of change. Nature is in flux, culture is in flux, everything is in flux. The climate will change, the shorelines will change. Human understanding and behavior is changing. But, nature is also self-regulating. This is the principle of self-regulation. Nature has evolved to maintain its stability in the face of many kinds of disturbances from planetesimal impacts to changes in atmospheric composition. Nature will continue to regulate itself even as human beings make dramatic changes. The danger is not so much that nature will collapse, as that humanity will lose those things that it values the most, from cool air to wilderness.

2.4.5.1. Ecological Principles
Principles of ecology, such as stability, have to contribute to the design of landscapes because those landscapes have derivative principles, or maybe emergent principles. Design has to incorporate those principles because it is in place, in an ecosystem, in a culture. Some cultural principles, such as sacredness, are actually emergent from ecological principles, such as the principle of pattern. It expresses the values of the locale and the culture. Principles must be flexible to mirror the flexibility of open systems; flexibility is provided by diversity in fact. Ecological principles include: The principle of flow, the principle of separation, the principle of growth, the principle of self-regulation, the principle of error (or play), and the principle of pattern.

These principles seem to be interactive, each forming part of the environment for the others. These principles result in a definite set of standards and behaviors that can guide ecological design. For instance: Work within the scale and duration of an ecosystem. Processes like succession can be assisted, slowed, or speeded up, but not skipped or ignored. Or, Make the smallest number of changes, in case they are not effective and have to be modified. Nature seems to follow its own principle of least effort.

2.4.5.2. Ecological Design Principles
Ecological design principles emerge from knowledge of ecological principles. They must combine the constraints of ecology with the ascendant sensitivity of design. Ecological design principles include: Spirit of place, sensory force, and the precautionary principle.

These principles also result in a further qualification of standards and behaviors. Some actions based on these principles might be listed. For instance: Contribute to excitement and to life (being); Act from the bottom, restrain from the top (and act locally in parallel, within the constraints from the top and blueprint); Cultivate feedback; Develop rather than grow; Use a sideways approach, rather than focus on details; Work with errors, learn from and allow them; Work with and allow disequilibrium; Structure the design to allow change; Pursue the satisfactory (*saticficing* in H. Simon's words) instead of a perfect maximum or even exact optimum.

2.4.6. *Applied Ecological Design As Lessons from Nature*
Design can imitate nature on many levels, from structure and process to landscapes. We can imitate the structure of mature forests by planting on every level of the forest hierarchy, from canopy to below ground. We can use native species. We can imitate the process of forests by allowing birds, bats, and other animals opportunity to distribute seeds and energy to other areas or prey on "pests." We can create microclimates within the landscape that may shift the landscape in new directions. Planting trees, for instance, allows new species to become established under their protection. It also slows and deepens the hydrological cycle. Ecosystem health is one of the goals of design. Although the goal is not an end point that can be reached once, but is rather a continual floating point.

The landscape provides its own metaphor for design. The landscape is a unique individual, a community, a dynamic system of interacting patterns—the human pattern is a part of it now and should be preserved as part of the whole pattern, but not necessarily as the only pattern or a completely dominant one. Most products of an ecosystem are produced and consumed and recycled within the ecosystem. Humans need to minimize the external inputs in the form of energy and exotic substances. The community must be restored to health. This means balancing human needs with birds or fish needs in a stable pattern. Each element in a pattern relates to others and to the whole.

Natural patterns can suggest a number of regularities to understand for the design of ecosystems, according to Michael Soule. Well-distributed species are less at risk than concentrated ones. Large blocks of habitat are safer from species extinctions. Blocks close together are more effective than those far apart. Contiguous blocks are better than fragmented blocks. Interconnected blocks are better than isolated blocks. Corridors can make functionally larger blocks functionally. Roadless blocks are better. Human disturbances similar to natural ones are more likely to be resisted.

These rules work well with natural processes that operate in ecosystems, such as metalysis (building up and breaking down), animal movement, interelement flows, human interactions, and shifting mosaics. For instance, forest fragmentation can be reduced through the design of forested areas, taking into account the genetic diversity of the trees, catastrophic conditions, minimum viable populations, corridors, and edge effects. The survival of organisms usually depends on one of two factors in the web of relations. These factors can be modified by design.

Wild landscapes are affected by climate, soils, interactions, and disturbances. Domestic landscapes are affected by these and by land use as well. The greatest changes have been brought about by the destruction and creation of forests. With the predominance of artificial forests, it is important to consider the qualities of naturalness in the landscape. Forests are expected to meet the needs of society by producing timber, creating wildlife habitats, and providing recreational opportunities for people. But, forests are also expected to look natural. The patterns established at these times may persist for many years or centuries. Good design maybe able to resolve conflicts between characteristic qualities of the landscape and the changes from use. Also, the design should last as long as possible and should be self-sustaining.

2.4.6.1. Levels of Ecological Design

As a design process includes the planning of ecosystems, this means a fourth and fifth level of design— notice that numbers lower than number four are all properties of traditional applications of design: (5) Regions, landscapes, and watersheds (as well as airsheds), (4) The community, for instance forest, city, or corporation, (3) systems, such as ecosystems, traffic, or industrial areas, (2) products, as habitats, houses, roads, or plant sites, and (1) components, such as trees, fungus, bats, tools, rooms, cars, or land. Many more problems occur at level three—still more are to be expected at the new levels four and five.

All levels of design need to be addressed, from the conceptual to the political, and are involved in all stages of the process. This involves new challenges for ecological design, which has to: Relate a project to its regional context (fifth level of design); this is the level of regional cycles relating to precipitation and waste recycling. Relate a project to its ecosystem context (fourth level of design); be concerned as much with cultural survival, justice, and wilderness preservation as with efficiency and aesthetics. Consider the whole perspective (ecocentric, perhaps)—the proper vision is of the whole community in which we dwell—and apply ecological concepts, such as networks and carrying capacity. And, make designs that are anticipatory, flexible, pluralistic, polyvalent, and polytechnic; make open guidelines for long-term decisions. Essentially, work backwards from values and goals, and from the bottom up and inside out, drawing designs from the genius of place. Finally, participate in place, care for all inhabitants, and assume responsibility for the designs. One of the shortcomings of design has been the lack of consideration of the higher levels, which can result in specific problems with safety or recycling.

2.4.6.2. Stages of Ecological Design

Ecological designs can be applied in eight stages. These stages should be typical of all designs:

• First, Decide to design; Use a design management matrix, review the situation; Evaluate ecological history of the site, observing patterns of movement; Account for interconnectedness, population change, land use, building and development, boundaries, limits, and life; Conduct ecological and functional analyses.

• Then Inventory, record all of the resources, from physical resources to cultural resources. Survey the area and create base maps, from geological to zoological maps.

• Next, evaluate the interactions in terms of impacts, needs, goals, and limits. Assess the whole system. Delineate and balance components.

• Create a series of plans, from the site plans to value plans. Integrate with biosystem productivity, and with awareness of kinds of integration: horizontal, vertical, temporal. Consider aesthetic-perception factors.

• Start to design, which is a community process requiring the participation of all people, including the elderly, handicapped, and poor, as well those ultrahuman beings who cannot voice their concerns. Synthesize simulations and models (conceptual, capability, and stability). Make another series of plans, from landscape plans to policy plans, within a master design.

• Implement the design together. Use appropriate measures and techniques, emphasizing native species over an adequate time period to ensure the stable processes of transformation. Create new connections, Reduce unwanted effects, such as road effects or heat island effects. Integrate into context. Optimize passive mode, integrate water, biomass, materials flows. Conserve water and energy

• Maintain and manage design. Provide services for continuity and management. Monitor and improve constantly. Monitor, Reassess.

• Prepare for undesign and disintegration. Be able to recycle parts and waste.

Ecological design must work within the components, structure, and function of ecosystems. Unless it does, it will not be long-lasting or satisfactory. Because ecological design has to work with wild ecosystems, whose aspects are often ambiguous, fuzzy, changing, and general, design has to understand those aspects. Furthermore, the design has to work within the constraints of the ecosystem.

Ecological design takes far more time than graphic or automobile design, due to the complexity, size and longevity of its subject. A number of factors have to be carefully assessed before design work starts. Wild ecosystems require a lot of observation before activities can take place. Wild ecosystems can be highly reactive to change, so some change has to be limited. Some people value different character of such ecosystems than others, so the values have to be balanced.

2.4.7. *Applying Ecological Designs to Places*

All design elements are related psychologically by designers, as focus or frame, as contrast or uniformity, as dominant or recessive, or in a number of other pairs. Good ecological design means not violating any of the aforementioned principles and ideas.

Design can improve the results of bad practices. Bad forest harvesting practices, for instance, often result in geometric wastelands. Good design can correct reliance on straight lines, parallel lines, right angles, and perfect symmetry. In cutting or planting forests to improve natural appearance, a number of things have to be considered, including the age of the forest, windthrow, the width of corridors, and the minimum size of the habitat.

2.4.8. *Ecological Design Management*

Ecological design is not finished with the design. The system may need to be managed as a result of the design. Noninterference matrix management is proposed as a technique for design. An ecosystem exists as part of matrix that many interacting elements. Any activity in the matrix can have some effect on these elements. The whole matrix needs to be managed with the ecosystem in mind.

Understanding of the principles of ecology can lead to better management. One critical message of ecology is that if we diminish variety in the natural world, we debase its—and our own—stability and wholeness. Many ecosystems have been simplified and degraded. Perhaps we do not have sufficient knowledge to manage a complex landscape because it is too complex to understand scientifically. But we can understand the pattern and drive it in a healthy direction with minimal intervention. We must do all that we can to restore its richness and the natural processes that created the richness.

2.4.8.1. Principles of Ecological Design Management

Management, whether it is archaic, traditional, industrial, or ecological, should adhere to basic principles. The principles of ecological management include: Holistic practice, retention, noninterference, least effort, respect, managerial flexibility, work with changing ecosystems, appropriate scale, profitability, keeping wild, and accepting management limits.

2.4.8.2. Noninterference Matrix Management

A noninterference approach to ecosystem management, the essence of a taoist way, is to let the system take its own course. Therefore, once the temporary constructs were in place, whether planting or cutting or any other manipulation, the system would be allowed to develop without further interference.

In nature, noninterference means ‘letting be.’ Noninterference matrix management (NIMM) is not indifference, which is diffuse. It is caring. Noninterference will not lead to chaos, poverty, and stagnation. The technocratic vision strives for “life under control,” but an ecosystem is self-managing, productive, efficient, and orderly. We need to practice the rule of noninterference so that all beings can enhance themselves. Noninterference can be derived from nonviolence, or from taoist nondoing. This attitude would entail using what is necessary, exploiting parts of some ecosystems, changing a place to fit human aspirations, and killing plants and animals for sustenance. But it would also mean limiting humanity and its technological effects, limiting human use to local impacts, and letting other beings live without interference. It is not necessary to dominate or terraform the ecosystem completely to save it. Noninterference matrix management weaves people back into the fabric that supports them and in a sense makes them subject to the constraints of ecosystem processes.

NIMM would manage the system with minimum subsidies; manage activities that could upset equilibrium; manage for stable conditions; align human activities with natural processes; work with system instead of attacking it; and, restore context. According to Garrett Hardin, many of the ideas necessary to fitting humanity into the pattern of nature are known but not yet popular. For instance, exponential population growth, or economic growth, cannot be maintained very long. Human communities cannot grow 4 percent per year without disastrous consequences to the infrastructure and the quality of life. Growth cannot be continued because the landscape is limited, in terms of productivity, energy, and resilience. Thus, we need to fit our population into the limits of the landscape, although some limits can be expanded by technology or by lowered expectations. The carrying capacity of the area is not only a function of the limits of the community, it is equal to the number of people multiplied by the level of comfort, the quality of life style. Having more energy and space means having fewer people.

The ecosystem may be too complex to design in detail. How do we design an ecosystem, such as a complex, self-making, self-sustaining wild forest? We could identify the parts and functions and try to duplicate them, but that would prohibitively expensive and time-consuming. Management has to recognize the limits of design. Limits of ecological design include the fact that ecosystems are wild, and we have no real control over them. The scale of ecosystems is often too large to manage everything. The longevity of ecosystems is too long, and we will never complete the design in human lifetimes. The costs may be prohibitive—indeed, we have depended on the free goods of ecosystems for economic advantages, which would disappear if we had to rebuild the system. Other human limitations apply to our ability to see and understand any ecosystem.

2.4.8.3. Uncertainty & Management

Carl Walters discusses how we recognize and measure uncertainty. He presents material on decision theory. He also distinguishes between three kinds of uncertainty in natural systems:

2.4.8.3.1. Regular disturbances over time generate unpredictable and uncontrollable changes. Certainly this is true, but we have found that regular disturbances are also responsible for creating diversity in ecosystems; furthermore, regular disturbances "habituate" the ecosystems, so that often the system requires the disturbance to continue. Certainly, as he suggests, monitoring is necessary. The uncertainty of these disturbances is usually just in the exact timing and scale, not whether they will occur or not.

2.4.8.3.2. Statistical uncertainty about parameter values of functional responses, e.g., production rates as a function of stock size, can lead to problems with exploitation. He suggests the solution to this is simply assigning probabilities to parameter values. Probability is mathematical way of describing "random events," such as coin tosses. Nature, of course, is not random, even at a quantum level. Probability is also a degree of belief, according to Savage (1954). Probability theory centers on the notion of uncertainty as it applies to independent or conditional propositions. There are at least two kinds of probability: Personalistic, which depends on personal beliefs and confidence, used in Bayesian contexts, and Objective, which deals with repeatable events. Probability, in history, becomes conditional probability to reflect events that have already occurred. In nature, unfortunately, we are not always sure which events have already occurred and which have not.

2.4.8.3.3. Basic structural uncertainty about what variables to consider can lead to indecision. Incomplete structural representation implies time-varying parameters and surprises involving changes. Surprises are usually the result of incomplete knowledge, but also can be from the emergent properties of systems.

These three kinds of uncertainty are not that different, being basically levels of ignorance. There are other levels and kinds of uncertainty. There are levels of uncertainty, from the quantum to the human. Elementary processes at the quantum level are not subject to a precise description in time and space. Predictions about location and velocity are just statements of probability—this is Heisenberg's uncertainty principle. The effect of this principle on epistemology is that our exact interpretation has to be abandoned. There are uncertainties at higher levels of organization as well; for instance, the hysteresis of some magnetic solids determines their subsequent behavior—without knowledge of initial conditions and all past events, it is not possible to predict present or future behavior. Furthermore, the higher up in levels of organization, the more kinds of uncertainty there are. There is genetic uncertainty, as well as environmental and social.

There are also many kinds of uncertainty, as suggested by Max Black. There is fundamental uncertainty in the thing/event/pattern, as well as in the channels (noise, meaning) of relationship. At the human level, uncertainty can be distinguished between ignorance and conflicting knowledge.

Ignorance can further be divided into kinds: Vagueness (indeterminate knowledge), probability (confidence in partial knowledge), incompleteness (of knowledge, missing elements), irrelevance (place in pattern unknown), and fuzziness (overlapping interpretations).

Conflicting knowledge also can be broken down into kinds: Anomaly (incongruity of knowledge, simple error), ambiguity (alternative interpretations of meaning), inconsistency (simultaneous untruth), equivocation (knowledge is constant and inconstant, true and untrue), and belief (confidence in subjective knowledge, taboo).

There are probably other components of ignorance, as well as other ways that they can be combined into a formal typography. There are many different kinds of ignorance, maybe more than kinds of knowledge, and that these determine our approach to the practice of making places. If we think of knowledge as an expanding sphere in a space of ignorance, then as the sphere grows, the surface area in contact with ignorance also grows.

Walters stresses that managers have to live with uncertainty, and then makes the great connection that management decisions are essentially gambles. Gambling is a profession that acknowledges the operation of chance and makes conclusions in the absence of facts—few people are successful at it. This is an important admission, that we do not have facts to base our actions on, that nature is a stochastic process, and that ecosystems always changing. Furthermore, we do not know for sure what effects our actions will have on ecosystems, which often extend their existence past human limits. If we do not act responsibly, we are gambling that the cost is more than damaging the planet. If we act responsibly we are gambling also. Successful gambling suggests that the proper attitudes for gambling with nature are awareness, humility and courage, not arrogance, fear and maximum use.

Although Walters suggests that inaction is an inappropriate alternative to gambling as a result of confusion, in fact, inaction is a very appropriate alternative in the face of confusion— when in doubt about an ecosystem, we should not interfere.

Embracing uncertainty is more realistic than always striving for "certainty-equivalent" policies. That is, managers should try to define a set of possible outcomes, e.g., models, consistent with experience, rather than make a single best prediction. They have to live with uncertainty, but they can make intelligent gambles, based on their ability to work within real ecological and physical limits. Of course, they should not gamble with all resources at once.

2.4.9. *Ecological Design Limits*

People often judge the health or wholeness of ecosystems by how they look, as a function of richness, despite the fact that ecosystems have to fit into extreme climates and places. Traditional design has emphasized visual results above all else. Ecological design, however, achieves the same results by paying attention to the structure and function of the system first. Design has been concerned for centuries with making domesticated landscapes out of wild ones. Now, design must address the opposite problem: how to preserve or provide the conditions for wild ecosystems.

Design must address the common good, that is, the good of the entire ambihuman community; it can do so by: Promoting the well-being of all individuals in the larger community, deciding what is preferable, attempting to regulate and anticipate all effects, encouraging convivial activity, recognizing links and dependencies, mediating the relation between technology and community, and alleviating some of the problems of industrial society.

Designs provide a framework for natural and artificial processes to work in. The patterns in design are echoes of patterns in nature. Good designs learn to embrace error and failure, so necessary in open systems. Most ecological designs of ecosystems will not be restorations, because of the uncertainty about the kinds and associations of native vegetation. Furthermore, humans are now a large part, although not yet an integral part, of the system; therefore it could not be restored to a premodern or prehuman state, even if we knew the proper or historical state. This design is not the biotechnological design of a new ecosystem, either; we cannot accurately control and predict ecological events in most ecosystems. However, we can steer some of the events in a known direction—known because we have historical records of the system, although not complete. We can also reduce those activities that we know alter the conditions of the forest, such as overcutting and pesticide use.

2.4.9.1. Ecological Balance

Although ecological design attempts to restore some kind of homeorhetic balance, the balance does not exclude human activity. Rather, it integrates it into the larger community. A moderate number of human impacts can be absorbed by the system—too many destroy the systems capacity for self-maintenance. The design should be open to evolution and to human technological and social development. The design should be based on a model of ecosystem functions, considering diversity, complexity, and the maintenance of natural process—natural here meaning a self-sustaining system composed of elements now lost through human disturbance.

How do large-scale processes influence design? That is, how can design be flexible and open enough to cope with change? How does design accommodate those processes?

The processes provide constraints on the designs, which when implemented, force some constraints on the processes themselves. The question is how to limit the latter constraints so that the processes are not fundamental shifted into a new regime. For example, a dam is located depending on waterflow, canyon walls permeability, location, rainfall, and other factors. After being built, however, the dam changes rainfall, erosion, waterflow, species groups, and other factors, which may reduce the rain upstream reducing the water behind the dam.

The role of designers is to optimize or satisfy the fitness of people with their environments. To fit cultural goals to ecological characteristics and limits. It is adaptive creativity, not just for the current technology, but because it needs to adapt to the technological and natural environments. An ecological design involves designers and people in reshaping and recreating a self-sufficient community. Individual resources are limited. The relationships to strive for here are community relationships. Furthermore, there are limits for human manipulation of other communities. Total control has limits, also. We should not aim to try to control the ecosystem and its habitats. We have to trust that natural processes are self-correcting and organizing.

Ecological design is the design of communities. We design places as organic wholes to promote the well-being of individuals and the common good. The immediate goals of design are to reverse degradation and reclaim places for communities, but also to work to increase public awareness of the interdependence of communities, to create environmental quality, and to transform public values by generating new metaphors for living. Unlike what Robert Bailey and others imply or say, regional design cannot ignore culture, politics, and economics. Design has to commit to limits, constraints, and optima (physical, biological, psychological, and social). Ecological design can restore the interconnectedness of the systems, especially ecological and human social systems.

2.4.9.2. Ecological Perspectives

According to Victor Papanek, an ecological perspective can change design, with a greater emphasis on quality and permanence. So products can be more timeless and age gracefully. An ecological perspective can improve design by questioning the ultimate consequences of a new product, regardless of profit or prestige, by adding new products for new approaches or new professions, by understanding that all design has ecological and cultural consequences that need to be discussed and evaluated, and by having a greater concern for and understanding of nature, preserving and restoring the health of the environment. Ecological design importantly has to do with ecological scale, which explains Papanek's conviction as a designer that: Nothing big ever works! Not corporations, building, schools, or bureaucracies (although it is argued later that global ecological design can work as a coordinated network of local designs and restraints). Ecological design has to fit designs into the scale of their context, so that they harmonize with it. Ecological design fuses art and ecology from the work on forests and rivers to agriculture and buildings.

On the other hand, our tendency to redesign nature, rather than to tolerate and cherish, is dangerous; it leads to "curing" abnormal people and "solving" weed problems. We do not respect the wild, complex side of human nature. So we need ecological designs that seem like 'dedesigns.' Ecological design does not have to merge technology with nature, as Van der Ryn and others define it. For buildings, technology is an important component, but for the shape of ecosystems, it may play a minor role, of necessity; we may not have the knowledge or the ability to completely control technological replacements for natural services. Ecological design has to respect nature and natural limits, while integrating human patterns into natural processes. The role of designers is to optimize the fitness of people with their environments, to fit cultural goals to ecological characteristics and limits. Ecological design is adaptive creativity, not just for the current technological fix, but because it needs to adapt to the technological and natural environments.

An ecological design is the creation of a clear vision of the ecosystem that is aesthetic, useful, and self-sustaining. Ecological design fuses art and ecology from the work on forests and rivers to agriculture and buildings. Some of the relationships can be captured by maps and drawings, but not the dynamic four-dimensional qualities of the system itself, which can only be understood by dwelling there for years. Nevertheless, a simulation of the view from foot or airplane is more compelling than a recital of the statistics or species lists.

The goal of ecological design is not to restore a damaged wild system to some vague prehuman state—it is to revitalize and reinhabit the wild ecosystems. We do not want to live in the dead bones of a mechanistic failure. We want to live in a healthy environment with aesthetic appeal—aesthetic appeal is a requirement for human health. Every system has physical, biological, economic, and political characteristics. The ecological design, planning, and management for a forest, for example, describes the system in a comprehensive interdisciplinary approach, using dynamic concepts such as feedback and stability, recognizing limits to change and sustainability with different levels and scales of structure and function in an anticipatory, flexible planning approach, recognizing human and nonhuman goals, and incorporating personal and institutional interests.

Ecological design is the design of whole communities. We design places as organic wholes to promote the well-being of individuals and the common good. The immediate goals of design are to reverse degradation and reclaim places for communities, but also to work to increase public awareness of the interdependence of communities, to create environmental quality, and to transform public values by generating new metaphors for living. The long-term goals require a wild, heroic design and extravagance. It is not contradictory or antithetical to living frugal lifestyles or to restoring a healthy environment to create ambitious, heroic designs—this needs to be repeated often. Life is exuberant; energy is used, lives are lived and used, not saved. Life is the accumulation of individual experiences that cannot be saved, stored, or owned. This ecological design is what brings all the problems into focus—or rather into context and out of focus. We have to creep up on the problems sideways like a crab moves.

2.6. *What is Global Ecological Design?*

Global Ecological design is not the additive design of ubiquitous factors such as roads or popular products. Nor is it the design of common structures or symbols, such as cities or money. Although it has to address truly global phenomena, such as the atmosphere or ocean, there is not the knowledge or power to change or reconstruct those structures and processes. So, it has to do mostly with fitting human activities within the framework of the planet. It can minimize the impact of human activities on the global anatomy of the planet, and it can minimize the impact of the planet on human constructs.

2.6.1. *Design at the Level of the Planet*
Global Ecology itself has to be broader that regional ecology, than community ecology, which is broader than human community ecology, which is broader than human ecology. Global ecological design is a human process that considers the emergent and unique factors of the planet. We have to change the framework so that we can shape new approaches. We no longer have an external point of view. We are inseparable from the environment and each other, but we can still differentiate and develop new designs.

2.6.2. *How is Global Design Different from Ecological Design?*
The major difference between ecological design and global ecological design is scale. The scale of the planet requires changes in design. In some cases, design simply permits global processes through benign neglect. In others it has to provide the constraints for local and regional design. Four areas of differences—biophysical systems, ecocultural play, economies, and values—are detailed between these two levels of design.

2.6.2.1. *Physical & Biological Environment of Global Ecological Design*
At the biophysical level, global design has to address many more systems as well as the new emergent properties of the globe.

2.6.2.1.1. *Repatterning*. The patterns of concern here are global patterns that are limited by climate and regular catastrophes. This includes the global cycles of elements and well as global distributions of species and communities.

2.6.2.1.2. *System emergent*. As the result of the local creation of forms and ecological constraints on systems, large-scale patterns emerge. But, these patterns depend on the continued operation of local processes, as well as on new global cycles. Design has to consider all scale levels as well as the planetary system itself.

2.6.2.1.3. *Growth/Development*. The autopoetic process is not just about generating forms, it is about degenerating and regenerating, where the two anabolic and catabolic processes run up and down simultaneously. It is about making, demaking and remaking on a planetary scale.

2.6.2.1.4. *Whole system*. The frame contains the local systems that may be the focus of local design, but the whole system also needs to be considered by local or regional design. Global design has to pull back from a focus and consider the aspects of the entire frame. The whole system has unique properties that have to be given opportunities to continue the process at the global scale.

2.6.2.1.5. *Feedback cultivating*. The ecosphere acts as one system in which energy from the sun is cycled. The functioning biomass is integrated by feedback responses to extract the maximum of energy and still maintain a balance. Most of the solar energy is used for maintenance by the biosphere, which is an indicator of the biosphere's high degree of ecological maturity. Lovelock hypothesizes that every element in the system is related in a feedback network to every other element, from the very strong to very weak. Cycles that do not operate with the right kind of feedback function as traps. Thus, on an elemental level, phosphorus becomes trapped in an ocean sink, and can only be recycled by long geological processes on a global level. On a cultural level, some organismic behaviors, for instance specific harvests of marine organisms by human activities, may unbalance a complete food webs, which would change rates of photosynthesis, which could affect planetary albedo. Global design has to consider many kinds of traps.

Table 2621-1. Comparisons of Biophysical Levels of Design

Natural Creation	*Traditional Design*	*Ecological Design*	*Global Ecodesign*
Self-patterning	Patterning	Repatterning	**Repatterning**
Creating forms	Conscious intention/form	Ecological restraints Experiential	**System emergent**
Autopoetic	Making/ Generation	Remaking Regeneration	**Growing/developing Degen-regenerating**
Complete	Focus	Peripheral frame/ system	**Whole system**
Systematic	Feedback accepting	Feedback driven	**Feedback cultivating**
Processing patterns	Objective/object-oriented	Dimensional process	**Diversity allowing**
Development/change Filtering/Sorting	Growth-permitting	Development after initial growth	**Evolution**
Place generating	Place independent /isolation	Place specific	**Place framework / context**
Place responsive	Principle limited	Fitness-oriented	**Place-supporting**
Dynamic equilibria	Equilibrium	Disequilibrium incorporated	**Change permissive**
Interaction limiting	Maximizing/ Optimizing	Optimizing/Satisficing	**Possibilizing**

2.6.2.1.6. *Diversity allowing*. One of the important factors in diversity is locality. Differences emerge from communities and species developing in isolation. So, isolation must be an important part of global design. Global designs must erect or allow barriers to human-assisted migration of exotic or invasive species to allow diversity to develop as it has. Combining many organisms at random may increase diversity briefly, but it may decrease it in a new settled-out system. On the other hand, human additions to some systems, such as reintroducing camelids to North America, could increase diversity in the long term.

2.6.2.1.7. *Evolution*. Evolution is the process of development. Although it applies to the survival of individual species, it also applies to their communities and ecosystems, and possibly to the entire planet. Landscapes evolve as well, even at the continental scale. As species compositions shift the landscapes shift also, and as they shift the planet changes.

2.6.2.1.8. *Place framework*. With global design, we want a framework that permits the natural processes that permit places to form and operate freely. Place generates design through participation. The framework of place comes with a long history of changes and successful patterns that can inform and limits designs. Global design considers all the places simultaneously.

2.6.2.1.9. *Place-supporting*. Although ecological design is place-specific, global design has to be context-aware. The frame for making places has to be healthy and productive.

2.6.2.1.10. *Change permissive*. The matrix of nature occurs in a dynamic disequilibrium. The framework of global design has to permit the processes to continue, in order to have designs on the local level.

2.6.2.1.11. *Possibilizing*. Living beings in local systems may maximize or optimize their populations, depending on their environment and qualities, such as territoriality. They may settle at satisfactory levels of population or feeding. Global design needs to keep many sets of possibilities open, rather than striving for explicit structures with optima or maxima.

2.6.2.2. *Ecocultural Play of Global Ecological Design*

At the level of ecocultural play, global design considers the sum of cultures and evolution acting on planetary patterns (See Table 2622-1).

2.6.2.2.1. Planet-based. More than being nature-based or culture-based, or nature and culture-based, global design has to consider the entire planet, so that processes of natures and cultures may be isolated or limited when necessary. The health of the planet, in all its history and variety, is considered first.

2.6.2.2.2. Nesting. Nature deals with aggregates. Ecological design may assemble species to restore an ecosystem; it may connect the niches and behaviors of species. Global design needs to nest the systems and species in the global framework.

2.6.2.2.3. Cyclic linking. The trial and error process of design works well with traditional design and even some ecological designs, where species are assembled in restorations according to their functions and allowed to sort out over time. Global design is concerned with making sure that adapted local species are not replaced with faster-growing or tougher exotics over large areas. Furthermore, species have to be linked with local and global cycles.

2.6.2.2.4. Failure allowance. Ecological design incorporates the failures of previous designs into newer designs. Global design has to be sure to allow failures to continue to occur within the framework of the designs. The failures are only of concern if a critical level is reached or if the failure is at the cellular level of life.

2.6.2.2.5. Novelty from history. Global design has to consider novelty as well as tradition and historical processes. In fact, it has to allow the processes of novelty and the history of traditions to both operate on a larger scale.

2.6.2.2.6. Reciprocal Quality breaks are important. In a system of global design, quality can be submerged by quantity. This can be a limit on the lifetime of products and patterns, as things break down and are reformed.

2.6.2.2.7. Chaotic development within restraints. Although local systems are formed bottom-up, global systems provide the context and restraints that limit not only global cycles and patterns, but local ones as well. At the global level, a designer can assess the overall situation and tune some of the limits and patterns. Trickle-up and trickle-down processes can be identified ad monitored to make sure that both processes continue.

2.6.2.2.8. Courageous neglect. Although traditional design and ecological design may be very attentive to forms and their consequences, global design has to display a courageous neglect, when it comes to allowing natural processes to work. That may mean that not every charismatic species should be saved in zoos or gene banks. Not every favorite ecosystem should necessarily be restored. Unique patterns of plants and animals may come and go rhythmically, without human design trying to freeze them in one configuration.

2.6.2.2.9. Health emphatic. At the global level, the overall health of the system, with degenerative and regenerative processes continuing, is more important than sustainable permanent patterns. Health is a measure of the harmony of the degenerative and regenerative processes, which may recycle dwelling places, especially those badly sited in earthquake or tsunami zones. Designer should take care to create healthy places, but on the global level especially, they have to be aware of short or long-term destructive processes at work. Health is the overall ability of a system to maintain itself under a normal range of environmental conditions. Obviously, a pioneer community may change the conditions to favor a new level of the system with new components. The global level may require a balance of mature and young systems.

2.6.2.2.10. Receptive. Simple behavior seems to work, with local feedback, and more sophisticated behavior "trickles up" to approximate a global perception. A global design level has to be aware of local centers and their places in a global context. Receptive in this sense means incorporating patterns that may not be conceived or perceived.

Table 2622-1. Comparisons of Ecocultural Levels of Design

Natural Creation	*Traditional Design*	*Ecological Design*	*Global Ecodesign*
Nature-based	Culture-based	Nature & culture-based connecting	**Planet-based**
Aggregating	Bricolaging	Niche-assembling/ connecting	**Nesting**
Trial & Error process Novelty testing	Conscious Trial & Error process	Ecological redundancy	**Cyclic linking**
Trial generating	Learning from failure	Failure incorporation	**Failure allowance**
Novelty generation	Novelty emphasis	Historical tradition	**Novelty from history**
Reciprocal interactions	Rules/Geometric grids	Quality emphasis	**Reciprocal**
Bottom-up organization	Top down direction Control of actions	Bottom up action with top down restraints	**Chaotic development within restraints**
Physical restraints	Creative Play	Consequences attention	**Courageous neglect**
Natural process	Goal-directed	Permanence sustaining	**Health emphatic**
Actual Existing	Conceptual	Perceptive	**Receptive**

2.6.2.3. *Ecological Economics of Global Ecological Design*

In terms of ecological economics, global design has to consider economics as the basic exchange of energy and elements at all levels (See Table 2623-1).

2.6.2.3.1. Capital-creating. Ecological design is concerned with using natural capital at renewable rates, with a minimum use of the productive accumulated "interest." Global design considers the capital-creating process on several time scales. Global design has to take care that those long-term processes are allowed to continue, even while we use renewable energies and materials.

2.6.2.3.2. Symbiotic. At a global level it is easier to identify and appreciate the advantages of systems living together for mutual benefits. These benefits extend to the global level. Although integrated, it seems that many of the partnerships become obligatory.

2.6.2.3.3. Reintegrative. All levels are integrated by global cycles. But, the patterns weave and reweave so much that global design has to constantly reintegrate the pieces. It can do this by following a monitoring program that is concerned with regular changes in patterns. Tools and designs are important extensions of the human mind. Their purpose is to foster and assist survival, not to make it more difficult. Tools and designs can be made appropriate to environmental limits and cultural preferences, both of which are often ignored by industrial approaches, by integrating them into regional and global patterns.

2.6.2.3.4. Constructively indifferent. Where ecological design is dependently constructive and minimally destructive, global design has to appear indifferent to the destructive parts of the process. The destructive is a necessary part of the cycle, in balance with a constructive process. Both are necessary; neither can be overemphasized. Small-scale operations in general, are less harmful to the environment than large-scale operations. But, we are pulled by our idea of global economics to make large-scale decisions beyond our immediate comprehension. Wendell Berry suggests that we are not smart enough or conscious enough to work on a global scale. This kind of design would assume that and scale down things to understood limits

2.6.2.3.5. Energy scales. More than appropriate energy use, global design has to balance all kinds of energy use. For example, energy use on a local scale, for instance capturing tidal energy in bays, might have negative consequences on a global scale, perhaps affecting local life styles in the bays or even the rotation of the planet. We have to ask if wind farm energy on a global scale will affect the quality and kinds of winds on a local level, as well as populations of avian and mammal species.

2.6.2.3.6. Minimal technology. Appropriate technology in ecological design is crucial. We cannot be sure what appropriate design is on a global scale. At the very least, technology on a global scale implies the ability to predict, control, and respond to the technology and its consequences. For instance, placing millions of small mirrored surfaces in orbit to reduce the solar constant might have effects on many species, as well as unforeseen impacts on ecosystem surface that have developed with expected light levels. Van der Ryn states that ecological design is about merging nature and technology. Certainly technology is emergent from human activity which is emergent from "nature" but global design also has to consider separating technology from nontechnical species.

2.6.2.3.7. Waste sorting. The adaptive ecological design applied to a global level has to be sure to channel the unavoidable waste of local systems into the global cycles that reuse it.

This means limiting waste and eliminating unnecessary kinds of waste that come from lack of design or bad designs.

2.6.2.3.8. No costing. Ecological design has to be cost effective at local levels. At the level of the planet, however, cost is not as important as effective survival. When we approach global design, it is because we have already thrown global cycles out of balance, and we have interrupted or interfered with local systems crucial to global functioning. In most cases design at this level is more about control of human interference than about replacing global functions. Losses from accidents and diseases can be reduced by preparedness. Losses from earth and climate changes can be reduced, also, with preparedness for 'normal' events, such as hurricanes, earthquakes, and droughts. Design can also be used to reduce impacts from these events; for instance, by denying building permits on floodplains. The losses from some events, such as droughts resulting from El Nino, can be ameliorated, by having surplus food and supplies stockpiled.

2.6.2.3.9. Multiscalar trends & Interweaving. Scale constraints are equally important at the global level, but perhaps it is more about minimizing the scale of designs. The patterns of designs can be interwoven at a global scale rather than trying to replace processes with specifically global ones. Scale-linking is important. Scale-linking in nature occurs from energy and matter flows (which can be represented by fractal geometry). Global biogeochemical cycles link organisms across many levels of scale, from photosynthesis chemistry to the planet surface. This has holistic ramifications, as any action at any scale impacts others at other scales.

Table 2623-1. Comparisons of Economic Levels of Design

Natural Creation	***Traditional Design***	***Ecological Design***	***Global Ecodesign***
Productivity	Capital-using	**Natural capital-using**	Capital creating
Interrelational	Constructive	**Adaptive process**	Symbiotic
Nested	Auto separation	**Integrative**	Reintegrative
Interdependent	Independent/ destructive	**Dependent constructive minimally destructive**	Constructively indifferent
Solar-life driven	Energy use (fossil)	**Appropriate energy use**	Energy scales
Aesthetic creation	Technological tool use	**Appropriate technology**	Minimal technology
Waste generating	Waste production	**Waste integration**	Waste sorting
Free play/change	Cost consideration Market-oriented	**Cost constraints based on physical constraints**	No costing
Gigatrends	Fashion fads Style	**Size/scale constraints**	Multiscalar trends

2.6.2.4. *Values of Global Ecological Design*

At the level of global design, values are expanded from human and species to those useful for the planet (See Table 2624-1).

2.6.2.4.1. Responsibility to not interfere with living cycles. Ecological design has to be responsible for the local environment and community. At a global level, responsibility has to be concerned with not interfering with natural cycles and landscape processes. In fact, it might be practically impossible to be responsible at the scale of the planet. Much of design, again, becomes concerned with limiting and directing human influences.

2.6.2.4.2. Whole goals. At the local level, we can design strategies to accomplish our ends. At the global level, we have to consider global goals and impacts before implementing those strategies.

2.6.2.4.3. Whole order geological time. Global ecological design is concerned with much larger frames of space and time. The recycling of elements globally, for instance, should consider at least a 10,000-year time frame for many compartments and pools, and millions of years for geological shifts. Although there is quite a bit of flexibility for local orders, at the global scale, it would be better to keep flows in dynamic equilibria. Long-term catastrophes teach long-term thinking, Large catastrophes teach large thinking.

2.6.2.4.4. Free motion interchange. The goodness of a traditional design can be related to any destruction it may cause. Ecological design considers how the design fits into the environmental context. At the global level the design has to permit the free interchange of elements and patterns, before any human design is applied to the pattern.

2.6.2.4.5. Respectful. As the precautionary principle needs to be followed in ecological design, a principle of respect needs to guide interactions at the global level of design. Perhaps even a principle of nonintervention should guide our thoughts of changing global cycles. By promoting the understanding of the inadequacies of bad characteristics and bad designs, eutopias can stop the plague of uniformity and paucity. Through an understanding of the consequences of human ambitions and actions, eutopias can avoid many of the evils that result from a civilization on technical autopilot.

Table 2624-1. Comparisons of Value Levels of Design

Natural Creation	*Traditional Design*	*Ecological Design*	*Global Ecodesign*
Living	Responsibility to product, consumer	Responsibility to living community & environs	**Responsibility to not interfere with cycles**
Fitting	Planning	Strategies	**Whole goals**
Harmony-build long-term	Meaningful order short-term	Flexible order Living order times	**Whole order Geological time**
Existence value	Goodness concepts	Fitness concepts	**Free motion interchange**
Learnable	Teachable	Limitable Cautious	**Respectful**
Adjusting	Exclusive	Inclusive	**Binding/spiritual**
Formation	Information	Knowledge Ecology	**Wisdom/harmony**
Chaotic/Free	Exciting	Inspiring	**Dangerous**

2.6.2.4.6. Binding. Design needs to be inclusive at every scale, but at the global scale it can also bind us to the planet spiritually. James Lovelock suggests that regarding the planet as a living entity may suggest proper ways to attempt changes that could affect global cycles. Is this what religion does, entreating us to ask rather than tell? We have lost a meaningful frame of reference. Our fabulous cyborgs, computer communications, and genetic engineering coexist with burning poverty, urban violence and ethical erosion. Few of us can bear to look at the total situation. Of course, no one wants this other dimension, the slums and the pollution, but they are emergent characteristics of an unplanned, free society—just as a leader may sincerely not want a war, but may be helpless to stop the mechanisms that trigger a war. The social roles that determine the social action that could correct these sad things do not seem to exist. But, can they be designed?

2.6.2.4.7. Wisdom. Knowledge, and the understanding of its limits, is important for ecological design. At the global level, the right application of knowledge, at the right time and in the appropriate way, is necessary. This parallels a definition of wisdom by Jonas Salk.

2.6.2.4.8. Dangerous. Nature is chaotic, exciting and inspiring, and these emotions add content to ecological designs. Global ecological design accepts that nature, and the planet, is dangerous also. Although design can allow us to prepare better for natural catastrophes, through siting or not, through fit designs or not, design cannot guarantee complete safety.

2.6.3. *Global Ecological Design Components Elements & Variations*

Global Ecological Design builds on the basic geometric elements of traditional design, which can vary in numerous ways, by number, position, direction, size, shape, interval, texture, color, and temporal. Furthermore, the elements can be organized into groups by nearness, similarity, and difference (diversity). Then they can be combined into whole structures by principles of rhythm, balance, and finally sensory force.

2.6.3.1. Elements

Global ecological design has the same elements—point, line, plane, volume—as traditional design (See Section 2.4.3.1.), but they are understood in a global ecological context foremost, in the movement of continents, the submerging of a peninsula, the volume of the atmosphere, or the spreading of the oceans.

2.6.3.2. Variations

Global ecological design shares the same variations—number, position, direction, size, shape, interval, texture, color—as traditional design (See Section 2.4.3.2.), but there are many more occasions: In global ecological design it is the degree or process of change in appearance. Thus, there is great variation between a seabed and a cloud formation. At a global level, the spin of the planet pushes air and water patterns 'eastward.' The moon looks larger than it is when it is near the horizon. For instance, the continents have unique shapes that effect air and water flow and quantities, as well as animal and plant movements; animals on the Eurasian continent can move along latitudes that have similar climates much easier than those on the American continents, which are oriented north-south. On the global level, the effect of human activities on the shapes of landforms and seaforms is less evident. For instance, storms in the Caribbean form at certain times of the year, depending on dust storms and water temperature near Africa. The larger palettes of regions seem more uniform than the local variations in a rainforest, for instance.

2.6.3.3. Organization of Variations

Global ecological design shares the same organizations of variations—time, groups, nearness, similarity, density, diversity—as traditional design (see Section 2.4.3.3.). Global time is planet time, measured in billions of years, and covering dramatic changes, from a volcanic planet, to a rustball planet, slimeball planet, snowball planet, and possibly a desert planet. Global ecological design has to consider much larger timescales for design patterns and events. Large islands seem to appear on the east side of continents, as a grouping. Nearness for global ecological design refers mostly to landforms. Cloud pattern density can be related to land elevation and wind currents. On a global level, diversity seems to decrease due to the scale, as elements become more difficult to perceive individually.

2.6.3.4. Organization into Structures

Global ecological design shares the same organization into structures—structures, rhythm, tension, balance—as traditional design (see Section 2.4.3.4.). On a global scale, biomes form that reflect similarities of temperature and precipitation. Many global rhythms are influenced by the tilt of the earth and its orbit around the sun, as well as its movements in the plane of the planets and through interstellar dust lanes. The dramatically large clearcuts in the Brazilian state of Rondonia create tension in the mature tropical forest landscape, as well as with global chemical cycles and rainfall patterns. In global ecological design, many human landscapes can balance wild landscapes.

2.6.3.5. A Thought on New Scales of Design

Global ecological design extends the scales of design from the traditional and ecological to the planetary level, with associated changes in perspectives, e.g., in the following sequence:

- Designing objects (in a product-centered environment)
- Designing interacting objects and human subjects (user-centered)
- Designing systems of interacting objects (practice-centered)
- Designing systems of interacting objects within dynamics of living subjects
- Designing systems of interacting objects within systems of interacting objects (multi-centered)
- Designing systems of interacting objects within ecosystems of interacting objects, species and nonliving things (ecologically conscious).
- Designing systems of interacting objects within ecosystems of interacting objects, species and nonliving things within a global system (noncentered, globally conscious)

2.6.4. *Characteristics of Global Ecological Design*

The characteristics of global ecological design are similar to those of ecological design. Due to differences in scale, they have to address the characteristics of ecosystems, places, biomes, continents, and the planet and its environment. The courses of the global ecological design have to imitate the processes of systems and places. The wholeness of the design has to address the ideas of spirit of place, and sensory force. After the processes are identified, they have to be related to the patterns. Design may have to try shortcuts, unless it can afford to accommodate global time, which is longer than the lifetime of species or continents (See Table 264-1)

2.6.4.1. Method of Imitating Courses

Design has to identify patterns of movement and construction, and then it has to imitate the processes and patterns, modifying them to include the things of human interest and need. This is more difficult than copying a shape or a structure. Fortunately, imitation is a human strength, even if the recognition of complex, long-term, moving patterns is not. Courses can be thought about using topological and mathematical models representing a four-dimensional landscape.

2.6.4.2. Self-extension of Identity & Wholeness

Global ecological design has to capture the integrity of a set of places, or restore them as a unit. Unity is a fundamental objective of landscape design. Unity is the way the elements, including shape and scale, of a landscape are combined. For instance, visually, a forest ecosystem usually dominates the landscape. From a distance, even-aged forests have much the same impact, in terms of color, shape, and scale, as uneven-aged forests. Diversity becomes more important visually at a smaller scale. Natural forms of the forest are unified with the landscape because the margins are very uneven, and open space in the forest is part of the mosaic caused by birth and death of individual or groups of trees.

2.6.4.3. Variety Openness & Flexibility

Because the operation of the universe tends to change systems, the design of a place should be open to the types of processes that could destroy the design. Furthermore, flexibility, defined as the unused capacity for change, can be designed into the system. The parts of a system have to maintain the potential for all possible behaviors that could flow from any other part of the system. Openness and flexibility are characteristics of healthy ecosystems, and they can be considered and enhanced by design.

2.6.4.4. Cooperation in Coconstruction

Designs are limited by the real biological constraints of ecosystem processes and biogeochemical cycles. We must know the constraints in order to create a healthy design. The design has to work within the constraints of the ecosystem. Rather than emphasize static equilibrium, the design should emphasize heterogeneity and learn to adjust to disturbance.

People have needs, animals and plants have needs, the site does have constraints, and these things can be married into a good pattern. Harmony is a constraint of the whole system. Design is the participation in the process of the ecosystem as a harmonious system, with mutually restrained conflicts and constrained influences. An ecological design is a form of co-constrained construction, where the organisms, environment and designs are co-implicative, co-defining, and co-constructing. They all engage in a process of self-assembly, where the whole is the whole system.

To participate means to take part with others in some activity. Designers should participate in a complete design process, guiding involvement and commitment to the art of living together as a community. Adaptation is a process of making fit by adjusting to circumstances, environmental or cultural. Here it means fitting into a global system, within established large-scale cycles and functions. It is adaptation that improves the chances of survival for communities of species.

2.6.4.5. Loyalty Stability & Constancy

People often judge the health or wholeness of ecosystems, or the goodness of designs, by how they look. Traditional design has emphasized visual results above all else. Ecological design has achieved the same results by paying attention to the structure and function of the ecosystem. Global design has to be concerned with making balancing domesticate landscapes with wild ones. This may mean preserving, then restoring and creating, the conditions for wild ecosystems so that they are stable or constant within the processes shaping and affecting them. It may mean limiting or reconverting areas of domestic lands.

2.6.4.6. Harmony Productivity & Health

Most products of an ecosystem are produced and consumed and recycled within the ecosystem. Humans need to minimize the external inputs in the form of energy and exotic substances. The community must be restored to health. This means balancing human needs with bird or fish needs in a sustainable pattern. Ecological design is the creative modification of ecosystems to repair or enhance their ability at self-organization and maintenance of their complexity and diversity. Health is the overall ability of a system to maintain itself under a normal range of environmental conditions. Ecosystem health is one of the goals of design. The goal, of course, is not an end point reached once, but is rather a continual striving.

Responsibility is the condition of being accountable for one's actions or obligations. Here it means undertaking all aspects of a design, regardless of the expected level of success. The only example possible is the planet, with its global characteristics and systems. The very purpose of global design is to respect limits (that means not trying to always exceed them and to be cautious) and especially to keep the capital intact, to allow cycles to operate in a constant building up and tearing down. These six characteristics have to be related to other levels and dimensions, especially by global design (Table 264-1).

Table 264-1. Properties at Different Levels.

— Nature —		**— Culture —**		**— Domiture —**	
Field	*Ecosystems*	*Place*	*Culture*	*Good Places*	*Good Society*
Motion Process	Course	Dynamic Change	Conduct	Action	**Method**
Autopoesis	Identity	Self-making	Wholeness	Individuality	**Self-extension**
Differentiation	Diversity	Uniqueness	Flexibility	Richness	**Variety**
Integration	Construction	Integration Investment	Adaptation	Conviviality	**Cooperation**
Constancy	Stability	Regularity	Endurance	Consistency	**Loyalty**
Development	Productivity	Renewal	Vitality	Health	**Harmony**

For instance, productivity at the ecosystem level promotes vitality in cultures and harmony in good designs in good societies, which are embedded in human places, which are embedded in ecosystems. And, diversity at the ecosystem level promotes flexibility at the cultural level and variety in good design in good societies.

2.6.5. *Principles of Global Ecological Design*

Principles of global ecological design reflect the differences between local and global systems. Principles, as fundamental rules, cannot be reduced to other principles, because they emerge from earlier ones and they expand into new forms. This expansion is why we cannot fit them back into the old can of old principles. These design principles are based on basic principles of nature, such as the principle of change. Nature is in flux, culture is in flux, everything is in flux. The climate will change, the shorelines will change. Human understanding and behavior is changing. But, nature is also self-regulating. This is the principle of self-regulation.

Nature has evolved to maintain its stability in the face of many kinds of disturbances from planetesimal impacts to changes in atmospheric composition. Nature will continue to regulate itself even as human beings make dramatic changes. The danger is not so much that nature will collapse, as that humanity will lose those things that it values the most, from cool air to wilderness. Ecosystem ideas can be formulated into principles that can be used for designing and building cities: Centering, timing, and connectedness to global cycles.

2.6.5.1. Global Ecological Principles

Principles of global ecology, such as stability, have to contribute to the design of landscapes because those landscapes have derivative principles, or maybe emergent principles. Principles must be flexible to mirror the flexibility of open systems; flexibility is provided by diversity in fact. Many global principles are similar to ecological principles, such as: The Principles of Being Flow, Separation, Growth, Self-regulation, Error, and Pattern. Other principles either emerge at the planetary level or become more important at that level, such as the Principle of Wholeness, which states that a whole emerges from the interactions of parts and that whole is more than the total number of parts.

Wholeness is a characteristic of the field of nature and of the planet. The whole is the environment of all parts. The parts cannot survive without the whole. Although the whole can survive without many parts, it is reduced in terms of completeness or resolution with the loss of any part. A whole is an organized system of subwholes. Each subwhole behaves as a whole to its components, as a self-contained whole, and as a dependent part in context. These subwholes, or holons as Arthur Koestler calls them, are stable in a hierarchy that displays rule-governed behavior and structural Gestalt constancy.

These principles, whether we accept or deny their applicability, influence our interactions with global patterns, cycles, and biomes. They influence our objectives, our standards, and our operations. The interplay of these principles with examples and exceptions will refine our approach to and understanding of global patterns. This is part of the process of living with and understanding global patterns. These principles are not a final presentation of a limited number. They are meant to be questioned, discarded, or expanded. You can help with that. From a limited set of principles, we can distill a definite set of standards and behaviors, for example: (1) Work within the scale and duration of the planet. Processes like long-term succession can be assisted, slowed, or speeded up, but not skipped or ignored. (2) Understand the patterns and connections. Make sure they are not broken.

2.6.5.2. Global Ecological Design Principles

Global ecological design principles emerge from knowledge of ecological principles. They must combine the constraints of ecology with the ascendant sensitivity of design.

2.6.5.2.1. The Principle of Spirit of the Planet: Act as if the Planet is Alive

The spirit of each place is unique. Place is not just location; it is the total sum of objects in the landscape combined into a unique whole. Every place has certain characteristics that enforce the spirit of place, for instance, a strong definition of place or indicators of great diversity. A sense of wildness and water also contribute greatly to the spirit of place. Each place expresses a unique combination of elements, including contrasts, dramatic features, and the presence of water. Design can work to be consistent with the recognized spirit of place. If the design recognizes this aspect of the landscape, it may be stimulated by the spirit of it and may further enhance it.

The identity of place often leads to human identity, thus people call themselves by their place names. The more unique a place the stronger the emotional attachment of the inhabitants. One of the goals of global ecological designs is to relink people with regional and global cycles that support specific places. Identity with the planet allows people to save all the planet, not just the beautiful places and the charismatic species, but the whole planet, with hurricanes, droughts, parasites, and viruses.

2.6.5.2.2. The Principle of Sensory Force: Use Every Sense to Appreciate Life

Visual force is a psychological interpretation of perceived power in a landscape. As a principle, it is embodied in psychology, art, graphic design, and architecture. The human mind responds to visual force in predictable and dynamic ways, for instance, where lines in landscapes draw the eye down convex slopes and up concave ones—the strength depending on the scale and irregularity of the landform.

The effect of any landscape is not completely visual, however. Smell, sound, touch, and even taste play a large part of our appreciation of them. Crawling—which is highly recommended by Gary Snyder—climbing, listening, and tasting things, such as soil, bark, or lichen, can expand our perception of other aspects of an ecosystem.

2.6.5.2.3. Principle of Valuation: Everything has Value to Itself or Someone

All beings have value in themselves (what is called intrinsic value in the Platform of Deep Ecology). These values are independent of the usefulness of the nonhuman world for human purposes. Life includes individuals, species, populations, habitats, and all human and nonhuman cultures. Like Deep Ecology, global ecological design expresses deep concern and respect for cultures, as well as for the well-being and flourishing of all life.

There are different ways to maximize value, according to John B. Cobb, Jr. One can act to maximize value for yourself at all times (this is selfishness); one can act to maximize value for yourself in the future (also called prudence); or, you can act to maximize value for all humans for the indefinite future (the greatest good for the greatest number). Cobb points out that these three ways are unstable and unacceptable. That leaves the final principle, which he suggests is to act to maximize value in general (the process view). This implies that the value of ecosystems and global cycles would also be maximized. But, should value be maximized? Would not that contradict a principle of limited good (that desired things only ever exist in limited quantities)? After all, nature contains good and bad (both human judgments, of course). Perhaps we should aim for satisficing value, rather than a maximum or an optimum.

2.6.5.2.4. Principle of Preservation: Do not Take Everything for Human Use

Focus on what to leave, not on what to take. Ecologically responsible design leaves fully functioning systems at all spatial scales through time. In other words, ecologically responsible design identifies the parts of systems, local, regional and global, that must be protected to maintain short- and long-term system functioning, and then determines what can be safely removed for human uses.

These systems must include large wild systems or wild areas, undominated by human processes, required to keep bioregional and global cycles operating, as well as for homes for ultrahuman species. This preservation of natural processes must transcend any economic, spiritual, or aesthetic needs. Preservation is essential for survival and self-preservation. Principles of preservation and protection suggest important standards, such as saving an optimum amount of habitat for the largest indicator species, limiting the use of species to a percentage of regeneration, or reducing the use of materials to natural rates of production.

2.6.5.2.5. Precautionary Principle: When Harm is Possible, Take Appropriate Action

We should adopt a precautionary principle, which asserts that, if harm is threatened, and if there is uncertainty about the seriousness of the harm, then precautionary actions must be taken. Since the 1970s, in fact, this principle has been incorporated into Swedish and German environmental laws. This principle means that not doing something, "benign neglect," becomes a valid management option. Carl Walters suggests that inaction is an inappropriate alternative to gambling as a result of confusion, but inaction is a very appropriate alternative in the face of confusion—when in doubt about any large complex global system, we should not interfere. As appropriate alternatives, both inaction and action can be suggested by theory.

2.6.5.3. *Actions from Principles*

Principles must be flexible to mirror the flexibility of open systems; flexibility is provided by diversity and redundancy. These principles also result in a further qualification of standards and behaviors.

2.6.5.3.1. Protect Diversity

Ensure that all plans and activities protect, maintain, and, where necessary, restore biological, ecological, and planetary diversity, from genetic, species, and community diversity to large cycle and pattern diversity. Protection and, where necessary, restoration of all types of biological diversity, is necessary to sustain life in wild ecosystems. Protecting genetic diversity means ensuring that viable natural gene pools are restored to the site following human use. Protecting species diversity means that viable natural populations of plants, animals, and microorganisms are maintained or restored, in previously degraded areas, throughout the various successional phases for each ecosystem type within a wild landscape. Protecting community diversity means maintaining or restoring, in previously degraded areas, the variety of ecosystem types that result from natural disturbances at a variety of scales through short and long time frames in a landscape. Biological diversity must not be viewed as a frill or luxury. Ecologically responsible designers understand that Protecting natural biological diversity is an absolute requirement to ensure maintaining fully functioning ecosystems.

Ecosystem connectivity is maintained, in large part, by ensuring the protection of water movement patterns. This includes microscopic water movement patterns in the soil and in riparian ecosystems, from ephemeral streams and small wetlands to large river systems and wetland complexes. Connectivity is also maintained in ecosystems by protecting and, where necessary, restoring the full range of composition and structures from the large landscape level to the smallest patch.

2.6.5.3.2. Restore landscapes

Global ecological design involves solving problems with finesse and ingenuity, rather than with force. Rather than use an approach that label some parts as valuable and other parts as worthless or harmful, global ecological design uses a softer approach that tries to keep all the parts in balance. In many places in north and south America, as well as Indonesia and the Philippines, it may be necessary to restore whole watersheds and large landscapes. For example, degraded stream channels and fish habitat are often the results of timber management activities that emphasize clearcuts throughout a watershed. A stream channel cannot be restored simply by replacing missing structures in the stream channel. Instead, all parts of the landscape that contribute to the loss of structures in a stream channel must be restored along with the stream channel. Restoration should pursue the satisfactory (*satisficing* in H. Simon's words) instead of perfect maximum or even optimum.

Ecological restoration can mimic natural processes. People need to recognize that natural processes are the way that ecosystem functioning is maintained, as well as the way that ecosystems rebound following disturbances. Wild design takes patience, since many ecosystems required hundreds and thousands of years to develop, and restoration will require hundreds and thousands of years to be effective.

Ecological restoration can recognize the complexity of interrelationships. Not only is there a wide variety of plant and animal interrelationships, but also there are soil, water, atmospheric, and geological interrelationships. Each directly influences the others. Unique regional climates are related on a global scale. Any change produces a chain of effects, many of which are unpredictable or unwanted. Small changes can be more easily corrected.

Sometimes destructive land use activities have been designed by specialists and accomplished by powerful tools, using unlimited amounts of fossil-fuel energy. Whereas ecological restoration strives to involve participants and to respect traditional practices in place-based cultures. It can plan and carry out restoration activities in local contexts with local inhabitants. It can act from the bottom and restrain from the top (i.e., act locally in parallel, within the constraints from the top and design). Effective restoration requires all kinds of people with different kinds of skills. People with shovels and ideas are as important as people with machines and plans. People who live and work in local communities are the most likely to have both the commitment and the patience for effective restoration. It can cultivate feedback from the participants. It can work with errors, learn from, and allow them. Ecosystem restoration can attempt to set up a transgenerational land tenure system to accommodate wild ecosystem time, which spans human generations.

2.6.6. *Applied Global Ecological Design As Lessons from Nature*

Design can imitate nature on many levels, from structure and process to landscapes. We can imitate the structure of mature ecosystems by planting on every level of the system hierarchy, from canopy to below ground. We can use native species. We can imitate the process of forests by allowing birds, bats, and other animals the opportunity to distribute seeds and energy to other areas or to prey on "pests." We can create microclimates within the landscape that may shift the landscape in new directions. Planting trees, for instance, allows new species to become established under their protection. By doing these things within a global design, we can effect the global patterns that emerge from ecosystems. Ecosystem health is one of the goals of design, as is continuity of the global system.

The landscape provides its own metaphor for design. The landscape is a unique set of communities, a dynamic system of interacting patterns—the human pattern is a part of it now and should be preserved as part of the whole pattern, but not necessarily as the only pattern or a completely dominant one. Most products of an ecosystem are produced and consumed and recycled within the ecosystem. Humans need to minimize the external inputs in the form of energy and exotic substances. The community must be restored to health. This means balancing human needs with birds or fish needs in a self-renewing pattern. Each element in a pattern relates to others and to the whole. The global system provides its own metaphor for design, also. The global system, however, has too many untraced connections to permit direct control through a design.

Natural patterns can suggest a number of regularities that could help us to understand the design of regional systems, according to Michael Soule; and they might be useful for global systems. For instance, well-distributed species are less at risk than concentrated ones. Large blocks of habitat are safer from species extinctions. Blocks close together are more effective for exchanges than those far apart. Contiguous blocks are better than fragmented blocks. Interconnected blocks are better than isolated blocks. Corridors can make functionally larger blocks. Unfragmented blocks are better. Human disturbances similar to natural ones are more likely to be resisted or accommodated in wild systems.

These rules work well with natural processes that operate in ecosystems, such as metalysis (building up and breaking down), animal movement, interelement flows, human interactions, and shifting mosaics. For instance, forest fragmentation can be reduced through the design of forested areas, taking into account the genetic diversity of the trees, catastrophic conditions, minimum viable populations, corridors, and edge effects. The survival of organisms usually depends on one of two factors in the web of relations. These factors can be identified and modified by design.

Wild landscapes are affected by climate, soils, interactions, and disturbances. Domestic landscape is affected by land use as well. The greatest changes have been brought about by the destruction of forests. With the predominance of artificial forests, it is important to consider the qualities of naturalness in the landscape. Forests are expected to meet the needs of society by producing timber, creating wildlife habitats, and providing recreational opportunities for people. But, forests are also expected to look natural.

The values of the land and forest must be most carefully assessed. The characteristic qualities must be identified and measured for uniqueness. Comprehensive landscape plans should be required when planting or extensive felling is planned on a large scale. The patterns established at these times may persist for many years or centuries. Good global design maybe able to resolve conflicts between characteristic qualities of the landscape and the changes from use. Of course, the design should last as long as possible and should be self-sustaining.

2.6.6.1. Levels of Global Ecological Design

As a design process includes planning of ecosystems, this means now a sixth level of design—notice that after number four, all are properties of normal applications of design: (6) Planet as a whole, (5) Regions, landscapes, and watersheds (as well as airsheds), (4) The community, for instance forest, city, or corporation, (3) systems, such as ecosystems, traffic, or industrial areas, (2) products, as habitats, houses, roads, or plant sites, and (1) components, such as trees, fungus, bats, tools, rooms, cars, or land. Many problems occur at level three—more are to be expected at the new levels four, five and six.

All levels of design need to be addressed, from the conceptual to the political, and are involved in all stages of the process. This involves new challenges for ecological design, which has to:

6. Integrate a project in the global context (sixth level of design). This is the level of ocean and atmosphere, where all cycles participate in global stability.
5. Relate a project to its regional context (fifth level). This is the level of regional cycles relating to precipitation and waste recycling.
4. Relate a project to its ecosystem context (fourth level); be concerned with cultural survival, justice, and wilderness preservation, as with efficiency and aesthetics.
3. Consider the whole perspective (ecocentric, perhaps); the proper vision is of the whole. Apply ecological concepts, such as networks and carrying capacity.
2. Make designs that are anticipatory, flexible, pluralistic, polyvalent, and polytechnic. Make open guidelines for long-term decisions.
1. Essentially, work backwards from values and goals, and from the bottom up and inside out, drawing designs from the genius of place.
0. Participate in place, care for all inhabitants, and assume responsibility for the designs.

One of the shortcomings of design has been the lack of consideration of the higher levels, which can result in specific problems with safety or recycling.

2.6.6.2. Stages of Global Ecological Design

Ecological designs, at the global, regional or local level, can be applied in eight stages. These stages should be typical of all designs:

- First, decide, then create a design/management matrix, then review the situation, evaluate the ecological history of the site, observing patterns of movement, interconnectedness, population change, land use, building and development, boundaries, limits, and life. Conduct ecological and functional analyses.
- Then Inventory, record all of the resources, from physical resources to cultural resources. Survey the area and create base maps, from geological to zoological maps.
- Next, evaluate the interactions in terms of impacts, needs, goals, and limits. Assess the whole system. Delineate patterns and balance components.
- Create a series of plans, from the site plans to value plans. Integrate with biosystem

services. Kinds of integration include: Horizontal, vertical, and temporal. Consider aesthetic-perception factors.
- Start to design, which is a community process requiring the participation of all people, including the elderly, handicapped, and poor, as well those ultrahuman beings who cannot voice their concerns. Synthesize simulations and models (conceptual, capability, and suitability). Make another series of plans, from landscape plans to policy plans, within a master design.
- Implement the design together. Use appropriate measures and techniques, emphasizing native species over an adequate time period to ensure the stable processes of transformation. Create new connections. Reduce unwanted effects, such as road effects or heat island effects. Integrate into context. Optimize passive mode; integrate water, biomass, and material flows. Conserve water and energy.
- Maintain and manage design. Provide services for continuity and management. Monitor and improve constantly. Monitor, Reassess.
- Prepare undesign and disintegration

Ecological design must work within the components, structure, and function of ecosystems. Unless it does, it will not be long-lasting or satisfactory. Because design has to work with systems, whose aspects are often ambiguous, fuzzy, changing, and general, design has to be able to work with these aspects. Furthermore, the design has to work within the constraints of the larger system, sometimes the global system.

Global ecological design takes far more time than graphic or automobile design, due to the complexity, size and longevity of its subject. A number of factors have to be carefully assessed before design work starts. Wild systems require a lot of observation before activities can take place. Wild systems also can be highly reactive to change. Some people will value different characteristics of wild systems than others.

2.6.7. *Applying Global Ecological Designs to the Planet*

All design elements are related psychologically by designers, as focus or frame, as contrast or uniformity, as dominant or recessive, or in a number of other pairs. Good global ecological design means not violating any of the aforementioned principles and ideas.

Geology, climate, disturbance, and stability all produce diversity. Landscape diversity is linked to ecological diversity, which depends on diversity of the substrate. Different ecosystems introduce diversity into a landscape, but different ecosystems often can look similar. The sum of regional and local systems yields a global system with a few large patterns composed of many smaller ones. Excessive diversity on the global level could lead to confusion in a global landscape design. Increased diversity also has the effect of reducing scale, so adding diversity can be used to do reduce the scale. A high level of diversity is acceptable if one element is clearly dominant or if the differences cannot be recognized from a distance.

Process applied to components yields pattern. Nature is composed of patterns. Organisms have characteristic patterns, such as the branching of trees or the cloud forms of tree crowns. Lichens have lobes, wood grain under stress has spirals. The cracks in tree barks form nets. Patterns are not still. A circular pattern through time can be recognized as a spiral (the earth's orbit for example). The pattern should allow for surprises and discontinuities;

it can do this if it is flexible. The design of continental forests, for example, is vulnerable to surprises because nature is chaotic (unpredictable) and science itself is uncertain (by definition) about patterns of change in forests.

2.6.7.1. Global Ecological Design Management

Global ecological design is not finished with the design. The system has to be managed in some way as a result of the design. Noninterference matrix management is proposed as a technique for design management (see discussion under ecological design). An ecosystem exists as part of a matrix that has many interacting elements. Any activity in the matrix can have some effect on these elements. The whole matrix needs to be managed with the local.

Understanding of the principles of ecology can lead to better management. One critical message of ecology is that if we diminish variety in the natural world, we debase its—and our own—stability and wholeness. Many ecosystems have been simplified and degraded. Perhaps we do not have sufficient knowledge to manage a complex landscape because it is too complex to understand scientifically. But we can understand the pattern and drive it in a healthy direction with minimal intervention. We must do all that we can to restore its richness and the natural processes that created the richness.

2.6.7.2. Principles of Global Ecological Design Management

At the global level, management principles will be broader than the ecological or traditional. Two sample principles are listed below.

- Work at the Appropriate Scale of Space and Time. Scale management to the size of the pattern. At the global level, a manager will have to coordinate regional and local managers. This will involve putting limits on some regional or local actions. The design has to be a partnership at all levels. This will involve putting human wastes and human bodies back into the system. Work with global time; do not try to do everything in the two-year (or five-year) industrial schedule. Be as slow as necessary to introduce system changes. Attempt to set up a transgenerational land tenure system to accommodate ecosystem time, which spans human generations.
- Accept Management Limits. Management is limited, by costs mostly, to regulating animal and plant populations in a local system, rather than climate, geology, or water, soil, and mineral cycles—that is, global things. Manipulating plants and animals to fit the environment is more likely to succeed than the opposite. Management limits are determined by the ecological characteristics of the resources and the scales, before any economic, technological, or political limits are applied. The use must be limited by the ecology before monetary considerations.

Principles, combined with common sense and good judgment, are necessary as guides in the absence of definite knowledge. And, definite knowledge is lacking in systems, such as large natural cycles, characterized by ambiguity, uncertainty and chaos. Principles give us a broad predictive ability. For each principle, we have to ask, how will it affect our objectives for that pattern, and how will standards vary? Only afterwards can we act.

2.6.7.3. Actions from Global Ecological Design Management

Recognizing global level problems is easier than deciding on appropriate global level actions. Due to the complexity of interactions, many actions will have the opposite effects of the intended ones (similar to enantiodromia in tragic plays).

- We should work backwards from known constraints. That will make sure that actions do not produce situations dominated by runaway positive feedback. At the global level, most action involves some form of restraint on technological interference or landscape conversion.
- If in doubt, we should do nothing. It is better to not do a right thing than to decisively do a wrong thing. Natural processes have billions of years of experience recovering from small and large-scale disturbances. So, the worst possibility of doing nothing is that we will not be able to correct a situation within a human time scale, which means that many people might suffer the consequences.

Cautious actions can nudge natural processes in directions that may benefit human needs. Other cautious actions can restore broken connections or empty niches. If the management actions are slow and small-scale, in terms of actions rather than ideas and designs, then the system can do most of the work and take most of the control itself.

2.6.8. *Summary of Global Ecological Design*

Geology, climate, disturbance, and history all produce diversity. Landscape diversity is linked to ecological diversity, which depends on diversity of the substrates and historical developments. The earth itself is a complex total system.

Gyorgy Kepes compares a total system to the growth pattern of the human nervous system. The development of the brain increases the range and scope of perception, which leads to the need for a greater control within the brain to coordinate more information. The capital of perceptual knowledge offers a richer resonance to further perceptions. However, our social perceptions, with our tools of knowledge and power, are growing without any essential control. Our environmental crises occur because of the way things are made and used according to our simple, finite, isolated, noncontextual designs. Victor Papanek states that it is a design problem. Psychologists have recognized the need for diversity for people's quality of life and emotional well-being. An increase in ecological diversity would lead to an increase in diversity of the landscape. It would also tend to reduce the scale, but this would not be a problem in large landscapes.

Global ecological design is a five-dimensional, six-level, eight-stage discipline in which we describe particular actions. This level of design can help us adapt to place; keep track of everything (using ecological accounting); design with nature; and make the designs visible as art. Global ecological design has to exhibit diversity.

Global ecological design has to particular attention to emergent global phenomena, such as atmospheric gases (especially methane and CO_2), oceanic currents, and continental drift. It also has to pay attention to global human effects, such as ship, plane and auto transportation lanes, as well as communications technology, from wires and spectra to transmission lines and satellites. And, it has to pay attention to large-scale conversion processes, such as agriculture and urbanization, which change entire landscapes.

Global design can be a bottoms-up process within the limits of global constraints. To use an analogy, architects can build buildings, but the most successful ones are built within the limits of gravity and entropy, as well as within human psychological and social limits. Design has to have the courage or influence to limit production, reduce use, or even reduce human populations and use rates if necessary. It has to do this to integrate the systems in a global pattern.

In order to accomplish a global ecological design, we have to include the spheres of human cultures and global processes. Without a modest redesign of cultures, any actions to balance global designs may fail as cultures focus on immediate local needs, without regard for atmospheric and oceanic cycles, at the least. The totality of human experience and its institutional systems needs to be tweaked. Cultures need to become aware of specific purposes and meanings to become viable as participants in global actions. Cultures have been a form of unconscious self-organization, a shared experiential system communicated between generations. But, they have to incorporate large forms of design, now.

We may not want to think of design as the conscious creation of the planet, which is self-organizing, although design may contribute to the creation of a more encompassing image of the planet (literally a world as human-image). Perhaps that image would be of a 'garden,' as Bertrand de Jouvenel suggested. And, certainly human measure is important—it may be the only way we can measure—but, the system is being built on a wild planet, and it supports all human activities with aesthetics and services.

In designing the planet, it is important to design a frame that allows natural processes that are only integrated with artificial processes through larger natural cycles. In this sense we are not concerned with the design of a product or a structure, but a living constraint on natural and artificial systems. In this sense the design is to restore broken linkages, that is, to recreate what was interfered with, to restore the system with native parts or with equivalent niche-makers, and to reduce the interference of human activities.

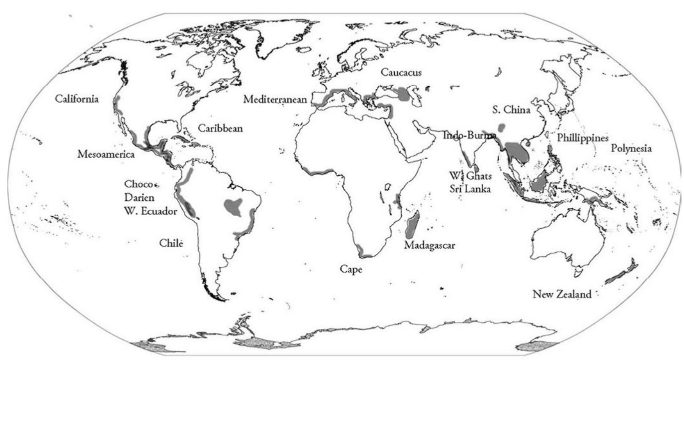

Figure 877-5.
Global Hotspots
for Diversity

2.7. *Fitting Local & Regional Designs*

Global designs are not going to work unless there are hooks at the local and regional scales to allow or to facilitate the designs. If an international organization tries to enforce a top-down decision model for everything, then local and regional decisions will be much more difficult. The challenge then is to start with global decisions and try to reach them based on local or regional actions that are necessary for the continued health of the global systems.

2.7.1. *The Global Emerges from & Constrains Local & Regional Systems*

The planet originated as an aggregation of small pieces, within gravitational and electro-dynamic constraints. Any local system seemed to resemble any other local system. At a point in its growth, the scale of the aggregation changed its interior and exterior conditions. The interior heated sufficiently to change the state of iron and nickel. Regions divided into separate spheres characterized by specific temperatures and pressures.

The sphere that was the molten center of the planet kept the heavier, hotter matter in the core. That part of the planet was not free to interact with the surface. The types of regions constrained their local systems so that they no longer interact outside the system.

Global systems emerge from local and regional ecosystems, from their properties and constraints. Other principles either emerge at the planetary level or become more important at that level, such as the Principle of Wholeness, which states that a whole emerges from the interactions of parts and that whole is more than the total number of parts.

The emergence of water from rock and from volcanic action created a global pool of water. The emergence of gases from the surface created a global envelope of gases. These pools then acted as constraints on regional systems in the planet. The suboceanic realm permitted anaerobic bacteria to thrive, as well as plants that could exploit shallow zones for light and animals that could use dissolved oxygen. The atmosphere limited most life to water, at first. As waste products, such as oxygen and methane, joined the atmosphere and built up, the scale of that change pushed the regional and global systems to change. Oxygen for instance, interacted with ultraviolet light, creating ozone molecules under those circumstances; this reduced the ultraviolet radiation reaching the surface of land and water, and allowed living forms to exploit the surfaces, especially terrestrial ones.

Global systems constrain regional systems as a result of the composition, action and movement of the planet. Global phenomena, such as atmospheric gases, can impose restraints on local systems, especially regarding carbon dioxide or fires.

2.7.2. *Are Global Designs Ever Independent of Local or Regional Designs?*

Because of the dynamics of the planet at least, local systems are not independent of the regional systems in which they are contained, as regional systems themselves are pushed by global flow patterns into distinct states with various degrees of temperature and moisture. Regional designs are never independent of global designs. Scale-linking occurs with processes at different levels, such as evaporation. In a sense, no regional system can ever be completely independent of the surrounding system, planet, or solar system.

2.7.3. *Leaving Hooks & Flexibility through Design*

Global designs can leave hooks and have the flexibility to link to local and regional levels. All the constraints of a system can influence or limit design. Harmony, of course, is a constraint on the whole system. The design imposes constraints on the system, but if it is flexible, it can be altered if the system is affected negatively. Some constraints, for instance, on technological interference, have to be top-down. Flexibility, defined as the unused capacity for change, can be designed into the system. The parts of a system have to maintain the potential for many possible behaviors that could flow from any other part of the system. Although there is quite a bit of flexibility for local orders, at the global scale it would be better to keep flows in dynamic equilibria. Diversity at the ecosystem level promotes flexibility at higher levels.

No local life form has had to consider the regional or global effects of its accumulated exploitations and wastes. Changes in interactions or scale happened or did not happen. Some local forms, such as bacteria, became ubiquitous within the global system. Humanity, however, has slowly, as individuals and small groups, become aware of the regional and global consequences of its wide-spread habitation, transformations and waste generation. As human designs, especially of transportation networks, waste disposal and habitations, have grown larger, people have recognized that the consequences have become negative and damaging.

A dynamic system can often reach a threshold or tipping point, beyond which the system enters a new stable state or an unstable state. A threshold is a beginning point, when perceived. A tipping point is a turning point. The action that precipitates change is often called a trigger. A trigger is a mechanism that activates a release of information or energy (or an immediate change in scale). A trigger is also a small impulse that can release the stored energy of a larger impulse; it is a form of energy amplification. The changes triggered can be much larger than the expected results. Past triggers can be recognized in the shift from the Ice Age to an interglacial warm era. For example, the extinctions of woolly mammoths, subarctic horses and other megaherbivores, as a result of factors from climate change to overhunting, triggered the shift to less palatable plant communities after cropping stopped renewing vegetation. Human-generated fires triggered land conversion. Domestication triggered differences in animal behaviors, shapes and requirements. Fossil fuel use triggered waste, speed and atmospheric changes. We have been transforming the planet for 12,000 years. We choose what plants grow where. We grab minerals, redirect water, and spread wastes.

External disturbances such as asteroid impacts or basalt eruptions have triggered significant transitions between different states. However, most transitions appear to have been generated internally with evolutionary change or innovation playing a role. There are many further considerations of the planet as a dynamic system: To what extent is the Earth system self-regulating? What is the contribution of life to maintaining habitable conditions? In what sense can the planet itself be said to evolve or fit its environment? Are there reasons to explain why regulatory feedback should predominate at the global scale?

There are many kinds of physical, biological, psychological or cultural triggers. A crisis can be triggered by a change in scale. A trigger can have connections to a global system. A trigger often creates positive feedback, causing dramatic amplification (See Section 17326 for a further discussion). The novelty and complexity of interactions of innovations can lead to thresholds that are tipping points, triggering punctuations in the functioning of the system with consequences that can surprise humans.

Is there a way that abrupt changes in the operation of the system can be anticipated and predicted? Can we identify the changes that are most susceptible to triggering by human activity? Many aspects of system dynamics are believed to exhibit multiple equilibrium states, and therefore may display abrupt transitions between equilibria. For instance, there is evidence for a transition from a green to an arid Sahara in the mid-Holocene, 5500 years ago.

We admit that design and its effects can have local, regional and global consequences from slums to the destruction of regional forests and to atmospheric change. That means that all designs are going to have to be studied for fitness with other scales. No global design to change atmospheric temperature should be tried without understanding the regional consequences of shifts in wind and moisture patterns that could destroy rainforests or agricultural fields. No design of pest control should be considered without understanding its consequences in poisons spreading through regional food chains. No design to restore the regional Sahara to forests should be considered without understanding the local consequences to endemic vegetation and local adapted cultures, as well as to global wind patterns.

Design has to leave sufficient hooks to respond to triggers and changes. A hook catches something due to its design, or connects the parts. Regional designs can leave hooks for local design to respond to changes. All the constraints of a system can influence or limit design. Harmony, of course, is a constraint on the whole system. The design imposes constraints on the system, but if it is flexible, it can be altered if the system is affected negatively. Some constraints, for instance, on technological interference, have to be top-down. Flexibility, defined as the unused capacity for change, can be designed into the system. The parts of a system have to maintain the potential for many possible behaviors that could flow from any other part of the system. Although there is quite a bit of flexibility for local orders, at the global scale it would be better to keep flows in dynamic equilibria. Diversity at the ecosystem level promotes flexibility at higher landscape or regional levels.

Globalization as a general trend is triggering a profound shift in human consciousness. First by forcing us to realize we cannot do anything that we want, and next that cultural differences are less important than what is held in common. Human societies, like climate, are open systems that have chaotic and complex dynamics. Recognizing that our industrial civilization is a dynamic social system that can evolve or devolve may be the key to managing its changes. At the same time our civilization has become unstable, we are acquiring the ability to design living systems. Buckminster Fuller said that to change something you have to build a new model that makes the existing model obsolete; do not bother fighting the existing reality.

Joseph Tainter notices that while converging stresses can result from disparate developments, such as a harvest failure at the same time as the invasion, they are often caused by cascading crises, for instance, when a harvest failure causes famine which then triggers a rebellion or the invasion of some other society. This whole idea of cascading stresses is very important in understanding many collapses such as the Mayan or Ik.

Thus, there may be multiple triggers or cascading triggers. Autocatalytic loops keep self-organizing structures going. A trigger of one energy form sets off flow in another, which can trigger the release of another flow in the first, and possibly a chain of trigger/flow interactions.

Triggers can also be hot or cold, depending on the lag time between the trigger and the effect. Culturally, B.J. Fogg says that Facebook puts hot triggers in our path. The opportunity triggers our behaviors. Some behavior requires a trigger, although it can part of the path also.

Cold triggers require later action, after a lag time. The goal with Facebook is connecting to people. Connection is important. Facebook and other interactive systems provide motivators, such as fear, hope or the desire to belong, for behavioral change. Change, however, has to be a satisficing amount to be immediate and effective, not maximal or optimal, which even if possible would require longer lag times.

Ecological design needs to make hot triggers, that is, the actions have to be immediate: Saving kilowatts, planting grasses or food, or lowering the thermostat. We claim the ability now to geo-engineer the planet with large-scale ideas and projects. Even so, there are alternate ways of intentionally reforming the planet: An easy engineering way or a more difficult way of ecological design. If we experiment with engineering ways, we might want to localize the effects, by keeping the change to as few systems as possible, maybe in the southern or northern hemisphere only. For instance, gassing with sulfur dioxide might have drawbacks: Acid rain, and shifting plant, animal and bird life. It might trigger uneven shifts. We rely on technology to 'change the game,' but we can change the game without involving more technology, or more than we have now, by choosing ecological designs that incorporate conservation and frugality as well as a technical design.

Ecological design requires the understanding of properties and principles that emerge from the local and regional levels; some regional properties cannot be understood without knowing global history. Global ecological design also requires a higher level of design, which relates everything into a global context; this is the level of global spheres, such as the lithosphere and atmosphere. And global design has to be unique to this level.

Figure 271-1. Sketch of Partial Northern Hemisphere Wolf Paths.

2.8. *Insurmountable Problems at the Global Level*

Civilizations have experienced problems that seemed insurmountable—at the least because those civilizations subsequently collapsed and disappeared. Many of the problems with civilizations are structural, logistical, or spiritual. Economic decline can lead to stagnation, disease and collapse. Many problems have to do with political power distribution, especially if related to the desire to conquer, control, and homogenize other cultures through war (and now the threat of nuclear war with nuclear winter). Over-administration has its own seemingly limitless costs that can lead to collapse. Imbalance as a general condition can lead to collapse. Some of these problems could have been solved or possibly had been solved for a time.

Urban problems, and some national and regional problems, seem insurmountable. Some problems, the largest ones such as earthquakes and tsunamis, are the result of global phenomena and seem insurmountable. The dedication of the legal system to human activities and ignorance of the context of plants, animals, and ecosystems seems insurmountable. The problems listed below, having to do with water, heat, crime and structural maintenance, seem to be insurmountable for any civilization, industrial or ecological.

2.8.1. *Water & Drought*

Water has been a problem in many civilizations, from Mesopotamian and Indian to Chinese and American. The changes in wind and rainfall patterns or river beds have resulted in drought. In Mesopotamia, for instance, cities compensated for declining rainfall by irrigating wheat and barley with canals. But that lead to salt retention in the soils. By 3500 BCE wheat and barley crops were equal. Wheat can tolerate salt at only 0.5% in the soil, but barley can take twice that. By 2500 BCE wheat had fallen to 15% of the crop, although overall crop yields were still high, then to less than 2% by 2100 BCE. By 1700 BCE no wheat at all was grown. Overall yields fell 42% between 2400 and 2100 BCE, and by 65% by 1700 BCE. It was written that the earth was white with salt. After much intensification, the land collapsed. Many of these things are long-term problems and do not become evident for several generations. They are also very difficult to reverse. For a society that needs surpluses to continue, with growing numbers of dependents and domestic animals, there is little flexibility to change. The only way to solve the problems was to let the land be fallow for long periods until the water table fell. This alternative was impossible due to food demands.

When cities started to fail, as a result of attacks or droughts, people were able to emigrate. Many returned to herding, or when possible, hunting and gathering. For thousands of years, starting possibly 11,000 years before the present, people participated in a cycle of emigration to rural areas when time were bad and immigration back into cities when the ecosystems recovered and could be made productive again.

In complex, self-regulating systems very small changes can have large consequences. In some cases, where conditions like drought are cyclic, in the Sahel region of Africa, humans expand during the good times, only to perish when the drought returns. In other cases, human activities, such as deforestation or the overgrazing of herds, can cause weather changes. The scale and rate of changes allows people to view the situation as natural, but once these catastrophes pass a threshold, the people and their cultures have been trapped by their demands, and only severe reduction or collapse can allow the system to regenerate.

Drought has been a major urban or rural problem. Even cities that have been located on rivers have been destroyed by long droughts (usually over ten years). Fresh water has become an intractable problem in the past 50 years, as more aquifers have been drained and more water sources are used for industrial purposes, such as cooling or washing away wastes. Areas of the Americas and Asia still rely on irrigation, and people steadfastly ignore the warning signs of drought and collapse.

These long droughts seem to be caused by changes in circulation patterns on a global scale. Many of these changes are the result of variations in the planet's orbit or the solar output. It is unlikely that these can be controlled by human efforts.

2.8.2. *Heat & Control*

Life can be described in terms of heat differences, as well as of order and disorder. The process of ordering is like a river that flows uphill, but it creates a more massive downhill flow. Heat is necessary for indoor comfort in cold climates, but it usually comes from burning fuel. When the entire environment enters a higher heat regime, then people either adapt or emigrate. Our current form of adaptation is cooling the air in buildings by burning fossil fuels.

Individuals and groups desire to control the environment or specific events in it. Personal control is not only integral to the concept of health, but it is crucial to health. People in dependent situations, such as the elderly in rest homes, live longer if they feel they have some control. However, when it comes to large-scale temperature changes, we do not seem to have control. Living in hot climates has always limited the number of plants and animals, as well as humans. Controlling the climate has not been possible with spiritual or technological techniques. Control of the environment on any but the very smallest scales has not been possible.

Heuristics, habits and shared illusions can become shortcuts for understanding data and making judgments, but they can lead to systematic errors and biases, according to L. Mlodinow. Biases play an important role in decision-making, especially when related to kin or groups. When we have an illusion or bias, then we regularly interpret data to support it, rather than to disprove it—even actively seeking evidence to support it, for instance, whether it is for or against global warming. Even if we recognize the patterns, many of them are caused by global changes, resulting from solar output, orbital variations or unpredictable collisions with bolides, again out of our control for the most part.

Even if we become efficient at recognizing patterns, we might neglect to assess them critically. We need to act critically on uncertainty and incomplete patterns. We can improve decision-making by understanding biases and illusions, and, by understanding that we cannot control every circumstance or avoid every unpredictable event or catastrophe. But, we can recognize negative patterns and plan for them, i.e., have a framework for making decisions about them. We can recognize irrationality and unpredictability in our behavior, and try to correct it.

2.8.3. *Liberty & Crime*
People like being free to do whatever they want, but they also like being secure or protected. Usually the two conditions do not occur together in one political system. Even in a favored political system, crime and civic unrest do not disappear. Dangerous weapons, from automatic guns to tanks and dangerous products, including land mines and biocides, are available to anyone to misuse. They are not adequately regulated. Some people cheat or monopolize certain resources or services, resulting in great wealth for themselves and great costs to others. One law that Adolphe Quetelet described in his social physics was that vast inequities in wealth were responsible for social unrest and crime. Large economic institutions have made inequities worse, but large society has explained it away as the cost of liberty.

Too much liberty is often the absence of agreed-upon cultural limitations. Too little liberty results in as many problems as too much. Too much division in a society, especially as regards material goods or luxuries, can result in crime as the best perceived way of leveling differences. Extreme political views are divisive in a society not bound by minimum standards of behavior, especially regarding honesty or responsibility. There are social controls on crime, including shame, which requires a smaller community where all people are known, and threats of punishment through laws, but shame is scale dependent, and only effective in small scale communities; laws are only effective if they are enforced at a large scale.

If humanity becomes a global phenomenon, it is questionable that we can control ourselves, even with laws and morals. Statistically, human activity has always been described as random motion, uncontrollable. Human intentions and goals have not been able to direct human activities towards a firm global goal of balancing liberty and crime. People will choose to act badly sometimes. If a form of government acts badly or is ineffective, people can alter it. They can learn from mistakes. If the scale is small, the injustice may be small and fixable.

2.8.4. *The Maintenance of Civilization*
In an ecosystem, the energy required to maintain the ecosystem is inversely related to its complexity; succession decreases the flow of energy per unit biomass until the system reaches maturity (Margalef's concept of maturity). In a mature forest, for example, almost 100 percent of the energy is required to maintain the state of the forest. Any system formed by reproducing and interacting organisms must develop an assemblage in which production of entropy per unit of information is minimized, that is, waste is minimized in cycles.

The same relation seems to apply to cities or civilizations. The simplest economic transactions were between individuals who gathered food or made tools and then traded. The number of artifacts seems to have increased as the populations increased. The number of artifacts seems to have increased as the complexity of a culture increased. Materials can be used to express power. With the increase in specialization and complexity, came individual traders, then guilds, and finally corporations. A complex (or mature?) civilization at some time must use 100 percent of its energy to maintain itself.

In every case where civilization has become more complex, according to Joseph Tainter, the cost of maintaining that structure has required an ever-higher percentage of income be set aside for maintenance; that income is no longer available to increase the standards of living. Modern civilizations have avoided collapse only by overusing fossil fuels to override their true costs. Eventually, when the costs of maintenance exceed the benefits, people will rebel and the system will collapse.

2.8.5. *Pollutions: Atmospheric & Oceanic*

Humanity has only recently become aware that many of its agricultural, industrial and personal habits have been changing in scale from local effects to planetary ones. The ozone holes were discovered, and the causes were traced to manufactured chemicals containing chlorine or bromine, such as chlorofluorocarbons (CFCs) or hydrochlorofluorcarbons (HCFCs); these were used in air conditioners and in solvents. There are many more chemicals that also contribute to the problem. An agreement to end the production of many of these was signed in 1987, and has had a measurable affect on decreasing the Antarctic Hole, although it will take another 2 hundred years for the chemicals to fall out.

Although Svante Arrhenius had warned in 1896 that human activities would warm the earth by adding CO_2 to the atmosphere, it wasn't until 1955 that Gilbert Plass reached the same conclusion from new scientific evidence. By the 1970s the carbon dioxide curves plotted by Charles Keeling confirmed the annual increase—but also noted a cooling temperature for those years. By the 1980s, however, the global annual mean temperature curve started to rise, and by the late 1980s the curve began to increase so steeply that the global warming was acknowledged by most scientists. Although basic animal and human activities put CO_2 in the atmosphere, the concentrated products of agricultural and industrial processes exponentially adds more. Billions of food cattle produce massive amounts. The burning of fossil fuels in manufacturing or by driving vehicles adds more. Buildings made of concrete contribute more. The atmosphere acts as a sink for many kinds of pollution from burning fuels and garbage. At the same time, we are reducing the wild ways of fixing carbon by clearcutting forests and strip mining the ocean of all large fish. Atmospheric heating is having visible affects on land and sea ice, as glaciers shrink and disappear at monthly rates.

Rivers and the ocean have been used as dumps for hundreds of human generations. But, the industrial scale has overwhelmed the ability of riverine and oceanic systems to accept and use the pollution. Artificial chemicals and structures cannot be broken down, especially plastic, which is just ground smaller. Over 40 percent of the ocean surface, mostly in gyres or along wetland margins, is covered with billions of pounds of plastic (90% of all trash). Many forms of marine life mistake it for food and eat; many forms get tangled up in it and die, especially mammals. Although the large forms of plastic could be scooped out, at high costs, the smaller forms about 5 mm escape everything but filter feeders, who ingest them and eventually starve to death.

How can we resolve these three problems? Obviously, we could ban the worst contributors to ozone loss, CFCs and others, and we are making some progress on that, although the new substitutes are far from perfect. We could also severely reduce coal burning, even 'green' coal, and reduce driving, even in 'high-mileage' cars. Some pollution is being reduced at the stacks or with restored garbage hills, but sea-going vessels are still mostly dirty and unmonitored. Restoring forests to the land and large fish and sea mammals to the ocean could cost many billions to do. Collecting 70 years of plastics could also cost many billions, and we are reluctant to spend that much, unless it is on war or corporate profits.

3.0. Facing Nature for Design

Nature is a name we assign to a complex, dynamic planetary system. The system can be described as a set of interacting spheres—the geosphere, the atmosphere, the hydrosphere, and the biosphere, which interpenetrate and interact. The system has specific characteristics that have developed over billions of years: The atmosphere, for instance, has a unique composition, which is kept that way by the cycling processes driven by the sun and equally by a diversity of living forms living in complex, changing ecosystems. As a result of these activities and the composition, the planet has a relatively cool temperature.

The environment of the planet, that is the solar system and extrasolar space, is relatively isolated from local high gravitational influences as well as from intense radiation. However, it is also dynamic and provides many kinds of surprises and challenges, from the shifting of the planetary orbit to interstellar gas lanes and colliding space objects.

The biodiversity of species and living environments has adapted to the planet and its larger system to survive. The very slow changes from plate tectonics or climate shifts are also challenges, as are medium and large collisions with planetesimals. We tend to call these events catastrophes if a large number of species or families of species are driven to extinction. We think of them as anastrophes (positive turnings) if the environment is stable for long periods of time. Thus, life suffers mass extinctions, but responds with stable diversity.

Energy from the sun, combined with material cycles and living ecosystems, keeps the global system in a mature high-energy state. It is these ecosystems that we want to redesign to keep the cycles going. We can redesign animal patterns and wilderness patterns. We have to try, because we cannot invent wilderness from rock, nor can we drive global material cycles with a technology of nanobots and computers. The designs may have to be limited to anticipating large events and deflecting them, to limiting human use and restoring ecosystems, to shaping human impacts and managing them in partnership with nature (with benign neglect as often as possible).

3.1. *Global Design Factors: Planetary Spheres*

As a whole planet with global processes, the planet can be reduced to various spheres for analytical purposes. The planet is composed of interacting spheres that interpenetrate and overlap. We tend to think sometimes of the planet as a rock decorated with a few fluids and gases, but the ocean and atmosphere emerged early from the denser elements as a result of cooling and development. The energy from the sun and the surface environment produced complex chemicals that learned to replicate their own patterns. As these patterns reproduced on the scale of the planet, their activities and wastes influenced and drove cycles that promoted more complex forms, which further modified global states and cycles. Although we identify major spheres on the planet—the geosphere, hydrosphere, atmosphere, and biosphere—they are very much interactive and their boundaries are open and shifting. These spheres intersect and interpenetrate. The biosphere produced certain kinds of rock, and the oceans produced atmospheric effects, and the spheres influenced each other, so that we cannot say that each sphere did only one thing.

3.1.1. *Geosphere*

The solar system formed through the gravitational collapse of a dense molecular cloud. Planets aggregated in the plane of rotation of the solar nebula, as a result of collisions of large and small planetesimals. The growth of the earth was aided by several giant impacts, one of which most likely resulted in the formation of the moon. The planet continued to grow as a result of planetesimal impacts and cold dust accretion.

Impacts made the earth very hot. Metals formed a protocore. A solid inner iron-dominated core formed with a fluid overcore. As a result of these processes, a silicate mantle and then a light, floating crust formed. The mantle is a thick, flowing solid on which the oceanic and continental plates float.

3.1.1.1. Lithosphere

Heat is conducted from the core to the mantle and then through the lithosphere. Radioactive isotopes produce heat in all the levels (possibly exceeding the heat from the mantle). Of course, the surface of the earth receives heat from solar radiation, which powers most of the pyramid of life.

The planet produces three general kinds of rock. Igneous is produced by volcanic action or intense heat; gabbro is formed deep in the crust, while basalt and pumice are formed at the surface. Under water, granite and obsidian are formed. As these basic rock weathers, they become sedimentary, such as sandstone or shale or gypsum. Mixed with the content of living organisms, they become limestone, chert, or coal. When these rocks are pulled under by tectonic action, they become metamorphic, like slate, schist, gneiss, quartzite, or marble. Minerals are limited artifacts from the formation, but many of them are used as nutrients for life.

The crust of the planet is dynamic. Mountains are limited in height by the thickness of the crust (which is not a problem with Hawaii which rests below the crust). The planet started as a mixture of chemical elements (over a hundred, including hydrogen, helium, and nitrogen) circulating over an active geology, driven by solar energy.

The action of the ocean and atmosphere tends to level the surface through erosion, but crust movements tend to build mountains. The division of earth into water and land and air determines directions of evolution, or rather limits the possibilities. Plate tectonics keeps a significant portion of the planet surface above water, permitting the evolution of land and land-air based life. The changing locations and sizes of continents, from the supercontinents of Rodinia, Gondwana, and Pangea, to smaller continents like Australia and Antarctica, produce different patterns of oceanic and atmospheric circulation, and thus changing environments, that push the emergence and diversification of terrestrial plants and animals.

Intensive plate tectonic processes continue today and recycle the crust, along with organic material that has not been recycled by living organisms. This organic material is transformed into petrochemicals containing high-quality energy.

3.1.1.2. Pedosphere

Radiant energy from the sun flows around the surface of the planet, contributing to the heating and cooling, and eventual breakdown, the disintegration and alteration called weathering, of rock. Water also flows over rock, getting absorbed, trapped, stored, and released. Plant roots find purchase in the rock and absorb water, send it to the leaves, and let it transpire back into the atmosphere. Plants also emit oxygen, which is used by other organisms to burn molecules for energy. Dead plant matter forms a layer on the rock, a loose assemblage of animate and inanimate particles, where other organisms recycle residues from plants and animals. The remaining water follows the gravitational gradient to streams, aquifers and the oceans.

The soil acts as a buffer to keep water in the system longer for the use of plants and animals. This slows down erosion and flooding, and sustains the gradual constant release of water into streams. Many nutrients in the water also move downstream. Water increases the mix of mineral particles, gases and nutrients that make up the soil substrate. The soil is a medium where recycling of nutrients takes place. Soil is a living filter that mixes nutrients, dilutes pathogens and toxins, and purifies water. It is very porous and has an active surface thousands of times larger where biophysicochemical processes continuously take place.

A small amount of soil contains the living roots of plants, as well as a large community of organisms of various sizes, from microscopic to macroscopic—in fact, billions of organisms, from viruses fragments and bacteria to worms and insects. Although the soil forms a relatively thin layer, possibly less than one meter averaged across the planet, it is exceptionally active. It is strongly interconnected to the ocean and atmosphere through water. These interactions allow soil processes, such as sequestration of carbon, to contribute to the composition and properties of the atmosphere.

Soil formation is a slow process in human terms. It is gradual and progressive, as living forms collect and are decomposed. That material is churned by earthworms, insects and small animals. Eventually, several horizons are differentiated. It may take thousands of years to form a millimeter of soil. Humanity inherited incalculable soil resources that allowed the entire enterprise of agriculture. Unfortunately, agriculture tends to simplify the soil ecosystems and to allow increased erosion. Although not necessarily an unnatural process, it is amplified and accelerated by the scale of agriculture, which converts entire grasslands and forests to 'smiling fields,' by removing vegetative cover for long periods, altering the biotic community, and changing the topography and microclimates.

3.1.2. *Hydrosphere (Ocean)*

The cooling of the earth's surface allowed oceans to emerge within several million years. Vaclav Smil states that major oceans formed as early as the early Hadean era, in a hot reducing environment, and they would have been strongly stratified, with a deep anoxic bottom. Subsequent collisions with large objects may have vaporized all or part of the ocean, eventually resulting in a new ocean after condensation for a thousand years.

Water is formed under conditions where molecules of hydrogen and molecules of oxygen react, that is, their elemental bonds are broken in a chemical reaction and recombine as water, releasing energy in the process. Water has some extraordinary properties: A high boiling point, high specific heat, and high heat capacity, due to its high heat of vaporization and low viscosity. Low viscosity makes it a good medium for swimming. The heat of vaporization allows evaporation to carry large volumes of water with a large thermal energy into the atmosphere.

Core heat flow and the radiogenic decay of elements perpetually creates new oceanic lithosphere as hot magma ascends and causes crustal spreading. This heat flux, especially from ocean vents, also supports bacteria and chemotropic archaea.

There is a vertical heat exchange in the ocean, as cold dense water sinks and is replaced by warmer water flowing poleward. This happens basically in two partially independent cells in the Atlantic and Pacific. Minor changes in ocean surface temperature can affect the expansion of surface waters (such as with El Nino events).

The ocean stores over 96 percent of water on earth; it is the source of most evaporation (86%) and receives most of the precipitation (78%—the difference is that much precipitation is caused by mountain ranges and falls to earth, and there are regions such as the north Pacific that have surplus precipitation). Every other reservoir of water is limited to below two percent of the total storage, including ground water (1.688%), atmospheric (0.0009%) and biota (0.0001%) reservoirs. Evaporation is influenced by mean sea level as it changes annually, as well as during ice ages or supercontinent formation. The importance of these small reservoirs is important. For instance, water vapor in clouds covers 60% of the planet in clouds at all times, which reduces solar radiation reaching the ground. And, living organisms pump water through their leaves, which evapotranspire it to the air. Much of the fresh water (65%) on earth is in underground reservoirs and aquifers.

Water is the medium of life. It is necessary for life. It is essential for metabolism. It makes up most of living biomass by weight. Life found a way to incorporate water in its cells. Water donates its hydrogen in photosynthesis and carries the sugars to every part of the plant.

Life would be confined to pools of water, except that water is evaporated and then precipitates back to pools. Water cycles between oceans and pools to the atmosphere and through the land. This cycling allows photosynthesis to occur in land and air as well as in pools. The sun drives the cycle and the ocean dominates it. A small amount of water is stored in living beings, although evapotranspiration pushes more water vapor into the atmosphere (maybe 10%).

Water is a wonderful solvent. The basic elements of life, especially carbon, oxygen, nitrogen, and sulfur, can be transported in solution in water. The cycling of these and other nutrients keeps the biosphere functioning. These cycles are carried to some extent by the water cycle, although they are driven by plant and microbial metabolisms rather than entirely by the sun. Mineral cycles participate in the water cycle, although they are pushed by a tectonic cycle that binds or liberates them.

Although the overall productivity of the oceans is about the same levels as deserts, some areas of the ocean are as diverse and productive as tropical forests or temperate wetlands. Since the surface area of oceans far exceeds that of deserts, the contribution of the ocean is far greater. Life in the ocean is limited by physical factors, from the abundance of nutrients to light, gas, and salt. The ocean has effects on the erosion of land as well as on the amount of water in air and the circulation of the atmosphere.

3.1.3. *Atmosphere*

The atmosphere is composed of gases, mostly nitrogen and oxygen, with argon and traces of others gases and particles. The first atmosphere was thought to be Argon and other inert elements. Continued development added CO_2, H_2O and N_2, which would create a weak reducing atmosphere. After life there was more ammonia and methane (from the anaerobic decay of biomass), which would have contributed to a strongly reducing atmosphere. CO_2 would have been reduced from 1000 times current to 100 times current levels by 2.5

billion years ago. At the same time, there was burial of organic carbon as a result of tectonic movements. After that the oxygen content rose from the activities of phytoplankton. The rise in atmospheric oxygen to 5-18% of current level is considered to have triggered the evolution of animals.

The atmosphere is the place of gaseous cycles, such as water vapor, oxygen, and nitrogen. Changes in the atmosphere is driven by solar energy. This is one reason why the atmosphere is so dynamic; The distribution of heat drives very rapid circulation patterns, much faster than oceanic or terrestrial changes. The composition of the atmosphere creates a greenhouse effect that traps solar energy.

3.1.3.1. Anatomy of the Atmosphere

The atmosphere stratifies at different densities. The temperature profile is not monotonic; in fact the temperature decreases into the tropopause, but then starts increasing to the stratopause, where it starts decreasing again until after the mesopause, it increases to over 100 degrees Centigrade.

Nitrogen comprises the bulk of the atmosphere (approximately 78%). Nitrogen is the one element found almost entirely in the atmosphere—there's very little on land or in the sea. Nitrogen cycles slowly through the earth. A molecule of nitrogen gas is made up of two atoms very tightly bound together. It takes tremendous amounts of energy, such as produced by lightning or fires, to break the bond. Nitrogen is a key element in proteins and nucleic acids and so is essential to life. But, if nitrogen is not available in a usable form, living beings and ecosystems would fail to thrive. There are bacterial species that specialize in taking nitrogen from the air and converting nitrogen into different usable forms. This conversion is difficult due to the high stability of gaseous nitrogen. These bacteria also release nitrogen from organic material back into the atmosphere, where it is once again available for fixation. Some bacteria carry out denitrification under anaerobic conditions.

Oxygen is found in the atmosphere at a stable concentration (approximately 21%). Because it is a very reactive element, it can quickly combine with other elements and disappear from the atmosphere. Yet it persists, and in high concentration. It is the cycling of oxygen through photosynthesis and respiration that accounts for its presence and stability. A world without cycles, without life, would retain little if any oxygen in its atmosphere. Some atmospheric oxygen is bumped high into the upper reaches of the atmosphere, the stratosphere, where it is converted into a new compound, ozone, in a series of reactions powered by solar radiation. Ozone absorbs ultraviolet (UV) radiation from the sun, which has the effect of protecting many life forms from damage. Ozone molecules unform and reform, as they are carried around the upper atmosphere. The formation and destruction of ozone by various reactions have been in equilibrium for hundreds of millions of years.

3.1.3.2. Physiology of the Atmosphere

Microorganisms, such as viruses, bacteria, fungi, spores, and pollens, may be carried high in the atmosphere, before returning to lower and more comfortable levels to reproduce. Many do not survive the temperatures or the UV radiation. Some forms are resistant to UV-rays, X-rays, and gamma rays. They can exist on their own or in aggregations. Birds and insects frequent the atmosphere for movement and hunting, although most travel and hunting occurs at low altitudes. Migratory birds (and a few insects) hit higher altitudes, which allow higher flight speeds.

Living ocean and land processes contribute to the composition of the atmosphere. For instance, sedimentation of a small fraction of the biomass removed carbon from, and released oxygen to, the atmosphere. This biomass formed large deposits of hydrocarbons that were cooked and distilled to forms of gas, coal, and oil. The process of biomineralization put carbon, calcium and phosphorus into great volumes of sediments that were elevated by tectonics to form large mountain ranges.

The atmosphere, through reflection, can limit the amount of solar radiation received. Living organisms can change the content of the atmosphere, especially in terms of water vapor, nitrogen, and oxygen.

3.1.4. *Biosphere*

Vladimir Vernadsky developed the idea of the biosphere, expanding and refining the term from Eduard Suess. Vernadsky pointed out that none of the works in geology treated the biosphere as a whole. The biosphere is the network of living organisms as they live in groups and patterns. Vaclav Smil notes that the atmosphere, hydrosphere and planetary crust are defined by obvious physical discontinuities, but that living organisms have invaded and further connected all three. He also notes that the boundaries are moveable and interpenetrating. In the atmosphere, microorganisms can be found throughout the troposphere and in the stratosphere (50 km in vertical distance). Birds can also fly to impressive heights (5-9 km). In the oceans, the entire water column (to over 10 km) has eukaryotic organisms, such as fish and whales, as well as viruses and prokaryotes. Hydrothermal vents host ecosystems on the ocean floor, where some organisms can tolerate high water temperatures. Some microorganisms and insects can be active in temperatures below freezing. In the land surface, soil-forming organisms work in the first 20-30 meters; Smil suggests that the extent might be as far in as 7 kilometers. Viruses extend the reach of the biosphere. Cryobiotic forms also extend it. And, autrophic ecosystems near thermic vents, without sunlight or chlorophyll, are energized by the oxidization of sulfides.

In general, without knowing an exact path, life seemed to have risen out of self-defining processes. Christian de Duve suggests that life began from a ‘protometabolism,’ after short polypeptides were formed from thioesters of amino acids in more acidic water (in volcanic lakes or near hydrothermal vents). A high-energy thioester bond may have cycled to form cells or RNA. Perhaps the origin was cold, however, and life formed on a metallic substrate under different conditions, based on inorganic nutrition and progressing to photosynthesis and organic matter. Smil notes that we know that the earliest organisms were prokaryotic, anaerobic, and tolerant of ultraviolet fluxes and planetesimal collisions. Many early living forms were cyanobacteria, which survived in extremes of salinity, acidity, extreme temperatures, desiccation, radiation, and low oxygen. Other Archean microorganisms were methanogens and sulfate-reducing bacteria.

Bacteria dominated the planet up to 1.8 billion years ago, when the first eukaryotic micro-algae formed. Bacteria still dominates in terms of biomass. Eukaryotes became short-lived specialists, rather than slowly-evolving generalists. Vernadsky concluded that life forms an indivisible and indissoluble whole, where the parts are interconnected with living beings as well as with the environment. The total biomass grows and shrinks, depending on the global environment, on seasonal cycles, and on long-term cycles and changes.

Living organisms drive global cycles of nutrients and elements. These cycles provides elements and nutrients to living organisms, including humans. Furthermore, some atmospheric gases are biogenically formed, especially oxygen. Life produces sulfides and binds calcium. The elements circulate in the biosphere in regular, more or less circular paths called biogeochemical cycles. The movements of the chemical elements necessary for life are referred to as nutrient cycles.

Human beings have started to evaluate these 'free' services' of cycles and biomass in monetary terms. Regarding ecological services, the biosphere can supply resources, as well as absorb wastes (materials and emissions), however, it is limited by amounts and rates. As George Woodwell (1976) put it, humans live as "one species in a biosphere whose essential qualities are determined by other species." Humans have metamorphosed with a technosphere, increasing its effects on some of the qualities of the biosphere. Perhaps this is how a biosphere reproduces itself, at the end of a chain of metamorphoses, leading to an artificial satellite or nearby planet.

3.1.5. *The Face of Gaia in the Mirror of Humanity*

Many religions regarded the earth as a god or goddess, and many of other phenomena, from lightning to wind, as gods as well. As gods became more universal the earth became an artifact made by a god. As societies became more secular, the earth became the outcome of natural processes. Yet, when modern ecology strives to think of the planet dynamically and holistically, it returns to personification. James Lovelock, to identify a collective global 'mind' immanent in the cybernetic structure of the global system, used the suggestion of William Golding to call it Gaia, after the Greek earth goddess. Nature was to be recognized as active, resilient and powerful—as Gaia.

3.1.5.1. The Gaia Hypothesis & Theory

James Lovelock and Lynn Margulis put forward a hypothesis that the planet exerts a living control of the atmospheric and hydrologic processes to maintain minimum conditions for life over long periods of time. The hypothesis (which can be disproved, but never proved) notes the phenomena to be explained: environmental natural regulation, atmospheric and oceanic homeostasis. Lovelock states: "It appeared to us that the Earth's biosphere was able to control at least the temperature of the Earth's surface and the composition of the atmosphere. ... This led us to the formation of the proposition that living matter, the air, the oceans, the land surfaces were parts of a giant system which was able to control temperature, the composition of the air and sea, the pH of the soil and so on, so as to be optimum for the survival of the biosphere. The system seemed to exhibit the behavior of a single organism, even a living creature."

Lovelock hypothesizes that every element in the system is related in a feedback network to every other element. This is reminiscent of Whitehead's organic philosophy, where every atomic unit has feeling and influences every other. For example, the biosphere can control the temperature of the surface and the composition of the atmosphere. On the other hand, soil types and the weather can limit vegetation. Lovelock and Margulis have shown that it is sophisticated enough to maintain a constant temperature and pH for billions of years, in spite of great atmospheric and solar changes.

The hypothesis is supported by four facts: (1) the average surface temperature of the earth has been in a constant range for more than 3 billion years, despite an gradual rise in solar energy; (2) the concentration of the atmosphere is improbable, compared to the composition of Venus and Mars; it should be mostly carbon dioxide; (3) each atmospheric gas is optimal proportion for a life supporting function; and, (4) the salinity of the ocean is far lower than it should be from runoff from land; the present percentage could have been achieved after 80 million years.

At a scientific level of thought, the Gaia hypothesis extends the fundamental ecological doctrine that all things in nature are densely subtly and systematically interrelated until it includes humanity, ethically and mentally, as well as physically. The entire earth is envisioned as a unified entity, actively shaping the material conditions of the planet for the purpose of maximizing the survival and variety of living beings.

Table 315-1. Anatomy of Gaia (Components of the planetary system)

Atmosphere	Keep surface warm; distributes solar energy
Oceans	Circulates things; substrate for life
Continental rock	Support and reservoir of mineral nutrients
Ecosystems of living organisms	Act as nutrient pumps

Like any good hypothesis, the Gaia Hypothesis can be used to make predictions: Elements are transferred from ocean to land by biogenic gases; the Climate is regulated by biologically enhanced rock weathering; Climate regulated through cloud albedo linked to algal gas emission; Oxygen has not varied by more than 5% from 21% for past 200 million years; Boreal/tropical forests are part of global climate regulation; Biodiversity a necessary part of climate regulation; the Interglacial is a systems failure in a physiological sense; and there is a biological transfer of selenium from ocean to land as dimethyl selenide. Many of these predictions have supported by undeniable evidence.

Table 315-2. Metabolism of Gaia (Processes convert energy to products and waste heat)

Carbon cycle	Influences climate, plant growth, oxygen production
Oxygen cycle	Evolution to allow increase in nutrients and energy fixation and speed up recycling
Nitrogen cycle	Building block of life, through peptide bonds. Sustains air pressure and is natural dilution
Trace gases, e.g., methane, sulfur	Allow homeostatic response to change
Biomass conversion	Concentrates biotic resources

The hypothesis has been advanced to a theory by Lovelock, by creating other hypotheses and models, notably Daisy World. Lovelock points out that to be complete, climate theory has to be based on geophysics, biophysics, and ecosystem science. His nonlinear model has strong positive and negative feedbacks that link the biosphere to atmospheric composition. The transition from negative to positive feedback occurs at sensitive points. Lovelock says stabilization seems only possible at 5 degrees hotter or 7 degrees cooler than it was about 200 years ago. The long-term climate history of the earth shows the existence of two stable states: hothouse and icehouse, with metastable states between, like the interglacial. Other competing models do not predict their existence. The best known hothouse was 55 million years ago, in the Eocene, the dawn of mammals. Thus, even if no extra carbon dioxide were produced for years, the planet will go to and stay in the hot state.

3.1.5.2. Discussion of Gaia Theory

Lovelock regards Gaia as a symbiosis of global dimensions. The Gaian ecosystem is a network of coupled smaller ecosystems connected by global patterns of water and air that adapt to each other through feedback loops that regulate physical and chemical environment—all based on great bacterial ecosystems mostly invisible to us. As a global ecosystem, the planet has special specific characteristics: The atmospheric composition is maintained by living cycles, at a relatively cool temperature; the ordered complexity and change produces a diversity of forms.

Lovelock suggests, in agreement with Garth Paltridge, that planetary environments are naturally selected to maximize the production of entropy. Possibly this is backwards, and the environments are selected for complexity, or ektropy order, which produces entropy as part of the process.

Lovelock considers the role of humanity in a Gaian system. Our first role as humans on Gaia was simply to recycle carbon and other elements. Now, he thinks that it might be to communicate for Gaia or perhaps to assist with the controls. We sometimes err to think that humans are superior because of our fascinating technology. Lovelock has expressed concern that humanity can impoverish the whole system by reducing the total variety. Although the planet seems to be very much self-regulating, changes in the atmosphere as a result of human transformations of ecosystems and wastes could trigger a new equilibrium that would be devastating to human civilization. The problems have much to due with global scale and global time lags compared to the two-year horizons of human business. Perhaps a great problem is simply too many humans consuming too many resources.

Perhaps the greatest problem is an aging earth. Lovelock states that there is only a small chance of reversing solar atmospheric heating. He calls the earth elderly, although he states elsewhere says that she was young 65 million years ago. Actually, if she is old now, she was old then; that would be like going from 65.5 to 66 years old in a human lifetime. At that time, she survived a global impact catastrophe. Gaia is 3 billion plus years old. The sun will continue to increase its output slowly for another 4-10 billion years. Of course, the planet will most likely live another billion or two as a self-regulated, living planet and easily another 4-5 billion years as a barren, rocky planet. The planet is not a body or a cell (as Lewis Thomas suggested it might resemble); it is a more loosely formed organism (as every organism contains various sizes of ecosystems). Tim Flannery suggests that this looseness may give the planet a substantially longer life, without the decay of aging, than smaller tighter organisms.

Lovelock states that soon Gaia will not be able to adjust to increased solar output. Michael Whitfield and Lovelock calculated in their model that in less than 100 million years the sun's heat will overwhelm the earth's regulation, and the atmosphere will move to a new hot state with a different biosphere. However, that is not the same as dying, even if the biosphere is not as comfortable for human purposes. Later, Lovelock states that any catastrophe that causes the Gaian regulation system to fail could lead to a hot dead earth, and human actions could precipitate that. Heat-loving plants and bacteria may not have a critical mass of living things to regulate the environment. There is a critical mass of life implied, and that may be related to a critical area inhabited—Lovelock mentions 70-80 percent of the surface, which may not have been maintained during the last ice ages, although the low sea level tripled the area of some surfaces, such as Florida in North America. What would happen if carbon dioxide (CO_2) went over 1 percent as a result? Would the earth transition to a Venusian state, clouded and cooked?

Whitfield and Lovelock also point out that self-regulating systems tend to overshoot a goal and stay on the opposite side of the forcing. If too much heat comes from the sun, the system regulates on the cold side of the optimum. In the past the planet developed this way through a complex web of feedback. For humans to keep the planet cooler, for our comfortable civilization, we will have to manipulate what we perceive as controls or triggers. We might enter another ice age, which might be healthier for the planet, but might be equally disruptive to civilization.

Lovelock refers to the interglacial state as a fever. For life, a cooler earth may be a safer response to solar increase, but there is not a lot of evidence that it was more productive during ice ages, even having a greater land area with vegetation and fewer deserts (or rather a large area of ice instead). Lovelock argues that, because of solar increase, Gaia has greater control during glacial epochs, which has a lower CO_2 concentration in the atmosphere, which he interprets as indicating that the biosphere was healthier and more productive, because cold ocean water is more biologically productive. He states this without noting that the oceans are relatively biological deserts, and life on land may be more critical for cycles. The argument needs to be filled out, since some data of the carbon composition in the deep ocean indicates that there was less organic carbon being fixed. Was the CO_2 too low for plant productivity, even with a larger land surface available near the equator? He notes that the rainforest is an adaptation to recycle water in a warmer environment. And, it is relatively fragile. And now it is important for carbon sequestration as well. The ocean deposition of CO_2 is important of course, as a physical process of the dissolution of silicate rocks, and as the biological flow towards a sink.

Think about this: Ice caps cool the atmosphere and lower the sea level. More land is exposed in the equatorial belt, which absorbs more heat. Do trees make the difference, creating more clouds? Are cool ocean currents less cool in glacial conditions? Do they bring up more sediments or less? Is there less sea life than before? Was CO_2 too low for more productivity.

There have been arguments against the necessity of naming the complex system and giving it an identity as Gaia. G.C. Williams suggested that Gaia was very sick since large desert areas have low productivity, as do large areas of nutrient poor waters. This is a weak argument. Life, however, does not have to be a constant maximum to be healthy and vital. After all, the human organism has layers of dead skin, as well as organs, like the appendix, that do not seem to have current uses. Life lives on an inorganic substrate that is dynamically changing, due to the environment, including planetesimal collisions, as well as the changing of living forms themselves.

Vaclav Smil asks how does natural selection at the individual level produce self-regulation at all higher levels up to the planetary one? Where is the scale coupling (in cycles)? How does the environment coevolve with the biota total? Smil proposes that the fundamental challenge for the theory is to show how natural selection at the individual level produces self-regulation at all higher levels, including the planetary one. But, the cycles connect all scales. Furthermore, the biosphere as a whole is self-organizing.

How could a planet have offspring? Send seeds to another dead or nonliving young planet? A dying tree makes more pinecones and seeds. Bacteria, viruses, and humans have escaped the planet. What is Gaia expected to do? Nothing? Ensure the survival of life? Maximize biomass or biodiversity? To live and be healthy? Is any living being required to have any other goals, other than living?

3.1.5.3. Summary: Limits of Gaia

Cognitive dissonance is mentioned as a problem by Lovelock. This is an effect of scale, also. Before dissonance can be resolved, the scale has to be right. Too big and the exchange is ignored; too small and it is ignored. It has to be a proper human scale, a proper gift exchange, or just what is understood from personal experience. Otherwise, self-deception or inattentiveness is the result.

Evolution makes mistakes and eliminates many errors. Natural events destroy billions of living beings. Is Gaia cruel, therefore, like Kali or Nemesis? Or, is that a problem with personalization? Earlier, Lovelock suggested that metaphors were crude ways of knowing; later he emphasizes that they are needed, however, to comprehend the earth. Darwin had described evolution as wasteful, blundering and cruel. But, cruelty requires consciousness. And, we humans consciously drive plants and animals extinct in a cruel way. Gaia only filters. Gaia is not a cozy mother and cannot be propitiated by gestures like carbon trading or sustainable efforts. We are not separate from Gaia. The earth can be benign like ancient goddesses, but also ruthless.

It is not likely that we will have to or need to save the earth; it can save itself, as it has done before. But, we may need to save the environments that we like as we know them. And this is what design can do. Gaia needs ecosystems on land and water for self-regulation. And, this is what global ecological design can ensure. Although the Gaia hypothesis renews the idea that the earth is a mother for us all, and reinforces our understanding of interconnectedness of biological processes, it falls short of demanding our responsibility and relies too much on our consciousness.

3.2. *Global Design Factors: Planetary Cycles*

In a mature ecosystem, most nutrients and materials are held in cycles; very little leaves the system. A cycle is defined as a pathway along which an element moves through biotic and abiotic compartments. All the chemicals, nutrients, or elements—such as carbon, nitrogen, oxygen, phosphorus—used in ecosystems by living organisms stay in a relatively closed system, which means that these chemicals are recycled instead of being deposited or lost. Virtually every material cycles through a forest ecosystem: Phosphorus, potassium, calcium, sulfur, magnesium, and water. Nutrient cycling involves many of these materials. Nutrient cycles change with the succession of a forest.

Materials cycle above and below ground, between the atmosphere and trees, between trees and insects, and squirrels and fungus. Chris Maser is fond of saying that most of the cycling is invisible because it is underground or in the air. Many cycles are investigated through ecosystem analysis, where energy and materials are traced through transfers through compartments in an ecosystem. For example, in the nitrogen cycle the compartments are the atmosphere, vegetation, forest floor, and mineral soil, while the transfers are precipitation, throughfall, leaching, litter fall, mineralization, fixation, and denitrification. Each compartment keeps the nitrogen for a certain time, termed the residence time; for a hardwood forest floor, for example, residence time is about 17 years. If the compartment keeps the element for a long time in large quantities, it is called a reservoir, like the ocean; if the residence is short the compartment is called an exchange pool, like a cloud.

Cycles require the movement of elements. Some reservoirs, such as the atmosphere, allow rapid movement. For example, almost any gas or fine particulate matter released into the atmosphere can spread across the planet in days. And, because of the movement, the atmosphere stays in a pattern of dynamic equilibrium.

Some cycles move at higher speeds than others. Some speed up seasonally or daily. Microbial activity speeds up an iron cycle. Some cycles grow or decline. Tectonic activity can renew some cycles, such as the phosphorus cycle. Some material cycles between other ecosystems or in larger patterns around the planet. Some of the cycles are daily; some are seasonal or annual; others are years or decades; a few, like the carbon cycle, are centuries or millennia long. Human beings do not pay much attention to very long cycles or to those we perceive as not affecting us. Sometimes we deliberately or inadvertently interfere with cycles. An excessive concentration of carbon dioxide in the atmosphere is an example of a disrupted cycle. The nitrogen cycle is being disrupted by runoff of fertilizers. Nitrogen fixation has doubled on the global scale, and this favors plants with higher nitrogen needs. Sulfur emissions to the atmosphere have doubled, also. Human interference in forest cycles can collapse the residence time; for example, clearcutting alder in Washington State causes very high nitrogen losses. Human interference in one cycle can affect other cycles.

Cycles are nonlinear systems, with limits and thresholds of which we are relatively ignorant. They allow unstable and improbable reactions to keep taking place. These cycles are not only interesting, but necessary. Without the oxygen cycle, for instance, all reactions would take place, and the atmosphere would reach an equilibrium (as it has on Mars).

Cycles are connected; for instance, the water cycle contributes to the operation of the carbon cycle; in fact, both meet in photosynthetic activity of plants. Carbon dioxide is part of the carbon cycle, which is tied to the heat cycle of the atmosphere. Carbon dioxide is the source of carbon for plants and it plays a role in the weathering of rock. All chemical elements occurring in organisms are part of biogeochemical cycles. In addition to being a part of living organisms, these chemical elements also cycle through abiotic factors of ecosystems such as water (hydrosphere), land (geosphere), and the air (atmosphere); the living factors of the planet can be referred to collectively as the biosphere. These cycles form the metabolism of the planet.

3.2.1. *The Water Cycle*

Water, in its different forms, cycles continuously through the lithosphere, hydrosphere, atmosphere, and biosphere. The energy for the water cycle is supplied by the sun, which drives evaporation. Evaporation is the process in which liquid water becomes gaseous—precipitation is the reverse of this. Water evaporates into the atmosphere from the land and the sea. Plants and animals use and reuse water and release water vapor into the air. Once in the air, water vapor circulates and can condense to form clouds and precipitation, which fall back to ocean and earth. At one time or another, all of the water molecules on earth have been in an ocean, a river, a plant, an animal, a cloud, a raindrop, a snowflake, or a glacier.

The sun provides the energy that drives the climate system, with its weather systems, which move the water vapor from one place to another, and from ocean to land. Once water condenses, gravity pulls water to the mass of the earth. Gravity continues to operate, as water flows across the surface or underground. It can be temporarily trapped in lakes or oceans. The main path through which water leaves oceans is through evaporation, which leaves behind salts and minerals. When water precipitates, it can pick up pollutants and acids and deposit them; over land, water can pick up minerals and pollutants—thus, evaporated water is relatively clean, but other water takes whatever is dissolved into traps or sinks. When water freezes, it can remain in a solid state for long periods.

Organisms participate in the water cycle, and most organisms contain a significant amount of water, although it tends to evaporate or transpire quickly. Animals and plants lose water through evaporation from the body surfaces, such as skin or leaves. Evapotranspiration, the evaporation from leaves, is responsible for significant amounts of water entering the atmosphere.

3.2.2. *The Carbon Cycle*

The carbon cycle tracks the water cycle; water is the vehicle that carries the complementary biological reactions of respiration and photosynthesis. Respiration combines carbohydrates and oxygen to produce energy, carbon dioxide, and water. Photosynthesis produces carbohydrates and oxygen from carbon dioxide and water. The outputs of one are the inputs of the other and vice versa. The reactions are also complementary regarding energy. Photosynthesis stores solar energy in the carbon-carbon bonds of carbohydrates; respiration releases that energy. Only plants (and a few other producers are capable of photosynthesis, but respiration is part of the activity of every living being.

The carbon dioxide produced by plants accumulates in a variety of reservoirs such as ocean and in rock. The volume of these reservoirs ranges from hundreds of billions of tons in land plants and the atmosphere to 100 million billion metric tons in carbonates. Carbon dioxide dissolves readily in water, and can precipitate as calcium carbonate (limestone).

Corals and algae build up limestone reefs with the process.

The carbon in plants now has three possible paths. Some of the carbon is released to the atmosphere by the plant through respiration, where it can stay in the atmosphere, be taken up by other plants, or dissolve in the interfaces of water bodies; some is consumed by animals and can be kept in flesh or released through respiration; and some is in flesh when the plant or animal dies, and can be recycled by decomposers or buried. All carbon in biological systems ultimately comes from plants, usually from predation. In the animal, the carbon also has the same 3 possible fates. Carbon from plants or animals that is released to the atmosphere through respiration will either be taken up by a plant in photosynthesis or dissolved in the oceans.

Buried carbon, treated by tectonic processes, ultimately forms coal, oil, or natural gas (fossil fuels). The fossil fuels are recovered and burned by traditional or industrial human processes, releasing carbon dioxide to the atmosphere. Carbon in limestone or other sediments can only be released to the atmosphere after they are brought to the surface, and weathered or released by volcanoes. Increased carbon dioxide in the atmosphere can cause atmospheric heating by trapping solar energy; it also pushes more into the oceans, making them more acidic.

Table 322-2. Residence time of Carbon

Atmosphere	3-5-50-300 years
Leaves	2-3 years (Amazonian forests)
Fine roots	3-10 years
Microbes	6-10 years
Living trees	200-260 years
Soil	25 years
Shallow ocean	350 years
Deep ocean	1000 years
Rock	8-10,000 years
Fossil fuel	Millions of years
Carbonates	150 million years

Because reservoirs are interconnected, the hyphenated short residence times are underestimates. The reservoirs with longer residence times, like the ocean, release carbon back to the atmosphere, increasing atmospheric residence time is over 100 years. The anthropogenic flux of carbon, from fossil fuel burning and deforestation, to the atmosphere is 8 billion metric tons per year, but the atmospheric increase is only 4 bmt/yr. Where does the other 4 bmt/yr go? There are two possibilities: Land Plant Uptake (Excess Photosynthesis) or Ocean uptake. Because the residence times are so different however, it is important to know which. Storage on land is much shorter-lived than storage in the deep ocean. These fluxes are important to understand (See Table 322-3).

The flux from volcanoes is relatively low, but the clouds from volcanoes can contribute to global dimming, with its cooling potential. The amounts in and out of oceans are close to balance as our photosynthesis and respiration. Anthropogenic processes have a much greater effect than weathering or volcanic action.

Table 322-3. Fluxes of Carbon (in billions of metric tons/year)

Land Plants	
Photosynthesis	120
Plant respiration	60
Soil respiration	60
Plants to soils	60
Fossil fuel formation	0.0001
Fossil fuel burning	6
Deforestation	2
Ocean Dissolving from atmosphere	107
Exsolving to atmosphere	105
Carbonate formation	0.3
Weathering	0.6
Volcanoes	0.1

3.2.3. *The Oxygen Cycle*

The oxygen cycle parallels the carbon cycle, since the atoms are often combined, as in carbohydrates and carbon dioxide. Oxygen of course is an important component of water. The oxygen cycle is driven by living beings. Oxygen is released from water to the atmosphere by autotrophs during photosynthesis and taken up by both autotrophs and heterotrophs during respiration. After two billion years of biological activity by autotrophs, mostly cyanobacteria, the oxygen content of the atmosphere increased significantly, allowing multicellular plants and animals to take advantage of the increased energetic reactions that oxygen allows.

3.2.4. *The Nitrogen Cycle*

The nitrogen cycle is more complex; there are many important forms of nitrogen, all created by the interconversions of organisms. Nitrogen is critical in forming the amino portions of the amino acids that form the proteins, which make up skin, muscle, and other important structures of organisms. All enzymes are proteins, and enzymes carry out many of the chemical reactions in the organism.

The main reservoir of nitrogen is the atmosphere, which is composed of about 78% nitrogen. Nitrogen gas in the atmosphere is in the form of two nitrogen atoms bound to each other. It is a relatively non-reactive gas, that is, it takes a lot of energy to break it up, so it can be combined with other elements, such as carbon or oxygen. Atmospheric nitrogen gas can be fixed in two ways: Lightning provides enough energy to burn the nitrogen with oxygen and fix it in the form of nitrate.

The other form of nitrogen fixation is accomplished by nitrogen-fixing bacteria, using special enzymes to fix nitrogen. Bacteria fix nitrogen, either in the form of nitrate or in the form of ammonia (nitrogen with 3 hydrogens attached). Most plants can take up nitrate and convert it to amino acids. Animals acquire all of their amino acids when they eat plants (or other animals). When plants or animals die (or release waste) the nitrogen is returned to the soil. The usual form of nitrogen returned to the soil in animal wastes or in the output of the decomposers, is ammonia. Ammonia is rather toxic, but, nitrite bacteria in the soil and water take up ammonia and convert it to nitrite. Nitrite is also somewhat toxic, but another type of bacteria, nitrate bacteria, take nitrite and convert it to nitrate, which can be taken up by plants to continue the cycle. The cycle is set up in the soil (or water), but denitrifying bacteria take the nitrate and combine the nitrogen back into nitrogen gas.

3.2.5. *The Phosphorus Cycle*

The phosphorus cycle is a more simple cycle, because the heavy phosphorus molecule can only be carried by water or living organisms. Combined with energetic oxygen atoms, it has a basic form, phosphate in rock; otherwise, it is found dissolved in water or as part of an organism. When phosphate is exposed to water, it weathers out of rock and goes into solution in watercourses or soil, where it can be taken up by organisms.

Animals obtain phosphorus by consuming plants. Fungi are efficient at taking up phosphorus and also form mutualistic relationships with plant roots, which gets more phosphorus and nitrogen into the plants. When plants die, the elements are returned to the soil. Phosphorus is an important constituent of cell membranes, DNA, RNA, and ATP, the cell's chemical battery. Phosphorus is a component of bones, teeth and shells. Phosphorus is a limiting nutrient. Because it has no gaseous form, it has limited availability as a nutrient—Isaac Asimov suggested it was the bottleneck for life—and its geochemical cycle is slower than the others. It is also vulnerable to being lost through erosion to the ocean.

3.2.6. *Interactions of Cycles with Other Cycles*

There are also cycles of hydrogen and calcium, as well as of trace elements, such as molybdenum, sulfur, magnesium, and iron. Other organic nutrients, such as sugars, cycle through ecosystems. There are even cycles of certain artificial exotic molecules, such as plastics, which are broken down and end up in ocean gyres or spread throughout the levels of water, where they interfere with the food chain.

The water cycle is linked to other cycles, especially the carbon and oxygen cycles. When the water cycle changes, as a result of naturogenic or anthropogenic actions, the other cycles change also. The interaction of cycles means that if one cycle is disturbed or interfered with by human activities, other cycles will also change.

Although the phosphorus cycle is pushed by the water cycle to the ocean, the activities of animals, especially fungi, fish and birds, bring this element back to the land or into ecosystems. Croplands may sequester carbon, for instance, although current models may overestimate the extent. Old growth forests also sequester carbon, although current models may underestimate that amount. The uptake of carbon by forests, however, is limited by the availability of nitrogen, as well as by water and nutrients.

The interactions of biogeochemical cycles with ecosystems and organisms means that disruption or interference of cycles can affect ecosystems and organisms; conversely, disruption or interference of ecosystems and communities of organisms, at a sufficient scale, can affect the global cycles.

3.3. ***Global Design Factors: Landscapes & Biomes***

A landscape is a heterogenous area composed of a mosaic of interacting ecosystems of various sizes. A Biome is a large ecologically defined biotic community smaller than the planet, broadly corresponding to a climatic region and the physiognomic character of vegetation. The tundra biome is an example. How are these regional design factors like cycles and spheres? They recycle elements regionally. Biomes contribute to climate, not only by the types of landforms, but also by biological activities and densities. Landscapes contribute to cycles and flows as a result of their form and size. Transforming an entire landscape alters flows.

Landscape is a convenient idea that serves as a unit of analysis. Landscapes have a range of scales rather than an intrinsic spatial scale. As ecology undergoes a scalar shift, microecology, with ties and cellular biology and dominating the field, yields some attention to macroecology, the study of wildlife and landscape ecology. Macroecology has fewer practitioners. Russian scientists pioneered the concept and only recently have other scientists perceived the need for regional and global scale ecology. Ecology can learn much from geology by working at multiple scales.

3.3.1. *Landscapes*

The patterns of ecosystems are addressed best at a landscape level. The word landscape was used by the geographer Alexander von Humboldt as a scientific term in the 19th century. A German biogeographer Carl Troll used the phrase "landscape ecology" about 1939 to describe land—and not just living organisms—as an integrated holistic entity to be studied in its totality by geographers and ecologists, geography providing a horizontal approach to the vertical one of ecology. F. E. Egler in 1942 emphasized the active role of humanity on the holistic nature of vegetation in the landscape. Later, Raymond Dansereau noted that landscape was the highest integrative level of environmental processes. Like G. P. Marsh, Dansereau described landscape modification by humans throughout history.

The modern science of landscape ecology was developed in Europe in the 1970s and formalized as a discipline during that time. Landscape planning is interwoven with the interdisciplinary aspects of urban and regional planning. Naveh and Lieberman list three factors that form a new science of landscape ecology: (1) Landscapes are recognized as natural and cultural entities whose health and integrity are vital for human survival; (2) As an approach to the study of landscapes, the conventional reductionistic scientific paradigms are replaced by integrative and holistic methods based on a systems view; and (3) Technological advances in remote sensing and satellite images, combined with the capabilities of processing large quantities of data, support the possibility of dealing with landscapes holistically.

Landscape ecology is a goal-directed science for studying the complexity of landscapes, as well as for preserving their integrity and health and natural and cultural diversity. Landscape ecology addresses the overall patterns of large-scale ecosystems, considering the biogeochemical, atmospheric, and hydrological cycles in relation to the shape and extent of individual landscapes. Landscape ecology can identify: Candidate ecosystems for restoration; candidate ecosystems for preservation, conservation, or reservation; and, patterns of forestry to preserve larger functional islands.

With its holistic, cybernetic ecosystems approach, landscape ecology can address the emergent features of large systems and large cycles. A landscape has to be large enough to offer diversity of resources for cycles, and small enough for exchange between organisms. It as to have sufficient time for development, that is, changes cannot be too fast. It has to incorporate a number and diversity of species, trends and patterns.

Before satellite data analyzed by GISs, ecologists and foresters did not have tools that could address the scale of landscapes. Regional and global data was hard and expensive to collect. The International Geosphere Biosphere Program (IGBP) coordinated by the U.N. uses GISs for global and regional issues, such as deforestation or desertification. The large images from satellites are exceptional for identifying landscape patterns, especially those related to the scale of species behavior, e.g., home range or breeding dispersion. Pattern can also be measured at the level of patch size and spatial relationships (that is, inter-patch distance), which is critical for relating the size of a habitat to the species in it. The data derived from satellite imagery and from field studies can be used to model the landscape at various levels. Some of these tools are used for specific problems in the classification of forest ecosystems and harvesting schedules.

3.3.1.1. Landscape Characteristics Morphology History & Productivity

The morphology of a landscape has effects on nutrients and soil. For example, slope stability determines the potential migration of material into watercourses, the effects on landscape structure, changes in overland flow of materials and nutrients, and changes in habitat conditions. Soil erosion causes changes in physical properties of soil, such as structure, texture, bulk density, infiltration rate, depth for favorable root development, and available water-holding capacity. These flows determine the productivity of a landscape.

As humans began to settle permanently to exploit their surroundings continuously through agriculture and animal productivity, landscapes became more disturbance-dependent and became less resilient to climatic events. Human cultures attempted to cope with risks or to exploit opportunities, which required more management of the environment, although different parts of the environment operated at a range of scales, most of the natural dynamics and landscape occur slowly by comparison with human dynamics. As a result humans adapted themselves to a dynamics of the environment at the beginning, but over time cultures served their own needs by modifying the environmental dynamics. Human cultures thus become dependent on colonized systems, which required certain social institutions, especially those involved in organized production and storage.

Descriptions of historic landscape disturbance regimes, e.g., fire magnitude and frequency, and the ecosystem component patterns they maintained, e.g., vegetation composition, provide an initial template for descriptions of ecosystem health. Some regimes result from economic needs, such as large timbers, as well as from cultural influences and human values, especially fads.

In a way, the internal disturbances have as much effect on the dynamics of forest communities and forest landscapes as fire and blowdowns. Castello, Leopold, and Smallidge suggest that pathogens, by eliminating less vigorous or genetically unfit (filtering them out of the stream of life), control the direction and rate of succession. Tree mortality from pathogens occurs on various scales: gap phases (small scale), forest development (large scale), and landscape patterns (immense scale). Pathogens are one of the determinants of growth and development. Pathogens determine tree mortality, which drives landscape patterns.

3.3.1.2. Human Uses & Impacts on Landscapes

Human use of fire, as mentioned, can shape landscapes. Geologists have noticed an increase in fossil ashes from the Pleistocene (1 million years BP) that may indicate that early hominids had fire. Peking man (250,000-350,000 years) definitely had fire. Deliberate fires for clearing land and accidental fires from lightning strikes and drought have all destroyed forests. Before European settlers arrived in the western America, there were few large fires—although large fires periodically occur in certain kinds of forests, e.g., in lodgepole pine forests every 300 years or so. Since then, large fires have become a regular feature. In Washington in 1865 and 1868, for instance, fires destroyed a million acres and 600,000 acres. The Idaho and Montana fire of 1910 destroyed 8.5 billion feet of timber. The Tillamook fire of 1933 burned 12.5 billion feet of timber. In Oregon from 1850 to 1908 (when fire protection began), about 32 billion feet were cut for lumber and 40 billion feet were lost to fires.

Environmental factors have shaped the course of human history to a greater extent than had been realized. The decline of Rome is a study in forest ecology. There were previous catastrophes in the Tigris and Euphrates valley, Greece, Khmer, Maya, Midwest United States, and the Australian outback. Many peoples could not solve their problems; many immigrated to new lands.

Only in the 19th century, beginning with G.P. Marsh, did people start to realize that humanity has done as much to change the environment as the environment has done to mold human history. Marsh, the first American ambassador to Italy, was one of the first to study the role of humans in changing the face of the earth. Visiting the near east in the middle of the 19th century, he was shocked to find deserted cities, silted harbors and wastelands instead of flourishing civilizations. He concluded that ecological errors had led to the deterioration of agriculture in Mediterranean countries (see the reading assignment). He advocated agricultural conservation practices.

Land continuously occupied by humans may form analogs of natural communities, guided by trial and error, by unconscious values, and by random changes. The American tall-grass prairie is a case of the creation and maintenance of an artificial but desirable ecosystem. Unfortunately, it was dependent on a multiplicity of unintended accidents. Ecosystems evolved through natural events, then as an effect of human activities, now through deliberate social choice in some places.

The archaic universe was regarded as the creation of order out of chaos, with humans contributing; nature and man are harmonious. Now, there is arrogance from Plato to Dubos, that all human action improves the spontaneous course of nature. Dubos was disturbed that farms are overgrown and does not like to see vegetation revert. Dubos dreaded forest regrowth in New York as barren and uninteresting, but Leopold felt in Wisconsin it was a welcome prophecy of nature's second coming. This is the same Leopold who had once wanted to raise deer in a wolfless world, but later realized the necessary function of predators in a balanced community. Dubos and others have claimed that "nature knows best is wrong," that nature is inefficient and wasteful. But ecosystems that seem inefficient and wasteful are many times extremely redundant, and therefore stable and flexible. Natural processes that seem destructive are cyclic and preservative also.

3.3.1.3. Landscape Management

Once a landscape has been exploited or modified, it has to be managed for as long as human use is considered. Of course, landscapes can be allowed to become wild again, but the process is lengthy. In the late 1970s, C. S. Holling described an Adaptive Management as a response to natural disturbances at the landscape level. Matrix management (Noninterference) can be used to deal with designed landscapes, especially forested landscapes exploited with ecological techniques (Wittbecker, 1992). Shortly afterwards Alan Savory applied his ideas of Holistic Resource Management to preserve the quality of the landscape. The 1980s also saw a comprehensive Integrated Resource Management (Mitchell), Permaculture as the expression of a permanent responsibility for the landscape (Bill Mollison), and the Wholistic Timber management (Herb Hammond), which was dedicated to maintaining the structure and functions of diverse forests.

We must pay attention to the processes that make up the habitat, for example, the role of herbivores on trimming vegetation (and diversifying it by predation). The design of the forest and its management must ensure that the processes operate to maintain a dynamic state. Furthermore, the context must be conserved. The forest, however, cannot be considered outside of the context of the entire landscape, including human images and institutions.

3.3.1.4. Conclusion: Importance of Healthy Landscapes

Healthy landscapes reflect a balance of processes, including extinction, colonization, and connectence. Colonization is necessary to equalize local extinctions. The loss of colonization, for any reason, can allow species in a local system to be depleted. Island ecosystems, surrounded by poor areas, may lose species without colonization. If the matrix is rich enough, there should be successful colonization.

Connectivity is a function of numerous characteristics, from the mobility of a species (its dispersal characteristics) and its autecological characteristics, such as food or shelter requirements, to the structural characteristics of the landscape (spatial patterns, too), the distance between patches, and the presence of barriers to movement, such as highways or rivers. Predation patterns and human interference are also important considerations.

Wild landscapes are affected by climate, soils, interactions, and disturbances. Domestic landscape is affected by land use as well. The greatest changes have been brought about by the destruction and creation of forests. With the predominance of artificial or managed forests, it is important to consider the qualities of naturalness in the landscape. Forests are expected to meet the needs of society by producing timber, creating wildlife habitats, and providing recreational opportunities for people.

3.3.2. *Biomes*

A biome is an ecologically defined area spread over water and land that contains geographically distinct assemblies of ecosystems and communities (similar to a bioregion or ecoregion). The patterns of ecosystems within a biome are associated with characteristic combinations of soils and landforms.

Many biomes have been altered tremendously by recent human impacts, especially grasslands and rainforests. Further landscape-level planning needs to be conducted over time and in cooperation with surrounding forestland owners/managers of both private and public forestlands. The negative effects of planning and nonmonetary effects are usually missing from such plans. The regional context is also missing.

Biomes are larger scale than landscapes, which are often applied as a term only to human modified areas. At this scale things build up slowly. The system can absorb or loss many components and still stay relatively recognizable and stable. The system has momentum. The time it takes for change to become apparent lengthens, often beyond the longest human plans or consideration.

Except for the scale, and longer-term persistence, the design and management of biomes shares many similarities with ecosystems. The goals would have to be larger at this scale, and the designs would have to be less certain and more flexible.

3.3.3 *Dealing with Change*

How we treat large-scale communities is an important question. Deep ecology is one form for asking questions about landscapes, especially forested ones. For example: How can we design forests for neutral elements in interrelated processes in a landscape? What are we restoring when we restore an ecosystem without all the parts or good knowledge about the ones we have? These questions highlight the uncertainty we face in dealing with large, wild, complex, long-lived entities at the scale of landscapes. Managers have to live with uncertainty; this means that management decisions are essentially gambles. Gambling is a profession that acknowledges the operation of chance and makes conclusions in the absence of facts—few people are successful at it. This is an important admission, that we do not have facts to base our actions on, that nature is a stochastic process, and that landscapes and biomes always changing. Furthermore, we do not know for sure what effects our actions will have on landscapes, which live so long, in such diversity, in many places. Successful gambling suggests that the proper attitudes for gambling with nature are awareness, humility and courage, not arrogance, fear and maximum use.

Perhaps we do not have sufficient knowledge to manage a complex landscape because it is too complex to understand scientifically. But we can understand the pattern and drive it in a healthy direction with minimal intervention. Perhaps we lack sufficient courage or willpower to manage large-scale forms. According to Garrett Hardin, many of the ideas necessary to fit humanity into the pattern of nature are known but not yet popular. For instance, exponential population growth or exponential economic growth cannot be maintained very long. Human communities cannot grow 4 percent per year without disastrous consequences to the infrastructure and the quality of life. Growth cannot be continued because the landscape is limited, in terms of productivity, energy, and resilience. Thus, we need to fit our population into the limits of a landscape or biome, although some limits can be expanded by technology or by lowered expectations. Redundancy at this scale, with regional self-sufficiency, keeps global limits less critical. The carrying capacity of the area is not only a function of the limits of the community, but it is equal to the number of people multiplied by the level of comfort (quality of life style). Having more energy and space per person in a limited system means having fewer people. Changing the scale of concern does not solve any problems relating to overconsumption or drawdown; it just displays the regional limits sooner.

3.4. *Global Design Factors: Ecosystems Communities Populations & Organisms*

Why should we be considering these factors? An ecosystem is a discrete unit consisting of interacting living and material components. An ecosystem is the unit of survival for living beings and communities. Organic structures, are building blocks for organisms for eating or nesting. They also nourish the soil. Ecology deals with the highest levels of biological integration, from organisms to the ecosphere. Autecology, for example, is the study of individual organisms in an environment. A group of individual organisms of the same species in a particular place is studied as a population. The assemblage of populations of different species in a habitat is studied as a community. The community in its biotic environment is studied as an ecosystem. Ecosystems comprise the ecosphere. There are emergent properties at each level of organization, such as the diversity of species and the structure of a food web. Furthermore, each level of integration has distinct attributes.

A living system is produced by living beings. A system is a set of things—such as people, cells, or molecules—according to Donella Meadows, interconnected in such a way that they produce their own pattern of behavior over time. The system may be buffeted, constricted, triggered, or driven by outside forces, but the response is characteristic of the system. A system is not just a collection. It is an interconnected set of elements that is coherently organized to achieve something. The system maintains its identity, despite the replacement of elements, molecules or organs.

Human perception of nature is hierarchical, regardless of whether nature is. Several theorists distinguish levels of hierarchy in nature. G.T. Miller includes particles, atoms, molecules, organisms, societies, and nations. Mario Bunge extends the list to include processes and knowledge: Elementary particles (atoms, bodies); physical systems (organisms, ecosystems); physical processes (chemical, biological, social); material production (ritual, culture); and knowledges (physics, history). Ervin Laszlo makes a distinction between a macrohierarchy, comprised of a space-time field, particles, stars, galaxies, and various aggregations; and microhierarchies like the earth, composed of molecules, crystals, cells, organisms, ecosystems, and Gaia. Hierarchies can be regarded as vertically arborizing structures whose branches interlock with those of other hierarchies at a multiplicity of levels and form horizontal networks; arborization and reticulation are complementary principles in the architecture of organisms and communities.

3.4.1. *Communities*

Plants and animals are always figuring out ways to live. If two plants happen to be living close to each other, they may compete for the same energy and nutrients or they may start shifting their requirements. Over time, a long time usually, plants and animals that have similar general requirements, in terms of solar energy, heat, water, and nutrients, tend to live together in associations. The plants and animals that form associations in a forest do not usually have the same requirements. Thus the ninebark beneath the ponderosa pine does not compete for the same nutrients or energy. Often, the plants and animals benefit from the presence of their neighbors, as alder benefits from nitrogen-fixing fungi.

The trees and other plants and animals evolve into a community of thousands of different species. The "checks and balances" of a complex number of predators, prey, and decomposers tends to dampen any one species from getting out of control (and becoming a pest). This is not to say that everyone lives in a disneyesque fantasy of good will. Organisms survive by defending themselves or attacking others. But, the defensive and attack strategies "coevolve" (Ehrlich and Raven's term) over time. Organisms specialize to avoid competing. Relationships become more intimate, as organisms cooperate for survival advantage.

Thoreau extended the idea of human community to animals and plants. In a romantic paroxysm, Thoreau proposed that nature was a vast community of equals. The word community took hold and was used to describe associations in nature. Botanists noticed that plants tended to live together in communities.

Although botanists recognized that change was inescapable as a principle of the new science, Frederic Clements insisted that change was not an aimless wandering, but a steady flow towards a stable state that he referred to as a final climax. The climax community was thought of as the final state after a series of developmental stages. For example, certain places, with variables of wind and rain and temperature always produced forests; others deserts or grasslands.

Community is one level of a pattern. A community can be described through a number of properties and principles. Properties include: Productivity and development. Principles include:

- Community is the level of survival
- Diverse species live in a stratified order
- Communities are named by structural features such as dominant species.
- Communities are stratified.
- Communities have a diversity of species.
- Communities are characterized by rhythmic changes in the activities of organisms, which produce regular recurring changes in the community (periodicity may be daily, lunar, seasonal, genetic, or climactic).
- Communities replace one another in a given area in sequence by an orderly process of change called succession (Succession appears to be a process of self-organization in a cybernetic system at the ecosystem level. It is primary for Odum).
- The final community in a successional series is self-perpetuating and homeorhetic, that is, in equilibrium with the physical habitat, that is, the energy/material budget is balanced in a mature community.

This concept of maturity, as an attribute of a community, is related to structural complexity and organization. Maturity increases with time in an undisturbed community. The species diversity, that is, the information content, of a community also increases with maturity, leading to a more complex spatial structure. Diversity incorporates species richness (how many different kinds are present) as well as a measure of abundance—how many of each, as individuals or biomass. Other aspects of diversity, such as life cycles, are less often considered. The energy in a mature system goes to the maintenance of order and less for the production of new materials. In general, diversity is higher, and life cycles are more complex; symbiosis between species increases, and nutrients are conserved. Complexity and diversity offer advantages for living forms. Complexity allows increases in size, which allows the colonization of harsh environments. Diversity allows more effective behavior through specialization; for example, a specialized organelle may digest less common molecules.

But, Odum points out, as some communities age, Wisconsin forests for example, there is a decrease in diversity (in the understory anyway). Also, diversity can decline with productivity, as in the eutrophication of lakes, for instance. While it is meaningful to speak of an optimum diversity, as the result of limits and the interaction of many factors, a maximum diversity may never be reached.

Conventional wisdom, starting with Charles Elton, holds that increased complexity in a community leads to increased stability. But in the 1970s, work with mathematical models tended to support the reverse, that complexity leads to instability. Robert May constructed simple mathematical models concerned with local stability, in which an increase in complexity lead to a decrease in stability. His connection, however, may have been a mathematical artifact, since his food webs were randomly assembled and sometimes unreasonable. May admits that his arguments are only true of mathematical models and that things "may be different in the real world." Ecosystems are the result of historical processes that are mathematically atypical. Furthermore, real communities are not randomly structured. A system drives to a nonequilibrium state as a mature ecosystem. The adaptively reorganized system is not necessarily more stable, but it is optimally resistant to the outside conditions that elicited the self-organization, a natural normalization process. The ecosystem learns the changes, periods, or seasons of the environment.

Every community is composed of a variety of kinds, numbers, sizes, and ages of plants, from unicellular organisms to trees. "Community" is a general term of convenience, like ecosystem, to designate complex units. The largest kind of community is a biome; in North America, according to Packham et al., biomes include tundra, montane coniferous forest, steppe/grassland, and temperate rain forest (for example, Vermont is in the cold-deciduous broadleaved forest with conifers; New Orleans sits in the subtropical summergreen coniferous swamp forest; and much of Arizona is thornbush/succulent). Biomes are then subdivided into regions, zones, and associations. Associations describe plants that grow in the same habitat. The deciduous forest biome, for example, is composed of distinctive associations, including beech-maple, oak-hickory, and aspen-birch. Associations may be subdivided further into layers (or unions).

All members of an ecological community contribute to the integrity of the whole, which is vital to maintaining what we humans consider important: visible animals, pharmacological sources, a moderate climate, and clean air and water (in a sense, nature has meta-economic values). Until old-growth is recognized as a vital organ in the functioning of ecosystems, as important as a human heart is in the functioning of bodies, it will continually be assaulted by the logic of economics, and it will not be safe until economics is on an ecological basis.

The entire community is considered. Human communities are embedded in forest communities. Furthermore, Leopold did not argue anywhere that natural biotic communities are most desirable and that it is wrong in principle to alter them. Land continuously occupied by humans may form analogs of natural communities, guided by trial and error, by unconscious values, and by random changes. The American tall-grass prairie is a case of the creation and maintenance of an artificial but desirable ecosystem. Unfortunately, it was dependent on a multiplicity of unintended accidents. Ecosystems evolved through natural events, then as an effect of human activities, now through deliberate social choice in some places.

3.4.2. *Ecosystems*

Some ecologists, like Arthur Tansley, felt that the word community was much too anthropomorphic, that plants did not voluntarily live together. So Tansley coined the word ecosystem to represent the interrelatedness of nature and to emphasize the flow of energy through a system, such as a forest or pond (the word system is derived from the Greek word meaning a number of things placed together). The systems concept, however, is concerned with more than just a number of elements or their kinds (species); it is concerned with relations between them. These relations are not explainable from the elements, hence, 'the whole is more than the sum of the parts.' The relations are emergent, that is, they are new 'things.' The theory of systems offers unique properties and principles, such as wholeness, novelty, growth, and openness.

Ecosystems comprise the ecosphere. There are emergent properties at each level of organization, such as the diversity of species and the structure of a food web. Furthermore, each level of integration has distinct attributes. Ecosystems are the result of historical processes that are mathematically atypical. Furthermore, real communities are not randomly structured. A system drives to a nonequilibrium state as a mature ecosystem. The adaptively reorganized system is not necessarily more stable, but it is optimally resistant to the outside conditions that elicited the self-organization, a natural normalization process. The ecosystem learns the changes, periods, or seasons of the environment.

A thing that grows, repairs, holds itself together, oscillates, and capture solar energy is an ecosystem, a system resulting from the integration of all the living and nonliving factors of the environment. An ecosystem is a community of organisms interacting with one another and their environment. Odum describes the ecosystem as a unit of organization undergoing an orderly process of development that is reasonably directional. Ecosystems, the essential unit of ecology, must be seen in dynamic and historical terms.

Ecosystems are unique and original. The circuitry between different species of an ecosystem is no different today than a billion years ago. Each patch (locality) supports a segment of the total species population in a unique context, with a particular set of predators, competition, food, or physical habitat. Ecosystems are ambiguous in a sense, since anything from a log to a watershed can be an ecosystem. Furthermore, ecosystems overlap and interact. It is possible to define close but not exact subsystems. The vast number of interrelationships between systems keeps them open. For example, grassland is affected by climates, soil conditions, fires, surrounding communities, and human agents. Ecotones between systems are usually shifting.

Ecosystems build up information. There are three different channels of information in an ecosystem: a genetic (in replicable individuals); an ecological based on interaction between cohabiting species (expressed in changes in their numbers); and the ethological or cultural, transmitted through individual learning based on experience.

Feedback within the interaction of a species is expensive memory with little storage capacity. Whenever succession starts again, after a volcano eruption for instance, old information in form of interactions has not been saved. Genetic memory has much larger capacity and is long-term. Cultural memory enlarged with higher vertebrates. Ecosystems are described with a variety of terms: energy, matter, entropy and ektropy, productivity, cycles, diversity, complexity, stability, and trophic structure. Many terms in ecology, such as biomass, stability and diversity are inexact. It is almost impossible to estimate the amount of degraded energy in an ecosystem (that is, entropy from transpiration, mixing of water, etc.).

One problem with describing ecosystem attributes is that both quantitative (measurable) and qualitative (conceptual) factors are included. Resistance to external factors, for example, is a qualitative attribute. This may be more the result of succession than a factor producing an ecosystem. All ecosystem properties are not equally important. There is no whole system without an interconnection of its parts, and there is no whole system without an environment. Behavior at any level is explained in terms of the level below, but its significance is found in the level above. Ecosystem behavior does not emerge from a set of organismic equations.

Properties (see Section 2.2.3.1.1) of an ecosystem include: Wildness, Productivity, Diversity, Complexity, Stability, Change and extinction, Historicity, wholeness and renewability, Multitude of parts, Structures, and Functions. Ecosystems can also be described through a series of principles:

- The ecosystem is the level of integration and the unit of organization undergoing a directional development (after Odum).
- Energy is bound into organic material, measurable as productivity.
- Energy/matter is transferred through individuals as a food chain.
- The interaction of individuals in a food chain results in trophic structures (pyramids).
- Chemical elements circulate in the biosphere in biogeochemical cycles.
- Energy and material no longer used by a system is the waste of that system (entropy)
- Energy required to maintain an ecosystem is related inversely to maturity (Margalef's concept of maturity).
- An ecosystem has a minimum size.
- An ecosystem has a distinct pattern, related to health.
- Ecosystem is a level of integration and organization undergoing directional development.
- Chemical elements, especially those of life, circulate in the biosphere in characteristic paths known as biogeochemical cycles.
- Life is limited by elements and physical factors (light, water, gas, salt); too little of an element limits (Liebig's law); too much limits (Shelford's law of tolerance).
- The transfer of energy and materials through organisms is referred to as the food chain.
- The interaction of individuals in a food chain results in the trophic structure of communities (ecological pyramids).
- The energy required to maintain an ecosystem is inversely related to complexity; succession decreases the flow of energy per unit biomass (Margalef's concept of maturity).

To maintain ecosystems, we can create standards based on those properties and principles. Sample standards (many of these based on Conservation Biology) include:

- Preserve the spirit of a forest place
- Preserve minimum species and habitat for wholeness
- Preserve diversity at all levels
- Retain appropriate shapes and corridors for pattern unfolding
- Retain hierarchy of all levels
- Allow for limits, disturbances, processes, adaptation, evolution
- Leave snags and fallen trees

- Leave double buffers around riparian zones
- Restrict roads/trails to appropriate terrain
- Use appropriate equipment, e.g. cable yarding, in steep areas
- Take/leave trees of all ages
- Avoid damaging activities, e.g., slash burning

Based on these standards, we can describe practices of exploitation, which would allow limited exploitation of an ecosystem, to keep it wild and healthy. Practices include:

- Maintain size and completeness of forest
- Strengthen shapes and margins
- Keep density and openness in a balance
- Preserve the interior/protect riparian zones
- Plan paths to avoid sensitive areas and emphasize pleasing perspectives
- Bundle paths (power lines, utilities) to minimize intrusion
- Preserve the character and all aspects of the forest

3.4.3. *Populations*

Each locality supports a segment of the total species population in a unique context, with a particular set of predators, competition, food, and physical habitats. Mammals are bound by biological requirements that must be met if a population is to survive. These functional requirements include food, territory, shelter, and reproduction. Mammals are the best regulated of highly evolved species. Their behavior is controlled and population regulated through the use of space. Most populations, furthermore, regulate their density well below the limits of the food supply, often by as much as 50 to 70 percent. Territoriality can be correlated inversely with trophic levels and productivity. But populations can also be limited by: Specificity of prey or plant source; size of prey or plant populations, predators, and natural events or catastrophes.

A group of individual organisms of the same species in a particular place is studied as a population. The assemblage of populations of different species in a habitat is studied as a community. The community in its biotic environment is studied as an ecosystem. Ecosystems comprise the ecosphere. There are emergent properties at each level of organization, such as the diversity of species and the structure of a food web. Furthermore, each level of integration has distinct attributes. A population has a property "density," the number of individuals per unit area, which is not applicable to individuals; a community has "species diversity," which is meaningless at the population level; processes like homeostasis or homeorhesis, which involve a relationship with the environment, occur on an ecosystem level. Principles that apply to populations include:

- The population is the unit that evolves in nature (according Krebs).
- A species population has unique properties, such as density, mortality, natality, potential, dispersion, age distribution, growth form, and structure (isolation, territoriality).
- Populations interact in neutral, positive, or negative ways.
- Competition limits the number of species in a niche (the competitive exclusion principle). Thus limiting it so that others develop to claim a niche.

Populations can exchange genetic information if they are linked with other populations. Degrees of isolation can allow differences and possibly speciation.

3.6. *Global Design Factors: Elements & Materials*

Natural materials have been created and broken down for millions of years. Exotic materials, from human industrial processes, are different. In most cases, there are no predators or recyclers that can eat or break down the materials.

3.6.1. *Elements*

An element is a unique form of matter that cannot be broken down into other substances; oxygen and nitrogen are elements. To analyze a rock, it is necessary to break it apart and identify specific elements. There is an external supply of materials: Elements, such as carbon or water, are obtained beyond the boundary of the system in question. Elements are stable holons, from particles and molecules to organic molecules, DNA, and societies. Elements can exist in mixtures, solutions and suspensions, as well as in compounds, where two or more elements are chemically combined in definite proportions, like water or ammonia.

The planet started as a mixture of chemical elements (over a hundred, including hydrogen, helium, and nitrogen) circulating over an active geology, driven by solar energy. At the risk of making life seem too simple, complex molecules formed from the action of light on primary gases, such as methane (CH_4) and carbon dioxide (CO_2). Materials on the earth include elements, compounds, and combinations. The atmosphere is composed of elements and compounds, such as nitrogen and carbon dioxide. The ocean is composed of hydrogen hydroxide (water, of course), with many dissolved elements, such as carbon dioxide, gold, and sodium chloride (salt, of course). Materials can be extracted from the landscape: Metal ore from rock, wood from trees, oil from tar sands, or stone from formations.

A material ecosystem recycles important elements in circular paths within the system. Elements frequently associated with life—calcium, phosphorus, iron, and sulfur—are preferentially concentrated and deposited by living organisms. Chemical elements, especially those of life, circulate in the biosphere in characteristic paths known as biogeochemical cycles. The elements circulate in the biosphere in regular, more or less circular paths called biogeochemical cycles. The movements of the chemical elements necessary for life are referred to as nutrient cycles. When one of these cycles varies, the other cycles are effected. Nitrogen and sulfur cycles, for instance, are effected by air pollution. In a mature forest very little material actually leaves the forest. It is held in cycles.

Organisms and communities are limited by elements and physical factors, such as gravity, light, water, gas, or salt. Living organisms produce food from sunlight, using various elements and compounds. Other organisms, bacteria and fungi, consume organisms. Life is limited by elements and physical factors (light, water, gas, salt); by too little of an element (Liebig's law); and by too much of an element (Shelford's law of tolerance).

Complexity emerges from the interpenetration of processes of differentiation and integration, processes running simultaneously from top and bottom and shaping the hierarchy from both sides. Microevolution generates macroscopic conditions for continuity and macroevolution generates microscopic elements for processes. Life is an emergent property of a hierarchy of chemical levels. It is not found in molecules but through autopoetic organization of molecules.

3.6.1.1. Pure Elements
An atom is the smallest particle of an element that can exist in a compound. Atoms rarely exist alone. They can also combine to form molecules. Atoms can store energy in their electron orbits. Atoms are made up of smaller particles, such as neutrons and protons, which are made up of other particles.

Hydrogen is the smallest atom, with only one proton. Possibly, there are $4x10^{79}$ atoms of hydrogen in the universe, based on the number of stars and galaxies, but not black holes or dark matter or dark energy. Ninety-two atoms exist, but in millions of quantum-mechanical energy states. Another hundred unstable atoms may be temporarily formed during stellar processes or in human experiments.

3.6.1.1.1. *Hydrogen*. Hydrogen is the most abundant element in the universe. It is also a resource for human civilization. Any resource is abundant, renewable, slowly accruable (Basically nonrenewable), or slowly dispersed (really nonrenewable).

3.6.1.1.2. *Calcium*. Calcium is a poison. Calcium can also be formed by the weathering of rock. Living organisms take it up, putting it in shells or bones. In an undisturbed forest the calcium cycle is relatively efficient, with little leaving the system by flowing downstream (Bormann and Likens, 1967).

3.6.1.1.3. *Sulfur*. Sulfur is also present in gaseous form, in dimethyl sulfide and carbon disulfide. Sulfur exists in sulfur bearing rocks, which are weathered into the oceans. Marine organisms use the sulfates to build strong bodies, which then emit dimethyl sulfide (the aroma of fresh fish) into the air. Sulfuric acid droplets form the nuclei needed for condensation back to the land, where it is available to plants for growing. The large sulfur cycle is beneficial to marine and land organisms, important to the general pattern of production and composition.

3.6.1.2. Pure Metals
The availability of natural resources, such as minerals, is a common concern. We have had to search over the earth for them. In fact, the word metal is from the Greek 'to search for.'

3.6.1.3. Relational Elements
We know that land-use and land cover changes are major elements in affecting the global carbon dioxide cycle, both the source and sink. Renewal occurs through a dissolution and recombination of the elements of a system. The system maintains its identity, despite the replacement of elements, molecules or organs. Organisms are affected by the quantity and variability of materials, if they require a minimum of them. Organisms are also affected by their own limits of tolerance to those materials. Life is limited by elements and physical factors, such as light or water; it is limited by too little of an element, such as phosphorus, or by too much of an element, such as salt. Human organisms are a geological force in the history of elements, moving minerals and disrupting mineral cycles. There is the addition of novel elements into the atmosphere, and, there is also a massive release of carbon.

3.6.2. *Molecules & Materials*
Novel elements can be created by humans and introduced into the biosphere. These elements have not been formed by natural conditions and added slowly over time as the result of natural processes.

3.6.2.1. Inorganic Materials
Inorganic molecules do not contain carbon. Inorganic molecules usually come from mineral sources; this includes metals and inert gases. Inorganic molecules, such as silicon, iron, and titanium are often used by human technologies.

3.6.2.1.1. *Carbon Dioxide*. Carbon dioxide is the second raw material necessary for photosynthesis. Forests not only assimilate CO_2, but CO_2 concentrations in forests may be three times higher than "normal" air. The higher CO_2 content is thought to contribute to undergrowth and seedlings growing in low intensity light under the canopy.

3.6.2.1.2. *Impurities*. Impurity refers to a state of mixture. Impurities are often taken up by living organisms, who then have to separate the nutrients from the undesired elements. Volcanic action can produce sulfuric acid that can injure trees—smelters, cities, and fires also produce toxic substances.

3.6.2.2. Organic Materials
These bacteria photosynthesized away their time for a billion years, producing oxygen and organic matter from carbon dioxide and methane. Forests build soil and then protect it. Trees assist soil formation with the addition of organic matter and the activity of roots. The organic matter is a result of: Living tissues, such as roots or fungi; soil biomass, such as microbes and earthworms; leachates and exudates, such as sugars or enzymes; litter, such as twigs and leaves; coarse woody debris, such as logs; and, organic compounds, as a result of litter decay—this humus can be over 90% of the organic matter. Organic matter has the effect of gluing soil particles together. Wind and water erosion are both usually reduced. Organic matter in the soil acts as a reservoir for nutrients and possibly a sink for carbon.

Matter also participates in cycles—not gaseous, but sedimentary, since the reservoir is the earth's crust and not the ocean or atmosphere. Oil, coal, peat, and some woods are functionally nonrenewable. Geological time periods are required to produce them.

The original vegetation cover of the planet was extremely diverse. The potential natural productivity of wild vegetation may be 120 billion tons of dry organic matter per year. But, not all of that is available for human exploitation. The proportion of net primary productivity (NPP) above ground could only be 80 billion tons. These are all rough approximations. This is the theoretical amount that would be produced by wild vegetation with no major environmental changes.

3.6.4. *Elements As Resources*
Virtually every material cycles through the forest: Nitrogen, carbon, phosphorus, potassium, calcium, sulfur, magnesium, and water. Nutrient cycling involves many of these materials. Nutrient cycles change with the succession of an ecosystem. Many of the nutrients for new growth are drawn from senescing needles and twigs in a forest ecosystem.

In most ecosystems, the minerals and elements have been concentrated by plants so that those necessary for life are more abundant: carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, and magnesium. Some of these elements, such as phosphorus and nitrogen, are not abundant in rock and may be available only in soluble forms (which requires water); they are available for growth only as they are cycled.

Materials, often in the form of ions, are released from litter and soil depending on their chemical characteristics. These are then absorbed at different levels as they percolate through the soil. Each species of tree has a unique propensity for taking up different soil solutes.

These materials become involved in cycles of use, release, and reuse. Some cycles, such as the leaching of cations (negatively charged parts of molecules) from leaves, then being taken up by roots and returned to leaves, are completed quickly (under a month); other cycles, such as the deposition of carbon in coal, are measured in geological time.

3.6.4.1. Nutrients

Removing even single trees in a forest can diminish nutrients in the system and affect or disrupt cycles. Other aspects of logging operations, such as skidding and clearcutting, can have an effect on nutrients, because of resultant exposure, compaction, erosion, and added chemicals.

The interactions among nutrient elements influences the nutrient cycle. David Perry notes that divalent cations, such as calcium or magnesium, enhance phosphorus uptake by mycorrhizal and nonmycorrhizal roots in a coniferous forest. The concentration of soluble phosphorus in the roots determines how fast and how much is taken up. Phosphorus combined with calcium (for instance) forms insoluble granules in cells, so more can be taken up and stored (the sheath of ectomycorrhizae increases the number of cells that can be used for storage.

3.6.4.2. Organic Energy

Energy can be bound in electron orbits, as well as in fats and lipids. Therefore, molecules, as well as plant and animals species, can be treated as resources. Organic energy can be released by consuming or burning. Fossil fuels are extremely concentrated organic forms. Some processes can release energy through fusion or fission. Almost all energy on the planet comes from the sun or from the original energy of the formation of the planet; energy cannot be recycled, but it can be trapped for long periods of time in various forms.

3.7. *Global Design Factors: Events Processes Flows & Connections*

Processes are responsible for the distribution of elements. This results in renewal. Processes range from wind and fire to erosion and succession. Most all processes require energy acting on materials. The sun is the source of energy for most processes, but we have to recognize that the human use of energy has consequences to the natural systems, especially when too much energy is dumped into a the system in terms of waste heat.

3.7.1. *Processes*

Global or universal processes include entropy and ektropy. Communities replace one another as a result of orderly processes (e.g., succession). In his approach to thermodynamics, Boltzmann applied statistical mechanics toward interpreting the properties of the microscopic system which make up the macroscopic ones. Entropy is determined in a completely different manner in statistical mechanics. Statistical entropy became a measure of disorder, described mathematically in six-dimensional phase space. This application not only reduces the level of explanation, but also changes the coordinates from heat and temperature to space, time, and force; it explains thermal equilibrium as the result of an undefined universal shuffling process.

A process opposite and complementary to the shuffling of entropy—a sorting process—has been proposed independently a number of times, from Georg Hirth to Schrodinger, Szent Gyorgi, Woltereck, and Whyte, but not developed adequately. With the connection of entropy and information by Claude Shannon, the concept of entropy has been extended to applications in engineering, art theory, Gestalt psychology, and cosmology.

In describing a general concept of nature, some ecologists follow Prigogine in emphasizing process over structure. Each assumes that energy flow is more primary than matter, that energy is a more fundamental reality than discrete entities. Although an organism may be characterized as a `configuration of energy,' that is an artifact of the quantum perspective (and, perhaps, of the desire for an absolute reality). There are philosophers and ecologists, such as Ramon Margalef, who consider `information' to be more basic than energy or matter and more in-line with patterning. But then organisms are reduced to information in a cybernetic perspective. These perspectives are useful to an understanding of complex behavior, but still reductive.

During the history of the planet, solar radiation 'worked' on the gases and compounds of the early atmosphere of the planet, which was composed of carbon dioxide, nitrogen, sulfur, methane, etc. Gradually, complex molecules built up from chemical processes driven by solar energy, the radioactivity of the earth and the geological processes set in motion by the formation of the planet. The effect of a bombardment of energy from the sun on rock over time results in the weathering of rock. The disintegration of rock from physical and chemical processes produces a substrate for soil. The physical layering of erosion results in a profile. The procession of living beings, from algae and lichens to ferns and trees has resulted in considerable organic matter getting mixed in to rocky rubble, resulting in soil.

In ecosystems, each level of integration has distinct attributes. A population has a property 'density,' the number of individuals per unit area, which is not applicable to individuals; a community has 'species diversity,' which is meaningless at the population level;

processes like homeostasis or homeorhesis (Living systems do not display homeostasis—constant value—so much as a particular course of change in time—homeorhesis. The course is stabilized, not the constancy, according to Conrad Waddington. Changes to a system are symbolized by trajectories in a multidimensional phase space or landscape), which involve a relationship with the environment, occur on an ecosystem level. In sum, each level acquires additional characteristics. Three processes—individuation, interaction, and evolution—are addressed in more detail.

Succession appears to be a process of self-organization occurring in every cybernetic system with the properties of an ecosystem. Process is the same as acquiring information. The ecosystem learns the changes (i.e., seasons) of the environment. Any system formed by reproducing and interacting organisms must develop an assemblage in which the production of entropy per unit of information is minimized. It is a general property of some systems that acquired information is used to close the door to further inflow. Climax needs less information, since it wants only preservation. Limit of climaxes allows maximum variability between systems with slight external differences, like temperature. Ecosystems consist of different prefabricated pieces: species. The supply of species is limited, so succession becomes asymptotic. Climax is an information ladder; at the top, there is no more information.

Successions are stopped by fluctuations, by volcanoes or storms, Margalef calls the process exploitation; adding that its effect is rejuvenating. Whatever accelerates change and energy flow in ecosystem reduces potential maturity. In an exploited system, diversity drops and the ratio of primary production to biomass increases. Mature systems can regress to earlier forms when exploited; then new species can form. Ecosystems are constantly evolving under the influence of physicochemical processes poorly understood and so far more powerful than those that result from human activities. The reality is more complex than just systematic succession and climax. Plant diseases, plagues, floods, volcanoes cannot occur too often. Nature can purify air and water, reseed devastated areas.

Varela states that succession is the result of an indefinite iterative process with a stationary end state to which variables tend. This cannot be true, any more than a shark is an end state in the ocean. Succession in ecology resembles evolution in general biology.

The process by which species reorganize their structures to adapt to the environment is evolution, an integrated, partly open process that selects whole individuals in whole environments. Evolution flows upwards and outwards as well as inwards and downwards, from the simple to the complex, but also back again. Evolution uses different levels: the chemical has generally been replaced by electronic. Plants are generally chemical; electronics becomes important with motion for processing information. But electrical systems outran their design (hunting) in humans.

Evolution runs in a direction of enhanced individuality (genetic autonomy), the dynamic process of generations. Mayr held the view that genes mutate, organisms are selected, and species evolve. Therefore genes are selected only indirectly, if the organism survives to reproduce. But, according to theorists like Gould or Stanley, special groups (populations or species) can be selected.

Evolution is an integrated process; partly open-ended, involving choices, selection of whole individuals in whole environments. The cost of evolution by selection is so heavy that most of the time most populations are not perfectly adapted to changing environment. Evolution is never total adaptation; it requires destabilization; a risk accompanying all innovation, a self-presentation offering new symbiotic relations. At all levels evolution includes freedom of action as well as interdependence. The ultimate principle of evolution does not seem to be adaptation, but transformation and diversification of evolution. The death of individuals and species furthers evolution.

Evolving systems play between adaptation and nonadaptation; completeness of either would result in death of system. A niche fits a species sufficiently without defining it and the reverse. Portmann pointed out numerous functionless features of evolution. There is always extravagance and beauty of features. Margalef describes the baroque of the natural world, meaning that there are many more species in ecosystem than would be necessary if biological efficiency alone were an organizing principle. This is the misconception of the fullness of nature. Nature is not full. Plenitude does not obtain in nature because species do not evolve effectively and because of predation (which can increase diversity and create gaps).

Nature is both an ordering phenomenon and a series of entropic processes, which result in hierarchies, where the system adapts to its medium and the medium itself becomes ordered. If there is anything in nature truly evolving, it is always the largest structure, the total system, which imposes constraints on entities and subsystems.

Communities and ecosystems are part of a process that is unending and imperfect, without a final state, and furthermore, that the attempt to perfect it results in disharmony. Ecoforestry accepts a constructive conflict in scale with the ecosystem. There are chaotic events, plagues and random frenzies in every system. Odum describes the ecosystem as a unit of organization undergoing an orderly process of development that is reasonably directional. Ecosystems, the essential unit of ecology, must be seen in dynamic and historical terms.

Extinction is a natural part of evolution, human activities have accelerated it 10,000 times. Natural selection is the process for strengthening biodiversity, while the unnatural selection prompted by people artificially robs us of most important genetic resources.

Over long enough periods of time, many improbable events are certain to occur. Life is a rare, but very certain event. Given definite conditions and processes, it seems certain to arise. The earth is suitable for life because: Solar radiation has stayed within certain limits for 4 billion years; the biogeochemical cycles of oxygen, carbon, nitrogen, phosphorus, sulfur, water have stayed within certain limits; and, the environment has been constant enough for organic evolution, but variable enough for natural selection to be challenged.

The enormous information capacity of biological molecules makes production by chance improbable. A random process could not have produced even a single organic molecule. But once one rare event occurred, another became possible, and so on, until organic molecules are inevitable.

There are physiological processes and metabolic ones. Transpiration of trees (a vital process) results in the air in the upper canopy having a higher humidity than in the open—although absolute humidity rises marginally, the relative humidity increases the most depending on the air layer and time of day (highest humidity is late night, when temperature is lowest).

There is uncertainty in basic processes. There are also levels of uncertainty, from the quantum to the human. Elementary processes at the quantum level are not subject to a precise description in time and space. Predictions about location and velocity are just statements of probability—this is Heisenberg's uncertainty principle. The effect of this principle on epistemology is that our exact interpretation has to be abandoned. There are uncertainties at higher levels of organization as well; for instance, the hysteresis of some magnetic solids determines their subsequent behavior—without knowledge of initial conditions and all past events, it is not possible to predict present or future behavior. Furthermore, the higher up in levels of organization, the more kinds of uncertainty there are. There is uncertainty in dealing with large, wild, complex, long-lived ecosystems.

3.7.1.1. Exploiting Processes

A.N. Whitehead suggested that process is primary; living beings are self-organizing systems like vortices in an energy flow. Continual change is fundamental in renewing ecosystems. If we were to study natural processes and understand them, we could use that knowledge for regeneration and protection.

Because of the uncertainty in dealing with large, wild, complex, long-lived ecosystems, ecosystem managers have to live with uncertainty; this means that management decisions are essentially gambles. They have to ask: How shall we use forests? For wood products? To protect watersheds and maintain global biogeochemical processes? As a home for other beings? Recreation? As some kind of balance? How many forests do we (or the earth) need? What kinds, in what shapes and forms? How many should be wild?

Exploitation has to account for uncertainty and change, as well as for need and scale. Scale is a problem. Large scale exploitation almost always affects local conditions and possibly regional and global ones. Smaller scales are more likely to allow natural renewal processes to continue to operate.

3.7.1.2. Keeping Processes Healthy

Environmental monitoring is an umbrella for many activities, including climatic variables and geological processes; for example, the systematic recording of soil and air temperatures, humidity, air pressure are measured by meteorological organizations to predict long-term climatic change. Ecological monitoring is the observation of communities to understand long-term ecological processes, such as succession and maturity. The processes of many forest ecosystems have not been researched, so there is no baseline to compare measurements with (it is difficult to measure change without a baseline).

Minimum habitat protection is necessary for the protection of endangered or threatened invertebrates, which are responsible for maintaining basic ecological processes through predation, recycling, and pollination. In situ—bounded areas with little human disturbance; The problem is that few are large enough for natural processes to operate in or for minimum viable populations of large species. Use cryogenic techniques to suspend material from rare or endangered species. Plan for changes in the evolutionary process as a result of massive human technological and social impacts (e.g., slower rates of speciation due to confinement of wild populations). Build national interest in diversity projects, such as salmon or old growth.

We must perceive that natural processes are balanced; some take thousands of years, but all effect one another synergistically. We are trying to preserve the character of an ecosystem, which is maintained by a large number of processes. Natural processes, such as fire, wind, or species explosions, would be allowed to operate freely, even if they altered the functioning of the system.

3.7.2. *Events*

Western science is based on an Aristotelian logic, a Cartesian dualism, and atomism. It is basically concerned with regular, reversible events. This kind of science has never been good with unique, irreversible, long-term, complex, catastrophic, or rare events, the kind that occur in historically-unique ecosystems, although some new approaches, such as chaos theory, are promising. There are chaotic events, plagues and random frenzies in every system. Ecosystems evolved through natural events, then as an effect of human activities.

Variations in the behavior of matter and energy enable rare events to occur. In a long evolutionary process, rare events are very significant. Events can be divided into the regular kind, like heartbeats or solar revolutions that occur in cyclic succession, and irregular ones, like earthquakes or mutations. The rarity of irregular events can be measured by a period of probability. Over long enough periods of time, many improbable events are certain to occur. Life is a rare, but very certain event. Given definite conditions and processes, it seems certain to arise. The enormous information capacity of biological molecules makes production by chance improbable. A random process could not have produced even a single organic molecule. But once one rare event occurred, another became possible, and so on, until organic molecules are inevitable. Humans have difficulty observing events on this time scale. Rare events are not really studied scientifically. Rare events are also revolutionary and may be very important. Ecological history has to address rare events. Evolution increases the levels of complexity through the operation of natural events.

The environment is constituted by a large set of events that are objectively definable by their outcomes. We tend to think that forests should exhibit regularity, but many forests, such as boreal forests, are arrhythmic, that is they are punctuated by surprise events (as Holling suggests). Events happen simultaneously. Disturbances in a forest are regular but unpredictable events. Many of them kill trees. Mortality is a normal part of the life cycle. Mortality in forests usually occurs from a combination of factors. By trying to prevent one kind of mortality, industrial forestry merely sets up another kind. Ecological forestry accepts a typical percentage of death as the normal condition, necessary for the renewal of the forest. The rate of death per year in an old forest is remarkably consistent at about 1-2 percent, even with wind storms, fires, disease outbreaks, and animal damage.

Scale of events. A significant amount of phosphorus has been dropping out of the cycle into marine sediments (which will require a catastrophic event, such as mountain building, or human collection to be returned). We already mine phosphates in bird guano for our fertilizers. Some phosphorus is taken out of the cycle due to human burial customs (such as steel coffins—although cedar boxes are making a comeback in Washington state).

In the Navajo image of the world, events are primary, not actors (although the world is also personal and orderly). A sacred event may give sanction to a rock or tree. When we try to represent things that are not directly observable, because they are too small (quarks), too large (the universe), or too complex (forests), we use models (from the Latin *modulus*, meaning small measure). Models can be conceptual or physical; they can be plans, analogies, maps, diagrams, graphics, mathematical equations, or even sentences. Holling uses a graphic model (see Figure 372-1) to show how the release cycle in ecosystems is related to other cycles.

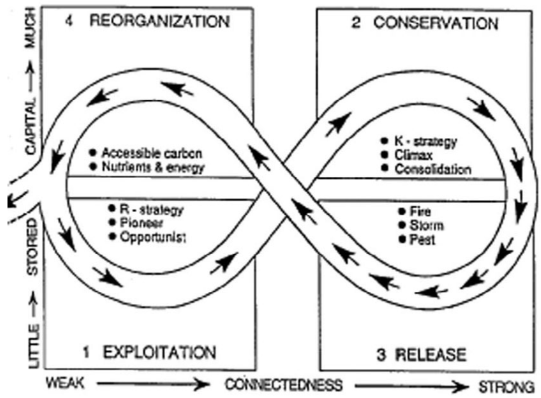

Figure 372-1. A model (after Holling) showing four ecosystem functions and the flow of events between them. The distance between arrows show differences in the speed of flow. The cycle reflects changes in two attributes: the amount of accumulated capital (nutrients and carbon—the Y axis); the degree of connectedness between variables (the X axis). The exit from the cycle indicates a flip to a different stage, that is, a catastrophe or epigenetic change—see following explanation.

These trends are partly the result of our unconsciousness of large-scale, long-term events, partly the result of out cultural amnesia about things that make us unhappy, and partly the result of our cultivated indifference (our remoteness from wild nature).

We need to create special practices for events: Keep plans flexible to anticipate and absorb rare or irregular events, such as forest fires, droughts, and disease irruptions. We cannot accurately control and predict ecological events in most ecosystems. However, we can steer some of the events in a known direction—known because we have historical records of the system, however much incomplete. We need to understand the relation of people to forest ecosystems, as well as the events that led us to our situation, now, where we have to kill forests to sustain our addictions to pretty, yellow tools and toys. Remember, chaos helped shape the forest ecosystem and us. It is still a part of the process of creation. Accept it. Go with the flow (which is also good advice from Heraklitus and Lao Tse).

3.7.3. *Elements as Flows*

Chemical elements circulate in the biosphere in biogeochemical cycles. Life is limited by elements and physical factors, e.g., water, salt. Too little limits life (Liebig's law). Too much limits life (Shelford's law of tolerance). Elements are air, light, water, soil.

Gases are elements. Oxygen is a chemical element with 8 protons in its nucleus. In fact, oxygen was poisonous to early forms of life, the methanogenic bacteria. These bacteria photosynthesized away their time for a billion years, producing oxygen and organic matter from carbon dioxide and methane. Oxygen in the air increased dramatically, as the amount of methane fell dramatically and carbon dioxide decreased. Many species of bacteria died off from oxygen poisoning and others learned to consume it. James Lovelock (the Gaia Hypothesis will be mentioned briefly then in more detail in Section 8.6) concludes that oxygen is poisonous, mutagenic (causes mutations), and carcinogenic (causes cancers), but that it has advantages to ecosystems of organisms: it enables organic matter to be recycled better; and it permits more rapid weathering of rocks, making more nutrients available. After another billion years or so, oxygen topped out at about 21 percent of the atmosphere, possibly because of the increase of forest fires (at 25 percent combustion is instantaneous and unstoppable—all forests and plants would be consumed). Lovelock suggests that the interaction between hardwood forests and softwood forests may act as a global regulator of oxygen for the planet. Fires in conifer forests burn cleanly, leaving little charcoal and decreasing the amount of oxygen (it is combined with carbon); as conifers become more successful, oxygen and forest fires decrease, allowing hardwood forests to increase (and oxygen increases again).

In addition to oxygen, the atmosphere is also composed of nitrogen, hydrogen, and argon. All organisms use hydrogen, oxygen, and nitrogen (as well as the solids like carbon, iron, sulfur, and magnesium) as structural elements.

3.7.3.1. Nitrogen

Nitrogen is a chemical element with 7 protons in its nucleus. It makes up 78 percent of the air. Because of its electron structure nitrogen bonds strongly with itself (N_2); the action of lightening can break this bond and allow nitrogen to combine with oxygen. The resulting nitric acid falls and rain and would eventually be locked up in the ocean as nitrates—except that nitrogen is fixed by bacteria in proteins and DNA (deoxyribonucleic acid); some bacteria break up detritus and return the nitrogen to the atmosphere. In fact, almost all nitrogen resides in the atmosphere, where it sustains atmospheric pressure and dilutes other gases. The movement of nitrogen into and out of the atmosphere is a nitrogen cycle (see Table 364-1).

3.7.3.2. Carbon Dioxide

Neither oxygen nor nitrogen can absorb either infrared or visible radiation. Larger molecules, like carbon dioxide (or methane or water vapor), vibrate at the same frequencies as infrared radiation, absorbing heat and reradiating it, warming up the atmosphere. The early atmosphere had a high percentage of carbon dioxide, much of it from volcanoes. The gas also reacted with rock to form limestone. Over billions of years, microorganisms and trees pumped carbon dioxide from the air and into the soil (it is only a 300th as common now—air spaces in the soil have 10-40 times the CO_2 as the air above). As trees die, much of the mass is oxidized by decomposers to CO_2. As carbon dioxide dropped, plants responded to lower levels. Grasses, for instance, can photosynthesize with lower CO_2 levels. (As the solar output increases over the next billion years, less CO_2 will be needed to maintain higher temperatures—then plants might change carbon pathways.) The carbon dioxide cycle seems to be a very slow cycle as the carbon ends up in limestone and chalk at the bottom of oceans.

3.7.3.3. Methane

Some of the methane that used to form a large percentage of the early reducing atmosphere over 2 billion years ago is still in the atmosphere at 1.7 parts per million. It is essential to keep carbon in circulation in the air to sustain life. The amount of methane moving into and out of the atmosphere is roughly the same by weight as the nitrogen (0.5 gigatons per year). Methane, as many politicians have noted, is excreted in farts by most mammals, including humans, who can each produce many cubic meters a day.

3.7.3.4. Trace Gases
Many gases, including nitrous oxide, dimethyl sulfide, methyl chloride, and ozone, also have a metabolic flux of millions of tons per year in the atmosphere. Methyl chloride, for example, is produced by fungi as well as by forest fires.

The elements circulate in the biosphere in regular, more or less circular paths called biogeochemical cycles. The movements of the chemical elements necessary for life are referred to as nutrient cycles. When one of these cycles varies, the other cycles are effected eventually. Nitrogen and sulfur cycles, for instance, are effected by air pollution. The sulfur cycle regulates the phosphorus cycle by converting it from an insoluble to a usable soluble form.

3.7.3. *Flows*
Ecological and economic processes and values are often the same. Benefits can be assessed in a common metric. Both ecology and economics attempt to understand and predict the behavior of complex, interconnected systems where individual behavior and flows of energy and material are important. There are many other common or similar processes: Resource allocation, optimal behavior, adaptation, trophic flows, element flows, and energy flow. There are other flows, including air, fluids, materials, and living beings.

3.7.3.1. Energy
Energy on (and in) the earth comes from two basic sources: From the radioactive decay of heavy atoms near the center of the earth as a result of the original formation of the planet, and from the sun. The energy from the sun is the result of nuclear fusion, where atomic nuclei are gradually fused from hydrogen to helium, oxygen, and iron under high temperatures and high pressures in the center of the sun. The constant energy from fusion pushes its way out of the sun as light.

Radiation is produced along a spectrum, with peaks depending on the kind of fusion process. Our sun, which is a medium-size main-sequence star, produces much of its light around 5300 angstrom units (yellow)—because life on the planet developed under light from this star, living organisms are very sensitive to this wavelength and in fact our mammalian sight organs have the features just the right size to collect this light. Having developed with other limitations, fish and insects see things differently. The output from the sun has not been constant over the long-term. When life first started to develop, about 3.7 billion years ago, the sun was about 25 percent less luminous. Due to the increasing complexity of the fusion processes in the sun—as the cores get larger—the sun will expand and produce more light energy. The evolution of the star is definitely a limit to take into account.

The ecosphere acts as one system in which energy from the sun is cycled. The functioning biomass is integrated by feedback responses to extract the maximum of energy and still maintain a balance. Most of the solar energy is used for maintenance by the biosphere, which is an indicator of the biosphere's high degree of ecological maturity. Chemical equilibrium is a global regulator. The steady effect of light, the availability of oxygen, the thickness of soil, and the area and depth of the oceans is almost a steady state, as is the mean temperature of the planet. Elements frequently associated with life—calcium, phosphorus, iron, sulfur—are preferentially concentrated and deposited by living organisms.

The concept of entropy will continue to be applied to biological systems as well as physical ones. The most important thing to remember about the second law is that it applies to a closed system. Fortunately the earth is not a closed system—energy is flowing through the system all the time. Furthermore, the entropy of one system may be useful to another system. The sun for example, produces light that causes pressure that balances the pressure of gravity. Once the light is diffused from the photosphere, a percentage of it is intercepted by the earth, where it is cycled in various ways. In a way, energy does not cycle because it is lost in equal quantities from the system; however, energy may be trapped by cycles on the earth for millions of years—in coal or oil, for instance.

Energy is bound into organic material, measurable as productivity. Animals and humans are dependent on this productivity. Plant productivity has impacts not only on food and energy, but on the atmosphere as well. Energy is required in all life processes, and all biological energy is converted from solar energy by green plants into chemical energy. Phosphorus is a key substance in the conversion; three molecules of phosphoric acid combine with one molecule of the base adenine and one molecule of the sugar ribose to form a nucleotide, ATP (Adenosine TriPhosphate).

3.7.3.2. Air/Wind

Wind is an influence on environment. Wind can also cause catastrophic change. Vegetation holds soil in place, reduces wind speed at the soil surface, and improves water absorption and transport in the soil. Erosion destroys soil and makes it difficult for plants to be reestablished. Recovery, if it occurs, may take decades. Erosion is an ecological catastrophe on a planetary scale, causing thousands of higher plant and animal species, and countless lower species to be lost forever.

Wind is a factor and variable influencing the environment and ecosystems. This is true also because the canopy trees change other factors, such as soil temperature and moisture, wind, and air composition. Wind is a climatic factor which can influence forests. Wind influences the shape of trees, the height of trees, the size of leaves, crown shape, and bole growth. Wind can cause continuous stress, branch death, and windfall—which depends on soil type, and age and composition of stands. Exposure determines the amount of sunlight or wind; the solar rays are more oblique on north-facing slopes (in temperate zones), while heat and evaporation are less. North slopes have other advantages relating to wind, drought and thaw-freeze, and dry-out protection.

Forests and their environments are dynamic systems. A forest exerts direct and indirect influences on many physical and biological factors, from water to air temperature, soil temperature/moisture/nutrients, humidity, precipitation, snow conservation and movement, air currents (wind), and plant and animal life (including humans). Forests moderate the direction and force of air currents, protecting the leeside environment from high, cold, or dry winds. In general all conditions are ameliorated (made better) by trees acting as a windbreak, including reduction of evaporation and transpiration.

Wind can be a threat to many ecosystems, especially forests that have exposed edges from harvests or other catastrophes. Wind can cause continuous stress, branch death, and windfall—which depends on soil type, and age and composition of stands

3.7.3.3. Water

Here on the water planet (Arthur Clarke suggested calling it Ocean), water is the dominant feature, especially seen from space. For over 4 billion years, water has ebbed and flowed over the planet. One hypothesis is that water derived from the interior of the planet, separating out as the continents started floating up. Another is that it preceded the continents. In any case, as the continents have drifted around the globe for at least 3.5 billion years, the total volume of water has been relatively constant, although the ice caps have expanded and contracted, causing the sea level to rise or fall.

The oceans are part of the global energy 'engine' driven by the sun. The oceans, along with the atmosphere, by its motion, distributes energy around the planet. Water is also a universal solvent. The oceans act as a reservoir of dissolved gases, which helps to regulate the composition of the atmosphere.

Water also cycles (see Figure 3733-1). It comes to the earth in rainfall and leaves through evaporation; it is thrown into the air by volcanic action; it flows into the ocean. By far the largest amount of water is contained in the lithosphere (roughly 20 times as much as in the oceans). The ocean holds most water. Smaller pools, in the atmosphere and circulating ground waters, are the most active and the most vulnerable to disruption and pollution. On the oceans, more water evaporates than returns as rainfall; just the opposite happens on land, causing a cycle of water flowing from land to sea, evaporating and falling back on the land. The action of water has shaped landforms, the shapes of embryos and the organs of plants. (For the power and spirituality of water, read *Sensitive Chaos*, by Theodor Schwenk.)

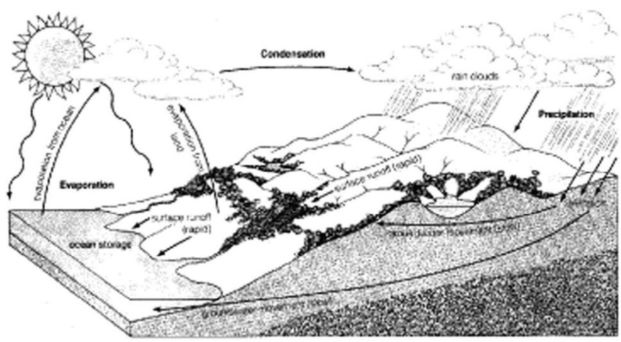

Figure 3733-1. The Basic Water Cycle. Note the possible design factors, such as vegetation, streams, ponds, and swales.

The impact of water on ecosystems is complex, considering the youth and age, deciduous or coniferous, openness or litter depths, of forests. Transpiration of trees (a vital process) results in the air in the upper canopy having a higher humidity than in the open—although absolute humidity rises marginally, the relative humidity increases the most depending on the air layer and time of day (highest humidity is late night, when temperature is lowest).

Precipitation increases over forests, especially montane forests. Evaporation from the land surface is decreased in forests (partially due to lower wind velocity and temperatures, as well as litter cover, in the forest). Winds passing over the British Columbia forests are enriched with moisture, which extends the rainfall further inland. Precipitation that reaches the land is removed in five ways: Surface runoff, seepage runoff, deep seepage (into aquifers), evaporation (from surfaces and tree crowns), and transpiration from plants.

Transpiration is the water taken up by roots and emitted from foliage and branches, a small part of which becomes part of the tree structure. Through transpiration, water is pumped from the ground to the atmosphere around the canopy. Trees consume a lot of water. A stand of beech can consume over 2,100 tons of water per year per acre—about 25 percent of the annual precipitation.

Forests not only retard runoff, but also shift the kinds of runoff from surface, which can result in destructive flooding, to seepage or deep seepage. The amount of runoff depends on precipitation, topography of the site, character of the soil and rock, and on the kinds of vegetation. By physically retarding water flow with stems and litter, which absorbs water, forests increase percolation into the soil. This water flow then affects springs and stream flow.

3.7.4. *Duration & Flow*

Stars can exist generally for 1 to 10 billion years, depending on their initial mass or other factors. Chemicals in interstellar space are linked to star formation. There are simple compounds like water, but also polycyclic aromatic hydrocarbons. Some molecules tumble in the form of gas or dust. On earth, oxygen has a metastable state as a singlet. Because hydrogen atoms shuffle from one water molecule to the next, each pairing only lasts about a millisecond. The lifetime of a water molecule in DNA seems to be about one nanosecond. The lifetime of an excited system is usually shorter than a relaxed one. An mRNA molecule in a cell may last from 30 minutes to 50 hours.

Water vapor in the atmosphere may only endure for 3 to 7 days. Carbon dioxide molecules can last from 100 to 500 years in the atmosphere. Proteins are long chains of amino acids. Proteins are polymers where the same molecular components are used again. The functions of proteins are connected to their practically infinite three-dimensional shapes. Sugar molecules have long chains, with branches and networks. Lipids are organic molecules like fats and oils; they are hydrophobic and will not dissolve in water. Cells have shapes held together by proteins. Single cells can move or be part of an organ. Nucleic acids, such as DNA or RNA, are polymers with long base chains that carry information. DNA is the code for new organisms. RNA moves the code from storage to execution at various times.

Species can last 2 millions years. Ecosystems can last millennia or millions of years. The Amazonian rainforest may be 11 million years old as a biome. Tree longevity can be up to 4000 years. Root longevity is often less than 1 year. The Great Barrier Reef ranges in age from 2 to 18 million years, although in its present form, it is only 8000 years old. Reef ecosystems may only last hundreds of years. Although the Sahara became a savanna about 10,500 years ago, and shifted again 5500 years ago to a drier state, it has been mostly dry desert for at least 22,000 years (and there is evidence of deserts in the area for 7 million years). Long-lived animals may rebound more slowly than short-lived species, which can rebound in 5-7 years. Ecosystems can rebound in 50-100 years, depending on the magnitude of destruction or time since collapse. The natural dynamics of ecosystems includes extinctions and invasions. Some ecological patterns may be almost 4 billion years old.

Natural processes—building up/breaking down, development, disturbance]—animal movement, inter-element flows, human interaction, shifting mosaics, operate in biomes, ecosystems and communities. Ecosystems and organisms are always interacting and changing. Conditions in an ecosystem are limiting factors that determine speciation or extinction. James Lovelock hypothesizes that every element in the system is related in a feedback network to every other element. For example, the biosphere can control the temperature of the surface and the composition of the atmosphere. On the other hand, soil types and the weather can limit vegetation; invasions of vegetation change soil types.

3.8. *Global Design Factors: Patterns*

What are the big patterns on the planet? At various times, ice has covered a medium to high percentage of the land and water area. The continents move over deep time and will continue to do so until the energy of the planet core is exhausted. At some time during the development of the earth, natural processes created a pattern that guaranteed the maintenance and reproduction of a system of processes. These processes were considered living. Large patterns such as living forests move across continents following the patterns of water. Mid-range patterns include vegetation, from oceanic algae to terrestrial forests. Small patterns include food webs and worm tunnels.

3.8.1. *Distribution & Density in the Theater of Life*

Living patterns, from individual organisms to the largest systems, overlay themselves on patterns of elements, nutrients and cycles. A species population, for instance, has unique properties, such as density, mortality, natality, potential, dispersion, age distribution, growth form, and structure (isolation, territoriality). Studies in secondary production are difficult because the species must be measured for population density, age distribution, food consumption and utilization, growth, and reproduction; bacterial, fungal and parasitic populations must also be considered. In a forest ecosystem, trees penetrate the soil, which can be penetrated much easier than the parent rock, to get water and nutrients to grow. The nature of soil determines the kind of vegetation on a site and the distribution of vegetation between sites. Thus, soil limits the occurrence of a species within the range allowed by climate. Soil moisture, even in a homogenous stand of trees, has a mosaic pattern, due to species and individual differences in water distribution. Thus, a diversity of microsites can govern the pattern of future tree establishment.

The distribution of forests is influenced by climactic, edaphic (soil), and physiological factors. The first two are also effected by the third, which creates microclimates and soil particularities. Physiological factors include configuration (such as mountains and valleys), altitude, slope, and exposure. The amount of water influences the occurrence, growth, development, and the distribution of forests, because water is vital for life.

Wildlife that inhabit the soil environment are sensitive to soil contamination. Air emission can cause reductions in soil organisms and shifts in trophic structures, such as insectivorous bird species. A reduction or change in decomposers can result in a decrease in litter decomposition and nutrient cycling. The distribution and abundance of salamanders may be influenced by soil pH. In the United States, approximately 50 percent of the species of frogs and toads and 30 percent of the species of salamanders use ephemeral forest ponds for reproduction. These small pools and ponds can be acidic because they receive snowmelt and spring rains that have little contact with the soil buffering system.

In their studies of biogeography (biogeography is simply the distribution of life over an area of the earth), Robert MacArthur and E.O. Wilson hypothesized a general theory of island biogeography based on the observation that the number of species (species richness) on true ocean islands is lower than it is on the mainland. The theory states that, assuming all other factors are equal, large islands have more species than small islands, according to a species/area equation. The number of species on an island reaches an equilibrium between the extinction of existing species and the immigration of new species from other areas. The rates of immigration and extinction, however, are a function of island size and remoteness. MacArthur and Wilson suggest that small islands have a reduced habitat variety, reduced immigration of species, and higher extinction rates of species; furthermore, the climatic variability is altered. These variables affect the stability and longevity of populations.

It would be difficult to develop strategies to prevent the depletion of genetic information, especially with intense public and industry demands on forests, without knowledge of the diversity and distribution of genes in the tree population. Although study of gene flow and genetic recombination is needed, a lot of this knowledge can come from careful observation of the forest, the mating systems of trees—e.g., pine species require pollination as a mechanism for outcrossing—and the shape and size of a forest area. Smaller organisms with limited distributions tend to become extinct faster. The biosphere also varies considerably in its density, from deserts and tropical seas to marshlands and tropical forests.

The greenhouse effect could drastically alter the species distributions in preserves, with the loss of many species. Placing the preserves on heterogeneous soil types and topographies increases the chances that the temperature and moisture requirements of species would be met. A range of elevations across areas would minimize the effects of climactic change—the possibility of extreme change is rarely considered in wilderness design. We need to be creating neopoetic areas with rewilding (See wilderness definitions in Section 4.7.1). Neopoetic areas may be one of the largest kinds of wilderness, now. These areas need to be zoned, with other definitions of wilderness, as well as with all other categories of use, using a formal zonagraphy to allow varying degrees of isolation from interference and industrial disturbance.

3.8.2. *Joy at Maturity & Diversity in the Theater of Life*

There are emergent properties at each level of organization, such as the diversity of species and the structure of a food web. Furthermore, each level of integration has distinct attributes. A community has 'species diversity,' which is meaningless at the population level.

Forests are what they are as the result of the diversity of life—all forms of life contribute some value to the forest as a whole. The whole forest is already self-ordering and self-renewing.

Any ecosystem not subjected to outside disturbance changes in an orderly and directional way: The complexity of structure increases and the energy flow per unit biomass decreases. The physical environment limits the type of change. Homeostatic (or homeorhetic) mechanisms protect the system from many disruptions. Thus, maturity is self-preserving.

This concept of maturity, as an attribute of a community, is related to structural complexity and organization. Maturity increases with time in an undisturbed community. The species diversity, that is, the information content, of a community also increases with maturity, leading to a more complex spatial structure. Diversity incorporates species richness (different kinds present) as well as a measure of abundance (how many of each). Other aspects of diversity, such as life cycles, are less often considered. The energy in a mature system goes to the maintenance of order and less for the production of new materials. In general, diversity is higher, and life cycles are more complex; symbiosis between species increases, and nutrients are conserved. Complexity and diversity offer advantages for living forms. Complexity allows increases in the size of organisms, which allows the colonization of harsh environments. Diversity allows more effective behavior through specialization; for example, a specialized organelle may digest less common molecules.

The number of species in an area is related to the idea of diversity, which is a description of the variety of life forms (or the condition of being different in quality—the greater the number of differences the greater the diversity). Diversity can also be related to the increase or decrease in ecosystem measures, such as productivity, biomass, and stability. Diversity is related to genetic information as well as to relationships of species (remember, predation, mutualism, etc.). In fact species number may increase depending on interactions, resources, niche overlap, redundancy, or exploitation efficiency in a community (as in old-growth). For example, deciduous forests in Europe typically have fewer species than deciduous forests in Asia or North America (as a result of ice-age effects).

Diversity, as a measure of genetic variability in ecosystem, is decreased by domestication and agriculture. Diversity is basically the bag of tricks for organisms facing environmental perturbations. Coevolution with humans reduces or destroys integration with other species; then, stability depends on human control. And human control is not always certain. Natural selection is the process for strengthening biodiversity, while the unnatural selection prompted by people artificially robs the Earth of its most important genetic resources.

The idea that diversity promotes stability has been defended and attacked elsewhere. The structure of food webs may enhance stability. May suggests that communities are more stable if they are compartmentalized (as holons, perhaps), that is, if there are subunits where interactions within a unit are stronger than interactions between units. The redefinition of wealth in an ecological framework would increase human enrichment and natural preservation. Diversity could be considered a form of wealth.

Biomass seems to increase with diversity. The native animals in Kenya, for instance, are diverse and adapted and support a greater quantity of biomass than domestic animals that are replacing them. Diversity is an expression of the dynamic properties of a complex system. It seems common that a complex of circumstances allowing a high diversity also permits high stability or constancy in taxonomic composition: "nature tends to become baroque in situations permitting high maturity, with little energy left for large changes," according to Ramon Margalef. Stability and diversity are not a matter of definition for Margalef, but reflect crude impressions of the behavior of physical systems.

Concepts of stability often include consideration of diversity. Using information theory, Margalef claims that higher information content and increased interactions promote stability. Margalef was the first to propose that diverse systems were more stable than less diverse. R. May and L. Ashby argued that the opposite may be true. However, by many definitions of stability the former is true—there is still a problem with the term in ecology.

Margalef states that biomass and primary production increase during succession; but the ratio of productivity to total biomass drops. According to E.C. Pielou species diversity decreases and pattern diversity increases during succession. There is also an increase in the proportion of inert matter, and an increase in structures like paths and burrows.

Odum has noted trends in ecological succession (as an ecosystem becomes more mature as it adjusts to a stable—even if cyclic—environment):

- The community production decreases; individual lives are longer and more complex
- Diversity is high and well-organized
- There is a closed slow exchange rate, where detritus is important

• Symbiosis has developed, and conservation and stability are good
• And there is a high biomass in a weblike food chain.

The increase in diversity is related to a multiplication of niches; this process goes with longer food chains and stricter specialization. Animals on top of food chains and those with more special habits show a higher efficiency. This results in gain in efficiency in advanced stages of succession. The more mature systems are found in regions of high temperature: tropical rain forests and coral reefs. Stability should be more important than temperature; there are stable and mature communities in deep ocean, caves, cold areas.

As a direct result of these influences, conservation biology is based on a set of ethical statements that suggest approaches to research and practical applications. The statements are:

1. The diversity of organisms is good. (Diversity provides greater variety, buffers against catastrophe, and aesthetic appreciation for humans.)
2. The untimely extinction of populations and species is bad. It is a catastrophe. (Extinction is a natural process, and at the evolutionary time scale it is balanced with speciation, but humans have increased it a thousand-fold.)
3. Ecological complexity is good. (A complex natural environment supports complex interactions, such as coevolution—that probably would be lost in artificial communities.)
4. Evolution is good. (The evolutionary process leads to new species and increased diversity—relatively large natural populations in natural cycles are required for it.)
5. Biological diversity has intrinsic value. (Species have value to themselves, as well as to others and to the whole, all of which are conferred by evolutionary history and supersedes human economic valuation.)

How do we value biodiversity? The diversity itself produces tangible economic benefits, as well as contributing to the maintenance of the biosphere. To some extent humanity is psychologically dependent on diversity (as a result of a long evolutionary history). How valuable is diversity? Obviously, it is very valuable if it can be linked to ecosystem productivity and stability. Michael Swift, M. Fukuoka, and others have demonstrated in agricultural systems that species diversity benefits crop productivity; trees, beans, and vegetables, for instance increased the crop of maize. David Tilman and John Downing, in their 11-year study of grassland ecosystems in Minnesota, found that an ecosystem rich in species was able to tolerate bad drought and recover faster than a species-poor ecosystem.

We are actors in a tremendous presentation. This metaphor formed the basis of a world view where nature was a theater of violent competition. The frame of the metaphor carried the conceptual baggage of the culture in which it originated. So, over time the play supported the idea of superiority of "favoured" races in the struggle for existence and emphasized the role of competition in biological and cultural situations, at the expense of other interactions.

Alas, the metaphor needs to be expanded. All species play a temporary role in the local stage in the ecological theater. Herb Hammond notes that all the actors and acts are essential. We are foolish to think some species as more important than others—that is ignorance or wishful thinking. All species and things contribute to the functioning of the whole, including rocks and gaseous elements. But, some are invisible to us because of their size or longevity. Some play their roles in a clump of soil, others in continental landscapes. Some acts last less than a second; others take millions of years. Even if actors seem to leave the stage or the act seems over, they influence the play with their corpses and elements.

There are many stages playing simultaneously in the theater, and it is not a one-act play. The human play has converted some of the stages, subverted and converted others. The human actors are ridiculously egotistical and ignorant, pretending that the stages and theater is for them only, and other are support characters. They pretend that the less important people are in the audience, but the only audience is other stages with partial perspectives.

And, some plays are embedded in others. One play is the evolutionary play, where autopoetic beings drift through filters in the morphogenetic landscape. Another play is the human conversion of ecosystems and the urbanization of human communities (with some companions, familiars and pests).

We have trouble understanding the theater or the plays because of our physical, temporal and psychological and cultural limits. We see species and ecosystems as individuals, when most of them are in fact communities. We see walls and barriers, and not permeable filters. We see philosophical constructs of classes in isolated locales. We have problems dealing with motion, indeterminacy, ambiguity, and vagueness. We are seduced by logic and fallacies to believe that we can understand and control the play.

Although the scales involved in a planetary theater are linked by processes, in fact the scale of the planet and its evolving life forms is significantly larger and longer. As important as human changes are to us, and to the ecosystems from which we emerged and on which we depend, for the planet those changes may only bump the global system to another stable state, well within the range of those from the past 2 billion years. We are the stewards only of ourselves and our companion forms, not of the planet.

On the other hand, Francis Bacon noted that we faced four major obstacles in understanding nature: The idols of the tribe, cave, marketplace, and theater. The perspective of the tribe is our inherent tendency to interpret and measure nature through our human senses, with their limits and scale. The idols of the cave refer to our personal peculiarities. Those of the marketplace refer to errors from language and culture. Most of the errors of the theater have to do with the fallacies of our philosophies and world views, even those based on good metaphors.

Where does joy come in? We feel joy that things are always new and different, that there is enough to continue to provide and to inspire. We are actors in a process, but we are genealogical actors in ecological roles in the evolutionary play in the ecological theater. As long as we realize that we are not everything or the center of existence, we can continue to feel joy.

3.8.3. *Living Places as Invested Ecosystems*

Human places are complex integrations of nature and culture that develop in particular locations. There is a feeling of a geography. Humans invest themselves in place by living there. An invested ecosystem is a large-scale pattern of millions of minute events. The intent of describing such patterns is to have the human patterns fit with observed patterns in nature; patterns have a form, sometimes repetition, and sometimes regularity, but each of these is caused by some limiting factor. Fitting the pattern can lead to both continuity and predictability, and both of these are needed to adapt human activities to natural limits.

In describing a general concept of nature, some ecologists follow Prigogine in emphasizing process over structure. Each assumes that energy flow is more primary than matter, that energy is a more fundamental reality than discrete entities. Although an organism may be characterized as a `configuration of energy,' that is an artifact of the quantum perspective (and, perhaps, of the desire for an absolute reality). Organisms may be configured by energy through time, but, organisms are material patterns in space as well. The focus on either frame permits subtle differences and limitations in interpretation. Even if energy is considered to be primary metaphysically, organisms are still composed of the atoms and molecules that energy forms under certain conditions of temperature and pressure, and their emergent behavior is more complex than just 'energy vortices' or 'patterns of energy.'

There are others, such as Ramon Margalef, who consider `information' to be more basic than energy or matter and in-line with patterning. But then organisms are reduced to information in a cybernetic perspective. These perspectives are useful for understanding complex behavior, but still reductive. As Paul Weiss noted, the patterns of organic nature are a combination of order and diversity; order involves constraint while diversity requires freedom for difference. Maximum order would result in a static universe, where a maximum diversity would create a nonordering chaos.

Nature, for Alfred North Whitehead consists of patterns whose movement is essential to their being. These patterns are analyzed into events. Everything that exists has its place in the order of nature. This does not mean that reality is an organism or that everything is reduced to biological terms. It does mean that every thing resembles a living organism since its essence depends on the pattern in which it occurs, and not on its components. In some ways, patterns are prior to things, in helixes, light, fields, and ecology.

3.8.4. *Patterns in Invested Ecosystems*

Process applied to components yields pattern. Nature is composed of patterns. Organisms have characteristic patterns, such as the branching of trees or the cloud forms of tree crowns. Lichens have lobes, wood grain under stress has spirals. The cracks in tree barks form nets. Regularities in systems are patterns. Patterns can be seen in things or even cultures. For instance, laws of genetics are natural patterns; human customs are artificial patterns. Where the natural ratios of females to males are altered by female infanticide or other action, the pattern is semi-natural.

Mario Bunge distinguishes four kinds of real patterns: Laws, trends, correlations, and rules. A law is a stable pattern inherent in things; it is discovered; laws like gravity are boundless; biological laws are bounded. After the 'Big Bang,' gravity was bounded. There are examples of cultural laws: "The inertia of a social system is directly proportional to the number of components and inversely proportional to its cohesiveness." Or: "Higher culture does not emerge in society until the basic needs of some of its members have been satisfied."

A trend is a temporary pattern, such as the globalization of capital or fertility. Trends can be reversed. A correlation, usually statistical, is a covariation of two properties, e.g., a correlation of sickness and education—but this correlation is problematic, due to fact that educated are wealthier and report their sickness more than the poor; the real correlation could be reversed. A better correlation is: Single-species forest stands can be correlated with standing armies in the northern hemisphere; standing armies were thought to be characteristic of people in tougher climates, which encourage large stands of trees. A rule (or norm) is a social convention set up by people, in force in a social system. The analysis of patterns is the strength of systems analysis.

Paul Shepard describes living natural 'objects' in terms of events that constitute a 'field pattern.' Relations are not prior to objects; they arise together. The wasp and the yucca coevolve; they are not co-linked by prior relations. Furthermore, a specimen is more than the sum of its species' relationships to an environment; it is an intentional being that, with other members of the species, can create niches, as well as adapt to them. Because the STEM field produces life, the qualities of life cannot be separated from its physical qualities. While it is true that living subjects are at a different level of description than events in field patterns, they should not be treated as ontologically subordinate. All of the aspects of the field have equal status. The ecosystem model, as a reaction to 'superorganismic' metaphors of early ecologists, attempted to be a field theory, but has been limited by its parentage, thermodynamics, and has been rejected by new practitioners.

Patterns are not still. A circular pattern through time can be recognized as a spiral (the earth's orbit for example). These patterns can be analyzed into events. Everything that exists has its place in the order of nature. This does not mean that reality is an organism or that everything is reduced to biological terms. It does mean that every thing resembles a living organism since its essence depends on the pattern in which it occurs, and not on its components. In some ways, patterns are prior to things, in helixes, light, fields, and ecology. Paul Shepard and others have written that relationships are as real as the objects that result from them. The science of ecology attends the overall pattern of relationships, beyond the details. The pattern should allow for surprises and discontinuities; it can do this if it is flexible.

3.8.4.1. Natural Patterns

Nature consists of moving patterns whose movement is essential to their being. As a rope makes the knot visible, so the body is a pattern made visible. The body is a movement that maintains a topologically stable pattern; it is a vortex but not the water. The thing, the pattern, is a cross section cut through the movement. The mind is an invisible knot that is capable of recognizing both visible and invisible patterns, that is to say, a rope is not always necessary for the demonstration of a knot.

An ecosystem has a distinct pattern, related to health. According to E.C. Pielou species diversity decreases and pattern diversity increases during succession. Protect and maintain diversity can preserve the patterns. Very small changes in complex, self-regulating systems, such as forests, that have large and important consequences, as when rainfall patterns shift after a forest is removed. Weather patterns on North America, for instance, have created 'nation states' (see Paul Colinvaux) of trees that surprised the first European naturalists because they were so different from the European forests. The large sulfur cycle is beneficial to marine and land organisms, important to the general pattern of production and composition. Some material cycles between other ecosystems or in larger patterns around the planet. Some of the cycles are daily; some are seasonal or annual; others are years or decades; a few, like the carbon cycle, are century or millennia long.

Ramon Margalef proposes maturity as a quantitative measure of the pattern in which the components of an ecosystem are arranged. The life-form communities and physical elements are related in a definite pattern, which is a real but untouchable property (structure). In general, this structure becomes more complex as time passes, as long as the environment is stable or predictable. The structure acquires a historical character.

A Principle of Uniqueness can be recognized in living systems. History creates unique patterns, especially in forests. Each forest is unique in its parts and structure, in its matter, energy, forms, information, and in its dynamics and history. Some patterns in forests are scale-dependent; for instance, hemlock trees may dominate small clusters, but be scattered all across the entire forested landscape. Pathogens determine tree mortality, which drives forest and landscape patterns. That is to say, the pattern changes with the scale. This is true of processes in forests as well. A typical forest is composed of many patterns, including vertical layering (stratification), horizontal segregation (zonation), activity patterns (periodicity), food web patterns, social patterns (including reproductive), interactional patterns (from competition or mutualism), and stochastic patterns (from random events).

There are long-term trends in ecosystems, that is, patterns of: Primary productivity, organic matter accumulation, inorganic inputs and movements through soils and water, disturbances, and populations in a trophic structure. The actual substance of which the forest environment is made consists of patterns rather than things or individual species. The forest environment is generated by a patterning of ecological ebb and flow of energy, substances, individuals and species across a suitable landscape.

The forest ecosystem is a large-scale pattern of millions of minute events. The environment requires an enormous amount of minuscule local adaptations between the earth and its users. The landscape is a unique individual, a community, a dynamic system of interacting patterns—the human pattern is a part of it now and should be preserved as part of the whole pattern, but not necessarily as the only pattern or a completely dominant one.

Evolution can be considered as a building up of complexity, an unfolding of patterns, in Maurice Merleau-Ponty's term, a 'pattern mixed-upness' of styles of living, as beings radiate through time and place. Evolution is not a hierarchical ladder or an up-escalator, but the history of forms adapting to changing environments.

The patterns of ecosystems are addressed best at a landscape level. Landscape ecology addresses the overall patterns of large-scale ecosystems (biota), thus considering the biogeochemical, atmospheric, and hydrological cycles in relation to the shape and extent of individual landscapes. The large images from satellites are exceptional for identifying landscape patterns, especially those related to the scale of species behavior, e.g., home range or breeding dispersion. Pattern can also be measured at the level of patch size and spatial relationships (that is, inter-patch distance), which is critical for relating the size of a habitat to the species in it—to apply the theory of island biogeography.

As Richard Hart mentions, patterns are the key to understanding the nature of a forest. These patterns are analyzed into events. Everything that exists has its place in the order of nature. This does not mean that reality is an organism or that everything is reduced to biological terms. It does mean that every thing resembles a living organism since its essence depends on the pattern in which it occurs, and not on its components. In some ways, patterns are prior to things, in helixes, light, fields, and ecology. Paul Shepard and others have written that relationships are as real as the objects that result from them. Ecology attends the overall pattern of relationships, beyond the details.

3.8.4.2. Cultural Patterns

Human beings create patterns, for food, places, events, and histories. Cultures create different patterns of living, from eating to building, language, relating, and changing. Many of the patterns are adaptive; some are not. Many patterns modify natural patterns. Humans have modified animal and plant associations in a different way, simplifying patterns of energy and chemical exchange, solidifying themselves at the end of many food chains as a dominant species. Patterns of eating have influenced the constitution of species and the very contours of the earth. Throughout their history, humans have used animals and plants for food and clothing. Animals were followed, herded, corralled, tamed, and finally bred. Plants were domesticated later. As technologies developed, human relationships with animals and plants changed. Hunting, grazing, and agriculture provoked large ecological disturbances.

Culture is also this kind of pattern. Culture can be analyzed into smaller blocks; the pattern of the whole organization is reflected at every division in differences of organization on either side of boundary. The wholeness of the character of a culture is reflected at every level. Patterning relates symbolic meanings in the context of a cultural system as a whole. The patterns form another level of meaning that has to be addressed in understanding a culture. Although the physical environment imposes limits and sometimes determines patterns and rates of change, the community controls the development of the system.

The general patterns of living landscapes— Patches, Corridors, Matrix, Connectivity, Extension, and Geometrization—have been duplicated in some extent by humans in agricultural fields and cities. Places are patterns of things and webs of relations that can be understood by observing and participating. Human cultures have other big cultural patterns as well, such as: Overshoot, reproductive success, ecosystem conversion, stupidity and violence, stagnation, and the asymmetry of sex and handedness.

The problems of cultures, of natural ecosystems, and of modern, industrial, corporate, urban civilization, have been documented quite thoroughly. We have identified most of the problems in the problematique, from erosion, pests, and fertility loss, to population migration and diseases, and we have addressed them separately, using technological innovations or political adjustments. But, we have not dealt with them in a whole pattern. We have not understood them as complex large dynamic systems.

The intent of describing large-scale trends or patterns is to have human patterns fit with observed patterns in nature; patterns have a form, sometimes repetition, and sometimes regularity, but each of these is caused by some limiting factor. Fitting the pattern can lead to both continuity and predictability, and both of these are needed to adapt human activities to natural limits.

4.0. Designing Nature

Due to its rotation around the sun, and to imperfections in mass distribution, the earth tilts on its axis. The moon stabilizes this tilt. This obliquity of the ecliptic creates seasonal variations, to which most plants and animals have adapted. Any changes, even relatively small ones, could be catastrophic for climate. Furthermore, plate tectonics can contribute to changes in global climate change, ocean circulation, and ecosystem disturbance. Climate change is controlled primarily by cyclical eccentricities in Earth's rotation and orbit, as well as variations in the sun's energy output. 'Greenhouse gases' the atmosphere also influence Earth's temperature, but in a much smaller way.

There are several major causes of global temperature shifts. Astronomical causes include the three Milankovitch cycles:

- A 21,000-22,000 year cycle of the Earth's combined tilt and elliptical orbit around the Sun (precession of the equinoxes)
- A 41,000-42,000 year cycle of the +/- 1.5° wobble in Earth's orbit (tilt). 2004 is in the middle of one.
- And, a 100,000 year cycle of variations in shape of Earth's elliptical orbit (cycle of eccentricity). In 2004 there was only a 6% difference between January and July.

The sun has two cycles of variability of sunspot activity, 11 year and 206 year cycles. And the solar system follows paths that cut through intersolar gas clouds and lanes every billion years.

Until humanity has the ability to control factors or cycles related to orbital changes, it will have to adapt to variable conditions over long time spans. We may never be able to design a stable solar system, given local or galactic uncertainties and changes. We may try to design planetary spheres that can accommodate some scales of environmental change.

4.1. *Global Problems: Atmospheric Change Heating & Chaos*

The atmospheric effects on temperature changes include heat retention due to atmospheric gases, mostly gaseous water vapor (not droplets), and also carbon dioxide, methane, and a few other gases—referred to as the "greenhouse effect." The atmosphere also controls solar reflectivity due to white clouds, volcanic dust, and white polar ice caps.

Tectonic changes can also cause temperature shifts. For example, continental drift can cause changes in the circulatory patterns of ocean currents. This cycle can initiate an ice age only when continental drift puts land near one of the poles, north or south, apparently regardless of the other cycles. 'Sea floor spreading' at central ridges, associated with continental drift, can cause variations in ocean displacement.

Global climate and temperature cycles are the result of a complex interplay between a variety of causes. These cycles and events overlap, sometimes enhancing one another, and sometimes interfering with one another. Therefore it is difficult to identify a statistically significant trend in climate or temperature patterns from just a few years, decades or centuries of data. At the extreme of cycles, the variation in sunlight received is less than a tenth of percent, but that difference can change atmospheric temperature by 9 degrees F (12.7 C).

Using various techniques and evidence to reconstruct a history of past climate, climatologists have found that during most of the planet's history global temperatures were probably 8 to 15 degrees Celsius warmer than our current era. In the last billion years of climatic history, warmer conditions were broken by glacial periods starting at 925, 800, 680, 450, 330, and 2 million YBP.

Around 540 million YBP, organisms began building skeletons of carbonate, as they absorbed CO_2 from seawater. This factor alone may have decreased the number of ice ages. Andy Ridgwell and his colleagues hypothesize that shell-forming plankton 300 million YBP stabilized the planetary thermostat. Planktonic calcifiers changed the positive freezing loop because they floated on the ocean and were not tied to continental shelves. This prevented too much CO_2 absorption and further cooling. About that time forests were covering the land, and this also tied the carbon cycle down somewhat. Finally, 55 million YBP, modern coral reefs drew volumes of CO_2 from the atmosphere.

During the period from 2,000,000 to 14,000 YBP, the Pleistocene Ice Age, large glacial ice sheets covered much of the Northern Hemisphere for extended periods. The extent of the glacier ice during the Pleistocene was not static, however. There were periods when the glacier retreated (interglacial) because of warmer temperatures and advanced because of colder temperatures (glacial). During the coldest periods of the Ice Age, average global temperatures were probably 4-5 degrees Celsius colder than they are now.

The current glacial retreat began about 14,000 years ago. CO_2 in the atmosphere increased steadily since then. The warming was interrupted by a sudden cooling, known as the Younger-Dryas, at about 10,000-8500 BCE. This event may have been caused by the collapse of the ice dam holding back Lake Agassiz. The release of massive quantities of fresh water into the North Atlantic Ocean may have altered vertical currents in the ocean, especially the Gulf Stream, which exchange heat energy with the atmosphere. Warming resumed by 8500 BCE, and by 3000 BCE average global temperatures reached their maximum level during the Holocene—1 to 2 degrees Celsius warmer than now. The atmospheric temperature and CO_2 levels reached levels similar to a previous interglacial cycle of 120,000-140,000 BCE. From beginning to end this cycle, the Emian Interglacial Period, lasted about 20,000 years, before the next ice age returned.

A shift in the orbit of the planet between 10,000 and 4000 BCE brought 7-8 percent more sunlight to the northern hemisphere. Rainfall in Mesopotamia increased 25-30% and available moisture increased by about 700 percent. After 3800 BCE the orbit reverted and the rainfall pattern shifted north. This event forced changes to tilling fields, double cropping, and irrigation canals by 3100 BCE. In this "Climatic Optimum," many ancient civilizations began and flourished. The city became a key adaptation to drier climates.

The global climate and the biosphere have been in constant flux, dominated by ice ages and glaciers for the past several million years. Approximately every 100,000 years Earth's climate warms up temporarily. These warm periods, called interglacial periods, appear to last approximately 15,000 to 20,000 years before regressing back to a cold ice age climate. Statistically, the end of this interglacial is near. Global atmospheric heating during the current interglacial warm period has greatly altered the environment and the distribution and diversity of all life. Approximately 15,000 YBP the earth had warmed sufficiently to halt the advance of glaciers, and sea levels worldwide began to rise. By 8,000 YBP the land bridge across the Bering Strait was drowned, cutting off the migration of men and animals to North America. Since the end of the Ice Age, the temperature has risen approximately 16 degrees F and sea levels have risen 300 feet. Forests have moved north, reclaiming land areas free of ice.

During the last 100 years there have been two general cycles of warming and cooling recorded. We are currently in the second warming cycle. Ground-based recording stations, show an upward distortion of increases in ground temperature over time, due to heat island and other effects. Satellite measurements are not limited in this way, and are accurate to within 0.1° C. They are widely recognized by scientists as the most accurate data available. Significantly, global temperature readings from orbiting satellites show no significant warming in the 18 years they have been continuously recording data.

4.1.1. *Anthropogenic Change & Global Climatic Chaos*

Is the climate entering a chaotic stage? Global warming is an unfortunate term, on the order of words as global toasting or gentle tanning. It implies a comfortable, warm future where plants grow more and people need less heat from coal. Global burning or suffocation might raise more alarms. How we use language influences how people react to catastrophes.

Human additions to total greenhouse gases play a relatively small role, contributing about 0.2% - 0.3% to planetary greenhouse effect. But, these small changes are effective in causing change. Total human contributions to greenhouse gases account for only about 0.28% of the greenhouse effect. Anthropogenic CO_2 comprises about 0.117% of this total, and man-made sources of other gases (methane, nitrous oxide (NO_X), other misc. gases) contributes another 0.163%. Of course, CO_2 and methane are triggers, and do not need to be present in massive amounts. CO_2 is a trigger for a more powerful greenhouse gas, water vapor, as heating allows the atmosphere to take up more water. CO_2 is very long-lived and 56% of it is still aloft. CO_2 levels may be as high as in the Eocene, 50 million years ago.

What will happen if it gets too high? Will all the icecaps melt? Do we need icecaps? Do we need permafrost? Low sea levels? Should we worry about the health of the planet? Is it just us that is going to be discomforted? Climate change could slow human economic and political progress, especially when combined with scientific uncertainty. More international cooperation on things like global climatic chaos is needed, in the form of the Kyoto Protocol (climate) or the Montreal Protocol (ozone). Better organization is needed. Global designs are needed to help restore forests and grasslands and develop alternative energy sources. Should we try a high-tech solution, with massive programs?

The temperature for optimum growth for plants is 25 degrees C. For humans it is about 14C or 41F. Optimum CO_2 is higher for plants than for animals; the plants would make more tissues but they would be tougher and less digestible. Plants might pump down CO_2 but that might increase O_2 which might cause a runaway positive feedback. This interglacial is warmer now, so it is more fragile in terms of interference.

We are expanding our effects. We are transforming ecosystems, such as forests and grasslands. We are inventing and using novel chemicals, such as CFCs and plastics. And, we are expanding our impacts, by using more energy and making more people. To the atmosphere, we add carbon dioxide, methane, trace gases, carbon monoxide, nitrogen oxides, chlorofluorocarbons, acid rain, and trace elements. To the soil, we change the salinity and acidification; we let it erode. We pollute water, then changes its courses and levels. We change the shape of the land, excavating, dumping, and stabilizing and destabilizing landforms. We change vegetation cover by cutting or converting, by grazing or burning, by extinguishing species or adding exotic invasive species, creating deserts and wastelands. We domesticate some animals and extinguish others, then we move around many others. All of these impacts and interactions have consequences, such as warming, altering cycles, making irreversible changes, and starting extinction spasms.

4.1.2. *Greenhouse Gases*

There are several possible causes of global climatic chaos or planetary heating. The first is increases in Greenhouse gases, such as carbon dioxide, from burning fossil fuels, volcanoes, deforestation, and respiration. What could be safer than carbon dioxide; after all, plants need it? Methane, from increase in agricultural field, rice paddies, cow pastures, termites, mining, and gas leaks. Methane is the simplest hydrocarbon, CH_4 which could be increased by the switch to a hydrogen economy. Gasoline is made of hydrocarbons, like C_8H_{18} (octane).

Water vapor increases from evaporation, and changes in water vapor are triggered by changes in CO_2 and other gases. Nitrous oxide increases from fertilizers, deforestation and fossil fuel burning. Sulfur dioxides increase from industrial and utility emissions. Ozone increases from engines and petrochemical processes, photochemical processes, and solvents.

Chloroflourocarbons (CFCs), Bromines & HFCs increase from propellants, coolants, and solvents. The HFCs and CFCs are 10,000 times better at capturing heat energy and last for many centuries. CFCs are wonder gases invented by Dupont in 1930s; their chemical properties made them good refrigerants and propellants in aerosols, and they were also used in solvents, plastics and foams. There is now about half a pound for every living person on earth. But, it had a side-effect, it destroyed ozone, by mimicking the ozone molecule and leaving only oxygen, not ozone. And many molecules last decades or centuries, such as dicholodiflouromethane (Ccl_2F_2). Corporations, such as Dupont, and many countries, especially European, are banning halocarbons and replacing them with less hazardous compounds, such as $C_2H_3C_{12}F$, which are more easily destroyed by low surface oxidation. These noncorrosive, nonflammable, low-toxic chemicals have fewer risks, except for scale effects and "side-effects."

Deforestation can be related to changes in the atmosphere, as rainforests, tropical forests, northern, and pacific forests are heavily cut. The evaporation from forests is a form of local and planetary cooling. Amazonia as a cooling system is worth 150 trillion dollars according to Lovelock.

Ozone loss is a contributor to heating. Ozone absorbs ultraviolet light, which splits O_2 into O which can combine to make ozone (O_3). Ozone is lost from photochemical reactions with pollutants and electrical discharges. Pollutants also absorb infrared radiation.

Urbanization and overpopulation are contributing factors. Human-modified environments change the surface area and increases the change. Energy comes from burning organic compounds and fossil fuels is 90 percent of that.

Greenhouse gases are increasing. This is certain. The average temperature is increasing. This is certain. Extinctions of more species are a certainty. We know the planet will heat by 2 F this century, or 5 F if business continues as usual.

What is uncertain is the rate, magnitude, and patterns of global climate change, as well as the long-term impact on the biosphere and the anthrosphere. Things are complex. By doubling methane and adding CFCs, it is the same as an additional 40 PPM of CO_2. The interglacial only added 100 PPM of CO_2. Because the system is so large-scale, there is a lag time of hundreds of years. The length of the cycles varies.

4.2. *Global Problems: Water Flow*

Our planet is a water planet. Life is water; water is life. Life is water dependent. Living beings average 75-90% water by weight. Trees are standing water. Water is a molecule, a perfect solvent, a medium for dispersal, a resource, a commodity, and a habitat. Water defines a sense of place; its state and form can measure seasons and time. It can be a solid, a liquid, or a gas. Water as a critical element of life, a means of renewal and regeneration. Water is a link to other ecological issues. Water is a metaphor.

Water defines and shapes habitats. The quality, quantity, form and fluctuation of water significantly influences the species and population of a watershed. The interaction of air, water and energy shape the weather and storm patterns of the planet. Water is critical for survival. Water is a crucial, although little-understood, resource. Human economic survival depends on water and its interconnections of place. Water ways and water sources have historically defined the locations of cites, communities and cultures—and been a limit of their prosperity. Water furnishes recreation, enjoyment and awe.

There is an uneven distribution of water on the planet. Water occurs in lakes, pond, streams, rivers, rapids, pools, currents, bayous, bays, oceans, estuaries, glaciers, snow, ice, frost, clouds, mist, fog, humidity, tides, floods, storms, springs, aquifers and ground water. It impacts the physical and ecological environments. It defines and connects ecological systems. It is collected and ingested by every living being.

Humans require water. In A. Maslow's needs pyramid, water is a basic physiological need, although it can contribute to safety and esteem needs in various ways. Water has to be in the connections at all levels for people and systems. That is, people have to be connected to the source of their water, as well as to other people to provide social comfort.

Human beings may have developed as a semi-aquatic species, according to E. Morgan. We may have used it for birthing as well as for protection. We have used water for transportation, from swimming to boats and ships. We have used it for drinking and washing food. Most environmental issues are water issues. Like land, water can be owned in a legal system; rights can be assigned, fair use can be allowed. There are issues with salt water intrusion, storm water runoff, yard and agricultural run off, non point source pollution issues, waste water treatment, freshwater and marine habitat loss, aquifer recharge, ground water protection, ground water contamination, desalinization, water diversion projects (dams and conduits), causes and impacts of changing water table heights, world wide water supply issues and projections, water demand issues, changing water use patterns, alternative water treatment options, alternative water catchment options, alternative irrigation techniques, watercourse restoration, aquatic habitats and watershed management. All of these issues and problems have economic and political dimensions.

4.2.1. *The Water Cycle Restated*

The water cycle is mostly driven by climate, meteorology, and geology—evaporation and movement down hills. The sun drives climate and meteorology. The sun provides the energy that drives the weather systems that move the water vapor (clouds) from one place to another—otherwise, it would only rain over the ocean or plant communities. Precipitation occurs when water condenses from a gaseous state in the atmosphere and falls to earth.

Evaporation is the reverse process in which liquid water becomes gaseous. Once water condenses, gravity takes over and the water is pulled to the ground. Gravity continues to operate, either pulling the water underground (groundwater) or across the surface (runoff). In either event, gravity continues to pull water lower and lower until it reaches the ocean or the lowest land basins. Geology and topography influence the cycle, by slowing or accelerating it.

Frozen water may be trapped in cooler regions of the Earth (the poles, glaciers on mountaintops, etc.) as snow or ice, and may remain as such for very long periods of time. Lakes, ponds, and wetlands form where water is temporarily trapped. The oceans are salty because any weathering of minerals that occurs as the water runs to the ocean will add to the mineral content of the water, but water cannot leave the oceans except by evaporation, and evaporation leaves the minerals behind. Thus, rainfall and snowfall are comprised of relatively clean water, with the exception of pollutants (such as acids) picked up as the water falls through the atmosphere.

Organisms play an important role in the water cycle. Water moves out of organisms quickly in most cases. Animals and plants lose water through evaporation from the body surfaces, and through evaporation from the gas exchange structures, such as lungs. In plants, water is drawn in at the roots and moves to the gas exchange organs, the leaves, where it evaporates (and is called transpiration) to the atmosphere. In both plants and animals, the breakdown of carbohydrates (sugars) to produce energy (respiration) produces both carbon dioxide and water as waste products. Photosynthesis reverses this reaction, and water and carbon dioxide are combined to form carbohydrates.

The amount of water on the planet is relatively constant. Juvenile water, which originates deep in crust, does not add much to the biospheric water cycle. Little water is lost to the reduction of water molecules.

4.2.2. *Interactions of Cycles*

Certain substances move endlessly throughout the earth's biosphere, hydrosphere, atmosphere, and geosphere, existing in different forms and being used by different organisms at different times, but always moving, always circulating. In addition to water, many other substances such as nitrogen, oxygen, and carbon cycle through the earth and atmosphere. These cycles are important to individual animals and plants and even to entire ecosystems. These cycles fundamentally influence the planet as a whole, especially by altering the atmosphere, which is the fastest global transport system of the four spheres.

The carbon cycle and heat cycle of atmosphere are limits, as are heat and water evaporation. The ability of carbon sequestration by plants is limited by water and nutrients. The health of a water system is more important than access or use. Water and phosphorus intersect in the water cycle at various times.

4.2.3. *Problems with Disrupted Cycles*

The biogeochemical cycles of oxygen, carbon, nitrogen, phosphorus, sulfur, water have stayed within certain limits, and the environment has been constant enough for organic evolution, but variable enough for natural selection to be challenged. The key term is limits. The carrying capacity of the ecosystem can sustain only a given amount of life, and there are other limiting factors that may not have a short time scale.

Human activities are modifying the cycles. We are changing the rates of nitrogen fixation, which skews the plants, especially due to leakages, applications and losses. We are increasing phosphorus 12-fold in systems. Waterborne phosphorus and nitrates cause eutrophication of streams and lakes, and even some estuaries and seas. We are changing albedo of planet, draining aquifers, diverting rivers (with dams and canals), changing evapotranspiration (from deforestation). Water withdrawals, globally, have increased 15-fold, although the population only increased by six fold (the same kind of increase holds true with energy use, also). These actions affect the integrity of the biosphere and global cycles. And, they do so rapidly. They may alter the course of biosphere development, away from the human comfort zones. How can we appraise the possibility or probability of change?

There are problems with water scarcity and water stress, not just in Africa but in Europe, Spain, Italy, and Germany. Some of these scarcities are hidden under national reasons. The demand for water increases as population grows. Cities may become more vulnerable to drought and heat waves. Water reservoirs are being drained. Water reservoirs are a significant feature of the planet. Water reservoirs take up an area of 0.5 million km^2 (less than 1% of ice-free land area). Stocks of water are part of systems. They usually change slowly. They can act as drags, delays, lags, buffers, ballasts and "sources of momentum in a system." Changes in stocks can set the pace of the dynamics of a system. The stock is a source that has in inflow and an outflow. A reservoir is a stock that lets farmers get water in dry times. Systems can have more than one stock.

The temperature or shape of water is important. Could the Gulf Stream stop? Vaclav Smil states that the Gulf Stream is not driven by thermohaline circulation. Like the Kuroshio and the Agulhas, it is a wind-driven (due to solar radiation) and torque-exerted (from the rotation of the planet) flow. He further says climate does not require a dynamic ocean. However, local weather does. The average may be the same but the details determine habitability and crops.

4.2.4. *Valuing Water*

Donella Meadows notes that any growing system runs into some kind of constraint. In the outflow or inflow or in the stocks. The higher and faster a population or system grows, the farther and faster it can fall. With exponential growth of a nonrenewable resource, even a doubling or quadrupling of finds of the resource, such as water, offers little added time for developing alternatives. Also the more the growth loops evade the control loops, the worse the fall after production.

In any commons system, there is a resource commonly shared. If it is eroded, then it can become a tragedy. The tragedy of the commons arises from missing, or long-delayed, feedback from the resource to the users of the resource. Some systems are thus allowed to get worse; this is a drift to low performance. Rivers get dirtier, the tragedy slows, and we adapt to it. All of the ways to avoid the tragedy are cultural ways, whether through education or from privatizing to regulation. Rich countries transfer technology and capital to poor, never questioning that capital or technology might not be the limiting factors. It may be clean water and ecosystems.

We need to learn to value water. There are three use values for water. Direct use value refers to goods that are consumed or enjoyed, such as water, food, or views. Indirect use value refers to environmental services, from ecosystems rather than individual animals or resources, such as climate or river flow. Option value has to do with the possibility or potential of getting benefits later. Nonuse values—there are three also—derive from the benefits of ecosystem services without using them in any way. Bequest value means passing on ecosystems to future generations of humans. Existence value is what people derive from knowing that something exists regardless of potential use. A final category of value, self-value is the value of nonhuman beings for themselves and their needs.

Simple conservation makes the most sense, as we just reduce the flow and have less to bury or deep-place in the ocean, or avoid with solar screens or aerosols. Efficiency alone promotes more consumption. Conservation may include additional rules on the size and efficiency of vehicles, no different than other restrictions on speed or driving laws.

We can identify nontrivial risks with water. We can identify areas of ignorance and fill a few in. But, we have to be willing to live within certain ecosystemic and biospheric limits. We also have to accept precedence of the health of the whole system. We have to accept multigenerational equality and commitment to general dynamic goals for health and fitness of the whole system. And, of course, have to deal with current inequities between groups and nations, as part of the program to fit in the planet.

Cheating is a trap; it is avoiding the rules. The solution is to redesign rules in the direction of achieving the purpose of the rules. The trap is seeking the wrong goal. The way out is identifying goals that reflect the real wealth. We need to focus on result not effort, on leverage points, and on where and when to intervene. Meadows cites Forrester's leverage point of growth, economic and population.

Systems goals are parameters, which can be leverage points, and can make big differences. Buffers are leverage points. Buffers are large stabilizing stocks. Delay length is a high leverage point. Balancing feedback loops is a leveraging point. Governments and corporations are drawn to a price leverage point, but sometimes push in the wrong direction.

Meadows suggests that strengthening market signals, such as full-cost accounting, does not go far due to the weakening of another set of balancing feedback loops—those of democracy. The self-correcting feedback has been disrupted by leaders who control information. Designing government here might help. Taking away the power to influence elected representatives with money might be a start.

4.2.5. *Designing Water Flows*

In Mesopotamia, farmers dug canals from the rivers to irrigate their wheat from the mountains. In many places around the world, farmers built up terraces to control the flow of water downhill. In Bali, temple systems controlled the complex allocation of water. Some civilizations dug canals between rivers. Others created reservoirs to hold water; lately industrial civilization has created huge, automatic dams to hold drinking and irrigating water, as well as to generate electricity. Some cities, like Colfax, Washington, built concrete river beds through the city. Other cities, like Providence, Rhode Island, covered the rivers with concrete roads and plazas.

How could we save the water of a river system, like the Colorado? Perhaps by assigning ownerships at each reach. Then, in each ownership, allocate 50% to the river, 30% to the first owner, then smaller percentages down stream. How can we save the ocean? Zoning or national ownership?

An artistic approach to designing water courses and water systems might help to express the sense of water in a community, as well as its role in reminding us of our individual connections and responsibilities with this resource and its continuity. When it comes to water, most of us consume it and discard it. But, droughts remind us that water is never guaranteed. Pollution shows us that water carries the history of its passage. Art can display the world as a whole.

All places are linked by global cycles. Of course each place has unique species and sets of species that function as parts in the whole planet. The whole matrix needs to be managed with water in mind. Matrix management weaves people back into the fabric that supports them and in a sense makes them subject to the constraints of ecosystem processes.

A noninterference approach to water management—the essence of a Taoist way—is to let water take its own course with plenty of room to spread. Therefore, once the temporary constructs were in place, the path of water would be allowed to develop without interference. Since flood control would be accomplished by a healthy watershed, artificial constructs such as dams and concrete channels, which have been recommended in earlier studies, would be unnecessary.

People can overestimate the power of systems thinking and think that it is a way to predict and control problems. But, self-organizing, nonlinear, feedback systems are inherently unpredictable. They can be understood generally, especially with knowledge of the goals, but sometimes need overwhelms knowledge and sense. This kind of need is a good illustration of why chickens cannot walk to the end of a fence and go around it, even when they can see the grain on the ground and have the end of the fence in sight.

Water is the kind of thing we should not try to control completely, perhaps just encourage it in other directions or prepare for its misbehavior with landscape designs that seem designed by the flow and overflow of water. Meadows suggests that we cannot control systems or even figure them out completely, but we can dance with them. And, the secret of good dancing is awareness of the music and the motions of the partner.

4.3. *Designing Spheres & Cycles*

The planet is a set of fractal ecologies that are linked by cycles in nested spheres. The planet, with its spheres and cycles, developed over billions of years. Land and ocean areas change over millions of years, as part of tectonic cycles driven by the internal heat of the planet. Is it reasonable to talk about designing continents, spheres or cycles? Certainly it is a fertile science fiction topic and within the realm of possibility. What we might be able to do, instead, is to design human artifacts and behaviors that influence cycles and spheres.

Global has been used to mean ubiquitous, that is, appearing everywhere in a widespread distribution, of potholes, soil erosion, aquifer depletion, smog, emissions. These have little impact on other local systems. Yet, because they are part of a whole system, their very ubiquitousness can influence that system. So, local generation of carbon dioxide can have global changes, such as affecting the radiation balance (from greenhouse gases) and ozone. On the other hand, truly global changes in the atmosphere and ocean may arise from changes in orbit or changes in composition of greenhouse gases.

We are not sure of the change in phytomass after 10,000 YBP or in the past 150 years. It might be only a half of the preagricultural amount. Vaclav Smil concludes that our understanding of the global scale remains poor. We could start by planning global extents of forests; this would require setting aside large areas and restoring large areas, so that the planet would have an optimum tree cover, based on largely native ecosystems. We could design paths and preserves for many species of animals and plants. Many of these areas would have limited human access or use, since they would provide 'services' to the planet and animals, as well as to humanity. This is a different kind of design, based on natural processes, but aided by human operations. It may be a more taoistic approach, characterized by benign neglect and minimal intervention in natural flows.

4.3.1. *Designing Spheres*

How can we design emergent, complexly interconnected phenomena like the atmosphere, geosphere, hydrosphere, and biosphere? Design has to recognize that the biophysical particulars are whole system emergent, and the system proceeds with feedback, making, demaking, and remaking patterns that we recognize as places that offer many possibilities for living and exploitation. The whole system has nested levels that are linked with levels of cycles in a planet-base. Many alternative patterns are tried by chaotic development, evolution and maturation. Failure is allowed, as novelty is generated by historical, constrained processes. Design has to mimic the health emphatic, but courageous neglect of reciprocal, receptive processes. Recognizing that natural order is capital creating and no-costing, design has to create its own economic forms and patterns with minimal disruption of that order—it has to interweave them within that order. It has to integrate its own processes with natural processes at the appropriate energetic and material scales. To achieve holonomic value, design has to refrain from interfering with living cycles. It has to respect geological and ecological time that is needed for ecological health and geological change. Danger and uncertainty are unavoidable aspects of change. The goals for design value have to be holistic, concerned with the whole ecological order. Finally, design has to display the characteristics of respect and wisdom to bind itself to the ecological order.

4.3.1.1. Designing The Atmosphere

Local systems do affect global systems. One large volcanic eruption can alter the weather within days. Other local actions can alter the atmosphere, although there are often significant lag times. Cutting down local forests may contribute to the discharge of greenhouse gases, such as carbon dioxide, into the local atmosphere. This may have the effect of increasing quantities in the global atmosphere, which if done over a large enough area or over a long period of time, from a hundred to a thousand years, could create a positive feedback loop that would lead to a runaway increase in atmospheric temperature.

We have identified some natural and artificial activities that potentially cool the earth: Growing trees take up CO_2; Sedimentation of plants in water or soil; DMS (dimethylsulfide) released to the atmosphere from ocean algae; Dust; and Jet contrails. DMS is the most abundant single biological sulfur compound emitted to the atmosphere. Emission occurs over the oceans by phytoplankton. These atmospheric DMS aerosol particles or droplets are oxidized to sulfuric acid and act as cloud condensation nuclei. Through this interaction with cloud formation, the massive production of atmospheric DMS over the oceans may have a significant impact on the climate.

Some people have proposed possible technical solutions to the human addition of carbon dioxide into the atmosphere, based on the overproduction of DMS. Iron doping of ocean surfaces would encourage algal blossoms, which would release more DMS, although if they died before sinking to the bottom, the situation could be made worse. Another technological approach would be pumping liquid CO_2 directly into deep ocean, so it would stay inert at the bottom; this could also be dangerous, if the material were disturbed by volcanic action or some other source of heat. We have the technology to manufacture and put in orbit some kind of physical sunscreens to reduce the input of solar radiation. They might work by reflecting light energy away from the planet. How would we get them down if we needed more light, or if a glitch doubled the incoming light? That would be part of the system of feedbacks and we cannot predict the feedbacks.

There are better, easier, cheaper ways that would eventually result in a more favorable circumstance—a balanced global ecology based on healthy ecosystems with healthy human populations. These ways would begin with a much stricter conservation: Eliminating the majority of plastics and recycling the remaining; just simply using less of everything, less energy, less burning, less consumption; recycling houses and buildings to reduce energy use and to add as much vegetation as possible for rooftop gardens or flower walls; and, rebuild the infrastructure of cities for public transportation and walking. We would also need to restore complete, functioning wild ecosystems. We could start by enhancing our local communities and cities with a healthy coverage of native trees, shrubs or grasses. Then we could restore the vast extents of forests that have been cut for toothpicks, matchsticks and woodchips. This would cost a lot, and people would complain, since we have already spent the profit from the clearcutting frenzy, but we have to do it to avoid having a desert planet later. We also have to being back the large predators and large herbivores that we have slaughtered for their meat, testicles or teeth, because without them, the forests and grasslands cannot continue. For example, the elephants and lions in eastern Africa, which are now in danger of being completely extinguished in the next 30 years, need to be helped back to healthy population levels.

4.3.1.2. Designing The Geosphere

Regarding the geosphere and design, it is not likely that we can or would want to try to anchor continents in place or try to modify their effects by adding rivers or grinding down mountains, especially due to the long-term effects and nature of plate movement. By restoring many forests and grasslands, we would return many rivers to health as a result of the pulsing of water through healthy ecosystems. Although we mine the lithosphere, our effects have more to do with ecosystems than that sphere itself. The pedosphere, however, we have been plowing up or ripping up for millennia. After restoring much of it to some form of health, we could design those areas where soil would not be sacrificed for crops, or perhaps we could redesign agriculture and just use less dramatic techniques such as seed drills or urban crops.

We could also let nature do most of the work. For millions of years, elephants, and elephantine mammals, have maintained grasslands on every continent. In Africa, elephants acted as ecosystem 'engineers by eating their favorite Acacia leaves and then trampling the trees and seedlings. Their eating habits formed elephant savannas that antelope and zebra preferred, and since lions and hyenas preferred antelope and zebra, and their leftovers attracted many kinds of scavengers and decomposers, the system was very diverse. The elephants also provided for other animals and plants: Their droppings were rich in seeds; their waterholes provided water for others; their hard trails were used by others; even their salt caves were used by bats and leopards. The social structure of elephant groups, with dependence on elders who had learned the timing and paths of movements, ensured that they kept the system stable. We need to set aside large territories for at least 2 million elephants (perhaps their numbers in 1800), with corridors connecting reserves, which can also be used by traditional or post-modern human cultures at the same time, as was once tradition.

We need to restore the grasslands and savannas in Asia, Australia, Europe, North, and South America, also, by reintroducing large herbivores or their elephantine or camelid equivalents. Where species, such as bison and wolves, still exist, the numbers can be built up; otherwise functional substitutes can be introduced, such as camels and elephants. These ecosystems would fasten more carbon into plant and animal bodies, and eventually into soil; the system would contribute to a better carbon balance than that from agriculture.

4.3.1.3. Designing The Hydrosphere

Possibly the best thing to design ocean processes is to stop the dumping of wastes, especially plastics, which are gruesomely dangerous to microscopic life. Although we have the technology to separate many peninsulas from a mainland, such as Florida from North America, that would change the course and characteristics of the Gulf Stream. Although we have the technology to separate North and South America, that change would have immense consequence on the Gulf Stream as well as on Atlantic and Pacific species. The Panama Canal caused numerous problems with competing species, not to mention exotic species carried by the vessels.

We also need to approach the ocean the same way, letting natural processes do as much of the work as possible. And, that is going to be very expensive, again because we have mined the ocean and spent the profits. But, we have to restore the ocean, and for the same basic reasons: In health, it can provide a stable source of reasonable exploitation—never again as high as when we mined it, but adequate for a reasonable human population with reasonable demands; and, very importantly, because a healthy ocean will help drawdown and balance CO_2 levels.

Whales also act as ecosystem 'engineers' by eating iron-rich prey at various depths and then excreting iron-rich plumes at the surface; these sink and filter through the food web. Whales also provide for the web of predators and decomposers that depend on them, as they are eaten or as they sink to the ocean bottom, thus sequestering more carbon. In fact, this natural system resembles, and long predates, a geoengineering proposal to fertilize the ocean surface with tons of iron, but it saves many millions of dollars and sequesters, or could sequester, billions of dollars in carbon trading, if the ocean were healthy. When the entire population of great whales and large fish species, such as whale shark and sunfish, and predatory species, such as shark or tuna, are considered, the amount of carbon fixed is considerable.

To coax the ocean back to health, we have to essentially stop fishing now, except for a few areas where it could be done at lower levels. Aquaculture operations, which pollute in so many ways, would have to be reduced drastically and heavily monitored. Reefs would have to be restored. Many fish populations, like Cod, could recover; others, like Atlantic salmon, might be reintroduced with care. Sperm whales need to increase to at least 120,000 individuals; Blue whales to over a million; Sharks by 90 percent; and, so on, all to precatch numbers. This is not impossible, but it requires our commitment and some sacrifice, because this needs to be done if our children are expected to eat, and if we want a cooler planet to grow food on, and if we want to enjoy watching whales and maybe polar bears.

4.3.1.4. The Biosphere

We have already altered the biosphere most effectively, starting with the use of fire, continuing with the hunting of all large charismatic species, and finally with the massive conversion of grasslands to host a few domestic grasses, supplemented with biocides and fertilizers, and disturbed annually with plows and planting equipment. Our unconscious interference has led to environmental changes in past 10,000 years and especially the last 150 years. The widespread use of fire for hunting and selecting kinds of plants. Then later for converting forests to fields. Wood needs resulted in massive deforestation. Other changes included: Land cover, soil changes, biodiversity loss, species invasions, water cycles, element cycles, and mineral patterns. Genetic engineering will have implications for more dramatic changes.

The the area of preagricultural forests has been estimated at 61.5 million square kilometers, by E. Matthews (1983). He estimated the reduction by 1980 to 52 million (or 15%), then by the 1990s to 29-34%. The FAO of the UN put agriculture at 15 million square kilometers, with urban areas about 5 million km^2, and water reservoirs at half million km^2. This totals to over 15% of ice-free land. Other breakdowns, from V. Smil, are: Permanent pastures, 34 million km^2; forest plantations at 6.5 million (I.R. Noble and R. Dirzo, 1997) and degraded forests 5 million km^2 (V. Smil).

Biomass means the sum of all living organisms on earth, or in a system, complete with nonmetabolizing tissues. Phytomass in the biosphere, from C.S. Potter (1999), is estimated as Land, 651 Gigatons of carbon; Ocean: 2 gigatons. In tonnage: Land, 56 Gt C/yr; Ocean, 49 Gt C/yr. A lot of biomass is in structural polymers and cell walls that provide supportive and protective roles. Forests contain 90% of the phytomass. Viral abundance in surface waters can be 10 to 25 times bacterial counts. Smil estimates the total biomass at 2200 to 4000 Gt C.

Human values for ecosystem ‘services’ range from 16 to 54 trillion dollars. Each system can be assigned a value, from ice packs to wetlands, but we ignore the operation of the entire system, where ice packs keep the planet cool enough for wetlands to operate at all. Converting grasslands to wetlands would increase the value of some services, as Smil points out, and raising the sea level would also increase wetlands and coastal areas, but that might increase further atmospheric and oceanic heating or climate chaos.

Valuing the biosphere in monetary terms is problematic. We can admit that the biosphere is valuable because it provides things of value to many species. We can also monetize the value if it would help us recognize that value in a familiar way. But, we must not lose sight of the fact that most animals and plants, most cycles, and most ecosystems do not have any monetary value. True valuation has to do with living experiences, the ability to live well and to live better. How can our appraisal be holistic if it is limited to a simple and recent economic indicator that does not apply to most systems or species? Complex systems cannot be reduced to physical elements and processes. They cannot be reduced to a simple one-dimensional indicator. Even as humans we now know that after our basic needs are met, overage in monetary values does not greatly increase happiness or satisfaction.

Some scientists, including B. Allenby (2000), argue that the biosphere itself is a human artifact. And, because of this, we need to manage it and engineer it. But, if necessary, our management has to be adaptive. It has to be based on an understanding of uncertainty, ignorance and the wild processes of change. Ignorance is a problem. We are ignorant of the chemical processes that formed life. We are ignorant of the current processes. The biosphere is unpredictable. Design has to recognize these limits.

4.3.2. *Designing Cycles*

A pattern is a regular array of similar units. The units do not have to be exactly the same shape or size, and the regularity does not have to be perfect. Many of the laws of physics are nondeterministic laws (or stochastic) and they influence natural and human systems. Our ignorance of them lets us get caught by surprises. These laws create patterns in space, as well as in human history. There are simple kinds of patterns. A linear pattern tends to be interpreted as progress or regress. This is the dominant concept of modern history, unending progress. Despite the chaos of individual events, there seems to be a direction.

The circular pattern, suggested by the myth of eternal recurrence, depends on regular repetition, as with the seasons. It allowed disintegration to be replaced by regeneration. The helical pattern is innovatively cyclic and the cycle is additive and seem to each reach a higher stage. Finally, there are nonlinear patterns. These seem to have more surprises due to the acceptance of complex nonequilibrium systems. They may evolve in a definite direction, but move by leaps and turns.

The definition of stability is related to linkages, especially flows and cycles at different scales, with other species and scales. This is why human improvements are often not stable. It is homeorhesis. Nothing is fixed or static. Everything is changing and flowing. But that is not design. That is bottom-up flowing and forming in nature. Nature has no design, no intent.

The world is a whole. All places are linked by global cycles. Of course each place has unique species and sets of species that function as parts in the whole planet. In that sense only there is no wilderness. We tend to divide them by boundaries (of our mental models) and classify them as wildernesses or domesticated areas.

Humans are increasingly perturbing planetary biogeochemical cycles. In addition to impacting the carbon cycle, humans have doubled the natural global sulfur emissions to the atmosphere, doubled the global rate of nitrogen fixation, enhanced levels of phosphorus loading to the ocean, altered the silica cycle, and perhaps, most critically, altered the hydrological cycle. Relative to many natural perturbations, the effects of human activities have been extremely rapid.

4.3.2.1. Atmospheric Cycles

There may be some cycles that we probably cannot alter, according to Vaclav Smil. They include the evaporation-precipitation cycle dominated by the ocean or the nitrogen cycle in the atmosphere. Nitrogen used to be fixed by lightning and natural biofixation, but now synthetic fertilizers and the combustion of fuels adds another 100% of reactive nitrogen to the biosphere. This creates tremendous interference in the global nitrogen cycle. Can we wean ourselves of fertilizers? We can decarbonize energy, but cannot denitrogenize life in organisms and ecosystems.

Carbon dioxide is an atmospheric constituent that plays several vital roles in the environment. It is a greenhouse gas that traps infrared radiation heat in the atmosphere. It plays a crucial role in the weathering of rocks. It is the carbon source for plants. It is stored in biomass, organic matter in sediments, and in carbonate rocks like limestone. The primary source of carbon/CO_2 is outgassing from the Earth's interior at midocean ridges, hotspot volcanoes, and subduction-related volcanic arcs. Much of the CO_2 released at subduction zones is derived from the metamorphism of carbonate rocks subducting with the ocean crust. Much of the overall outgassing CO_2, especially as midocean ridges and hotspot volcanoes, was stored in the mantle when the Earth formed. Some of the outgassed carbon remains as CO_2 in the atmosphere, some is dissolved in the oceans, some carbon is held as biomass in living or dead and decaying organisms, and some is bound in carbonate rocks. Carbon is removed into long term storage by burial of sedimentary strata, especially coal and black shales that store organic carbon from undecayed biomass and carbonate rocks like limestone (calcium carbonate).

We do have the ability to influence carbon sequestration or carbon emissions in carbon dioxide. To stabilize carbon dioxide concentrations in the atmosphere to 450 ppm, various models suggest they must be reduced by 50 percent by 2050 and 80 percent by 2100. Another group has targeted the number at 350 PPM, as a threshold number. It might be better to put the target at 240 and then try to limit it to 275, the number before 1800 AD. Is global climatic chaos something that can be changed on a human level? Will a warmer world be worse? Yes, for cold species most likely. Yes, for many human companion species. Should we give up and let it happen? Should we do the best we can with the least waste? We need to make changes to avoid human and other suffering, rather than try to balance the planet. As if we could. Do we know enough about how the planet moderates the atmosphere? Should we try to trigger these? The physicist and novelist Gregory Benford suggests two strategies: Hide the carbon by burying it in the Gulf of Mexico; and reflect away sunlight. Both of these require large-scale technology or a large-scale concerted effort (to be discussed under Technology). Anthropogenic changes to the atmosphere are usually limited to trace compounds such as carbon dioxide or aerosols from biomass burning or fossil fuel combustion.

A famous example of a feedback cycle is the scheme proposed by M. Shaw, and later by Charlson, Lovelock, Andreae, and Warren. In this model, global temperature homeostasis occurs through a negative feedback cycle of phytoplankton, which produces dimythylsulfide, which gives rise to cloud condensation nuclei, which aid cloud formation and thus diminish incoming solar irradiance and global heating, with a consequential adverse effect on phytoplankton activity. The chain of influences becomes cyclic, with a net negative feedback.

At smaller scales we can assemble genomes and detail chemical reactions. We can also conserve and alter carbon sequestration or energy input with large-scale technological approaches. But, we cannot predict the changes to atmospheric cycles.

4.3.2.2. Water Cycle Again

The water cycle is driven by climate and geology. We are influencing the water cycle by increasing the rates of evaporation. This is through the drawdown of ten-thousand-year-old aquifers. Too much water in a system or cycling through a system leaches nutrients, resulting in a nutrient-poor environment, such as tropical rainforests. Although the rainforests have a tremendous biomass, they need rapid nutrient-cycling to survive. Cutting trees and burning shrub areas can result in erosion, which depletes nutrients faster, so that the environment is not capable of supporting regrowth of rain forest nor even swidden farming. Cutting trees on a large-scale or over a large area in a rainforest is to be avoided.

We need to keep the reservoirs for water, like the ocean, healthy and clean. The exchange pools for water, such as clouds, need to be in active turnovers.

4.3.2.3. Solid Cycles/Nutrient Cycles

Some material cycles between other ecosystems or in larger patterns around the planet. Some of the cycles are daily; some are seasonal or annual; others are years or decades; a few, like the carbon cycle, are century or millennia long. Human beings do not pay much attention to very long cycles or to those we perceive as not affecting us. Alan Drengson is fond of saying we do not see important operations of nature because we are looking through the wrong paradigm (a paradigm acts like a pair of glasses, focusing on what we want to see).

Many cycles are investigated through ecosystem analysis, where energy and materials are traced through transfers through compartments in an ecosystem. This information is critical for designing cycles. Design for an optimum phosphorus cycle, for instance, has to do with keeping it in cycles, but out of the ocean. And it is equally important not to concentrate it in agricultural systems or water bodies. As for the nitrogen cycle, human interference in forest cycles can collapse the residence time; for example, clearcutting alder in Washington State causes very high nitrogen losses. We have to make sure that nitrogen is abundant, but not too abundant, as it is in many agricultural systems. The nitrogen flux is not particularly high. For the nitrogen cycle, we need to keep the transfers, such as precipitation, throughfall, leaching, litter fall, mineralization, fixation, and denitrification, moving. We need to make sure the compartments of the nitrogen, that is, the atmosphere, vegetation, forest floor, and mineral soil, are optimally full.

4.3.3. *Conclusion: Designing to Adjust to Change*

We could design civilizations to minimize or avoid collapse. Such designs would have to determine optimum areas for wilderness and food-producing areas, the relate the human population and intensity to that. That would involve setting goals. Then we would have to survey and monitor resources and ecosystems. We would have to figure out how to make budgets for all foods (maybe in terms of kilocalories), then make budgets and follow them.

For instance, to address atmospheric warming, we could create a series of planet carbon budget. First we would set up an emergency budget, using carbon totals from 8000 YBP. This would sharply decrease carbon emissions. Then, figure a second budget with carbon emissions from 1400 or 1800 CE for 10-50 years later. Finally, we could install a permanent budget, by calculating a world cultural carrying capacity (CCC), based on ecosystem productivity and population goals. We would sum all capacities and assign that to be 100%. For example, if China has 13% of the CCC, then it would get 13% of the carbon use at 8000 BP levels or at whatever level was decided on.

All corporate CEOs have things in common, even those of energy companies: Responsibility to a board, shareholders and employees. The benefits of Contraction & Convergence, a suggestion by UK politician Aubrey Meyer, is this: Everybody has an equal right to pollute with greenhouse gases. This right could be traded, similar to those outlined in Kyoto. Under a global C&C agreement, citizens of the US would have to buy or trade carbon credits from poorer countries where people use a hundred times less. Meyer suggests 3 steps. Reach an international agreement on a cap on atmospheric CO_2 concentrations. Then, estimate how to cut back to that goal, Then, divide the budget among the worlds population on per capita basis. That would not work; that is why it should be based on a CCC number, as above—otherwise the system would reward fast breeding.

We understand that many factors can potentially cool the earth: Growing trees take up CO_2; the Sedimentation of plants in water or soil; dust and jet contrails, and DMS (dimethylsulfide) evaporation into the atmosphere from ocean algae). DMS is the most abundant single biological sulfur compound emitted to the atmosphere. Emission occurs over the oceans by phytoplankton. These atmospheric DMS aerosol particles or droplets are oxidized to sulfuric acid and act as cloud condensation nuclei. Through this interaction with cloud formation, the massive production of atmospheric DMS over the oceans may have a significant impact on the Earth's climate.

We need a push for sustainability. Right now, we have problems agreeing on anything. Will a grave emergency alienate those who do not recognize it or care? Or will it galvanize them into acting? There are many things we can do, from small things, to effective things, to heroic things. We can regulate our lives, especially the three Cs: Cattle, cars, and chain-saws. What kind of things can we do?

There are five small things, of course, and these are heavily recommended and advertised: Save energy with better light bulbs; Drive less, travel less; Consume less, consume smarter, and stop using CFCs; Conserve more land; Suggest changes, and participate in making changes.

In addition, there are five effective changes that are more difficult on a personal level: Stop eating meat; Share tools and machines; Stop deforestation and plant a lot of trees; Reduce conversions of wild systems to croplands or pastures; Change the tax structure.

Then, there are five heroic changes: Reforest regions; Turn off the air-conditioning; change energy generation to alternate sources like solar or wind; Do not have children; Stop building new houses; and Participate in a Jeffersonian revolution.

Reducing human population would make everything else easier. We could start by having a year of consideration, where no children are planned. We could base population on ideas of ecosystem and cultural carrying capacities.

We could cut our wastes dramatically, simply by using less and sharing more. We could place waste in the context of industrial ecologies. To reduce the chances of anthropogenic atmospheric heating from carbon dioxide, we could start a carbon budget for the planet, by decarbonizing the power grid with solar, wind, and other sources; we could ban new coal-fired plants and regulate existing ones; we could extract CO_2 from the atmosphere by planting trees under permanent agriculture.

We could reduce our transportation networks, especially road and logging roads. We could cut transportation by half, by not travelling as much or as ignorantly. We could optimize transportation; cars have to have 40 mpg or better, and increase the number of hybrid or solar cars. Trains could be solar or electric. Ships could return to sailing, perhaps clipper ships, especially for cross-ocean trips. Airplanes could be grounded regularly.

We could stop expansion of urban and agricultural areas. We could severely reduce the conversion of wild ecosystems and preserve larger wild areas; and, we should preserve wisely, with north-south ranges, as well as regular, wide corridors to connect wild areas and allow animal populations to exchange individuals, even through cities and fields.

Is that it? Things are really complex, but we should try to make it better. We do not need to protect the planet as much as fit within its limits and healthy cycles. The cycles are connected in many ways, such that we need to refrain from interrupting them. Making natural cycles and processes visible brings the designed environment back to life. Effective design helps inform us of our place within nature.

Figure 45423-1. David Parker (left), unidentified state biologist, and Mike Barnes consider restoration options for Woodford Creek, Oregon (finished in 2003).

4.4. *Designing Elements to Bioregions*

We could actually place landforms of various heights and shapes to precipitate or channel water. We could create forms to channel wind and noise, as well as change shade patterns and water flow (in fact, we have already done this in cities with blocks of large buildings). We could set up conditions where natural processes modify the structures over long periods of time (in fact, this is what happens when we restore streams and forests). Natural processes, such as building up and breaking down structures, development, disturbance, animal movement, inter-element flows, human interaction, and shifting mosaics, need to operate freely in landscapes.

4.4.1. *Designing Elements & Processes*

Most stable elements have been around for billions of years. These elements have been incorporated in biogeochemical cycles that are crucial for life. Although we can create new elements physically or chemically, they have limited lifetimes and limited use. Molecules have been combined chemically to replace many resources that were rare or located elsewhere. Many of these molecules are exotic and have not been incorporated into diets or cycles. They tend to behave like inorganic molecules, even those based on carbon. We need to try to design molecules that can be used as nutrients or resources, yet can be broken down into elements by natural processes such as wave action or digestion. Plastic nurdles is a good example of a molecule that needs to be rebuilt (See Section 6.8). Many processes do not need to be designed, but we need to design human behavior around them, so they can continue to operate. Surprisingly, this would include: Decay, soil production, litterfall, temperature or precipitation changes, which are highly variable, tectonic flow, climate change, fires, and earthquakes. Would should design monitoring and warning systems to avoid catastrophes. Other catastrophes could be avoided by not building on unstable or dangerous areas, such as floodplains or the sides of volcanoes.

4.4.2. *Designing Ecosystems and Landscapes*

Design itself has many dimensions. The size and scale of reserves have already been mentioned. The shape of a reserve is also of critical importance.

Edge effects started out being considered as centers for diversity. Now, many edge effects are considered to be destructive. In the 1940s, it was thought that edges should be increased to provide bountiful game crops. Edges have proven to be good for both game and weed species. Edge effects, however, are detrimental to populations adapted to forest interiors. Too many edges reduces forest diversity at local and regional scales. Different species perceive edges differently. A general rule might be that edges penetrate forest stands to 50 meters.

The pattern of a design is also important to control patchiness and fragmentation and to allow for future change. For example, for a Palouse grasslands preserve, a spider-shaped area was recommended to incorporate many north-facing slopes and to allow for possible greenhouse effects (Wittbecker, ICE 1986, and *Wild Earth* 1994). A good pattern should also anticipate temporal change. Conservation biology suggests some general principles of reserve design:

- Species that are well distributed across their native range are less susceptible to extinction

than those confined to small areas.
- Large blocks of habitat, containing large populations of each species, are superior to small blocks with small populations
- Blocks of habitat close together are better than blocks spaced far apart.
- Habitat in contiguous blocks is better than fragmented habitat.
- Interconnected blocks are better than isolated blocks.
- Corridors can function to make small blocks function as large blocks, although some corridors may be too narrow for many species.
- Roadless blocks preserve interior better than accessible roaded blocks.
- Human disturbances that are similar in scale and timing to natural disturbances are less likely to threaten species than those disturbances that are radically different from a natural regime.

Naming the elements of a landscape, such as ridge, hollow, or river, helps to identify the priorities of design. Lucas suggests that the less dominant features can be unobtrusively changed with good design. Forest fragmentation, for instance, can be reduced through the design of forested areas, taking into account the genetic diversity of the trees, catastrophic conditions, minimum viable populations, corridors, and edge effects. The survival of organisms usually depends on one of two factors in the web of relations. These factors can be modified by design. Conservation biology can make several specific recommended practices that would preserve diversity and complexity in forests (and avoid numerous extinctions).

- Stop logging old growth and mature natural forests. Grant timber leases that are contingent on the maintenance of productivity and diversity of the land.
- Promote cutting practices that respect the productivity and complexity, leaving snags, logs, and many-aged forests.
- Maintain natural habitat structures in a surrounding wild matrix.
- Reduce fragmentation through the design of forested areas, taking into account the genetic diversity of the trees, catastrophic conditions, minimum viable populations, corridors, and edge effects.
- Maintain and restore natural connections. Avoid artificial connections. Stop constructing new roads; close and revegetate old roads; integrate new roads.
- Retain the structures and processes (which produce the complexity and diversity) of the system, including legacies and special areas. Soil is an important structure.
- Restore clearcut areas; replant with native species.
- Restore damaged streams and wetlands.
- Recommend that reserves be made large enough for minimum viable populations and minimum viable ecosystem areas.

Because current reserves are usually too small to hold viable populations, corridors must be planned to intersect with the larger areas set aside, and highway routes and underpasses must be modified. According to Harris, highways are a major force in fragmenting habitats. Conservation biology recognizes the need for planning at a landscape level. The design of forests is vulnerable to surprises because nature is chaotic (unpredictable) and science itself is uncertain (by definition) about patterns of change in forests. Social and economic activities that complement and enhance, rather than oppose and degrade, ecological processes are to be preferred and encouraged (Norton, 1992).

4.4.3. *Designing Patterns & Biomes*

The word 'design' means 'marking off a pattern.' Our effort should be to make sure that we are using the whole patterns. Characteristics are qualities that distinguish unique individuals, systems, or patterns; Gregory Bateson calls them differences that make a difference. Principles are fundamental rules or laws. Standards are models or examples of quality or value established by authority or consent. Practices are behaviors in line with the aforementioned. A sample practice would be: Retaining appropriate shapes and corridors for pattern unfolding. Designs can be applied in five stages (Wittbecker 1988):

- First, review the situation, observing patterns of movement, population change, land use, building and development, boundaries, limits, and life. Conduct analyses.
- Then record all of the resources, from physical resources to cultural resources. Survey the area and create base maps, from geological to zoological maps.
- Next, evaluate the interactions in terms of impacts, needs, goals, and limits. Assess the whole system and create a series of plans, from the site plans to value plans.
- Start to design, which is a community process requiring the participation of all people (including the elderly, handicapped, and poor, as well those ultrahuman beings who cannot voice their concerns). Synthesize simulations and models (conceptual, capability, and suitability). Make another series, from landscape to policy and master plans.
- Finally, implement the design together and start to maintain it. Use appropriate measures and techniques, emphasizing native species over an adequate time period to ensure the stable processes of transformation. Provide services for continuity and management.

In appraising the Forest Landscape, forest design must work within the components, structure, and function of the forest. Unless it does, it will not be long-lasting or satisfactory. Because design has to work with a forest, whose aspects are often ambiguous, fuzzy, changing, and general, design has to be able to work with these aspects. Furthermore, the design has to work within the constraints of the forest.

Designs provide a framework for natural and artificial processes to work in. The patterns in design are echoes of patterns in nature. Good designs learn to embrace error and failure, so necessary in open systems. The intent of describing such patterns is to have the human patterns fit with observed patterns in nature; patterns have a form, sometimes repetition, and sometimes regularity, but each of these is caused by some limiting factor. Fitting the pattern can lead to both continuity and predictability, and both of these are needed to adapt human activities to natural limits. A model is pattern or object representing another object; it is a tool that permits thought to be extended.

The pattern of a design is also important to provide minimum viable areas and to allow for future change. For example, for the North Slope of Alaska, a large amoeboid shape was recommended to contain as much area as possible within the limits of the range of caribou (Wittbecker, 1992). A good pattern should also anticipate temporal change.

By consciously creating meaningful ordered patterns, we can develop ways of producing widespread community wealth while positioning the community for a long, sustainable future in a healthy environment. Designs and computer-based models can permit complex explorations, as well as suggest new patterns and further hypotheses. Through thought experiments, many of the dangers and expenses of our activities can be avoided.

4.4.4. *Designing Landscapes & Fitting Humanity Inside*

Design is needed to create natural spatial patterns and temporal phases across watersheds and entire landscapes. Ecological design considers the whole context. Large-scale ecological design is based on principles specific to the scale and extent of landscapes and ecoregions, for instance: The scale of a forest should reflect the landscape; Optimum diversity in a landscape is valued; Landscape is unified when scale and diversity are optimum; Any one sense, even smell or touch, can dominate a landscape, so careful balance is a consideration; Maintain ecological and evolutionary processes in healthy forest landscapes.

The landscape provides its own metaphor for design. The landscape is a unique individual, a community, a dynamic system of interacting patterns—the human pattern is a part of it now and should be preserved as part of the whole pattern, but not necessarily as the only pattern or a completely dominant one.

Design can imitate nature on many levels, from structure and process to landscapes. We can imitate the structure of mature forests by planting on every level of the forest hierarchy, from canopy to below ground. We can use native species. We can imitate the processes of forests by allowing birds, bats, and other animals the opportunity to distribute seeds and energy to other areas or prey on 'pests.' We can create microclimates within the landscape that may shift the landscape in new directions. Planting trees, for instance, allows new species to become established in forming soil. We can mimic processes such as small fires. The design of the forest and its management must ensure that the processes operate to maintain a dynamic state. Furthermore, the context must be conserved.

According to the Forestry Commission, forest landscape design depends upon an appreciation of six key design principles: shape, scale, diversity, visual force, unity, and 'spirit of the place'. These elements need to be expanded and related for ecological design. The specific properties can be described in more detail. For instance, diversity is the number of differences in a framework. Geology, climate, disturbance, and stability all produce diversity. Landscape diversity is linked to ecological diversity, which depends on substrate diversity.

Different ecosystems introduce diversity into a landscape, but different ecosystems often can look similar. Excessive diversity can lead to confusion in a landscape design. Increased diversity also has the effect of reducing scale, so adding diversity can be used to do reduce the scale. A high level of diversity is acceptable if one element is clearly dominant or if the differences cannot be recognized from a distance.

Scale is a contrast of relative and absolute size. Scale is also determined to some extent by perception. The scale of a forest should reflect the scale of the landscape. But, since scale depends on human perception, which depends on perspective, it is difficult to keep scale for all perspectives. The scale of a landscape increases with the distance and width of the horizon and with elevation. The scale of a landscape is greater from mountaintops than from valleys.

As the scale of the landscape changes, the scale of forested land should change accordingly. Change between areas should be gradual. When a landscape seems to be composed of two kinds of texture, the ratio between them should be a golden mean (also, the ratio of a rectangle in Renaissance paintings), which is judged as most satisfying. The golden mean produces a pleasant symmetry, unlike an equally divided landscape.

The scale of agriculture and development should be related to the scale of the landscape. As it is, the creek area is diminished even more by the scale of cultivated fields. The buffer zone should be increased up the hill, perhaps to a ratio of 1:3. Of course, seen from the air the ratio would decrease radically, as most of the landscape is farmed. The scale also seems greater on hilltops. Because the highway is in the creek corridor, the scale of the landscape is reduced, and because it is smaller scale finer textures can be discerned and therefore must enter the design.

Unity is a fundamental objective of landscape design. Unity is the way the elements, including shape and scale, of a landscape are combined. Visually, a forest usually dominates the landscape.

The spirit of each place is unique (Norberg-Schulz 1980). Place is not just location; it is the total sum of objects in the landscape combined into a unique whole. The identity of place often leads to human identity, thus people call themselves by their place names. The more unique a place the stronger the emotional attachment of the inhabitants. Every place has certain characteristics that enforce the spirit of place, for instance, a strong definition of place or indicators of great age (trees or rocks), or where a place distills the essence of larger landscapes. A sense of wildness and water also contribute greatly to the spirit of place.

Each place expresses a unique combination of elements, including contrasts, dramatic features, and the presence of water. Design can work to be consistent with the recognized spirit of place. If the design recognizes this aspect of the landscape, it may be stimulated by spirit and it may further enhance it—what it should not do is degrade it. Forest design can emphasize some features above others.

Goals of good designs include: Relinking people with genius of their places, revivifying images and identity with places, and developing and maintaining identity of places.

All the elements of design can be combined in an image. Every organism creates an image of its place from what is meaningful to it. This image is what fits the organism to its place. Suckers and caddisworms have simple images; coyotes and humans have more complex ones. Boulding (1956) notes that the image as a cognitive construct of the world has several aspects—spatial, temporal, personal, relational, value, and emotional—for each individual.

Thus, landscapes abound in nostalgic or consumptive trends on many levels of explication—some are iconic, some invisible. We originally perceive the landscape symbolically, but the landscape has other functional dimensions that increase with use.

Visual force is a psychological interpretation of perceived power in a landscape. As a principle, it is embodied in psychology, art, graphic design, and architecture. The human mind responds to visual force in predictable and dynamic ways, for instance, visual forces in landscapes draw the eye down convex slopes and up concave ones—the strength depending on the scale and irregularity of the landform

The effect of a forest landscape is not completely visual, however. Smell, sound, touch, and even taste play a large part of our appreciation of forests. This is sensory force. Crawling (recommended by Gary Snyder), climbing, listening, and tasting (soil, bark, lichen, etc.) can expand our perception of other aspects of the forest.

Character is partially determined by a distinct pattern of elements in a landscape. The character may be desirable, or not, to different groups of people. Character develops out of the interactions of the elements over a period of time, usually a long time. Some of the character is derived from human perception and values, from color to balance.

When we change landforms, we have to consider how the climate and water flow will change, and then how the communities will change. We have to consider changes in cycle and spheres also.

4.5. *Global Design Factors: Forests*

Twila Jacobsen, Mike Barnes, and Alan Wittbecker

Forests hold a disproportionate amount of biomass on the planet. Forests are able to survive a wide range of climate changes. The importance of forests, not just to the balance of the planet, but for human use, is often severely neglected.

4.5.1. *Forest Planet*

The earth seems to be an ocean planet, in terms of surface area. On the land surface, there are deserts, grasslands, ocean, rivers, swamps, and snowfields, but forests are the most significant feature. In fact earth is very much a forest planet. About ninety percent of the biomass of the planet is in trees. Trees allow water to achieve greater heights, that is, to stand against the force of gravity of the planet. Trees are animated, standing water. A forest, however, is much more than trees. Trees are embedded in the vast interconnected process of living, participating in an implicate order (David Bohm's term to describe internal relationships).

Most forest ecosystems, like many marshes and oceans, are detritus ecosystems, where only five to ten percent of the production is grazed and the remainder sinks to the forest floor. This allows biomass to build up, which concentrates carbon and increases soil depth. The forests are connected to the land, air and water; everything is constantly changing in a gigantic intricate web. The patterns are persistent configurations of processes. Order and chaos seem contradictory because of our linear thinking.

4.5.2. *History of Forests: Environment & Use*

Forests have been changing for millions of years. If we could compress space-time in a macrochronoscope in low orbit over the planet for the last several billion years, it would show forests moving like shadows over the landscape, as a result of climate changes, glaciers, and shifts in moisture. Then, at one of its greatest extents, forests would start shrinking, as humans learned to use fire to select certain plants or landscapes, and as they converted large areas to agriculture. Later we would see pyramids, irrigation grids, small changes in green, the Great Wall, then gray-white cities, then smog, plumes of smoke, fleets of ships, and lights everywhere. The immense patterns are easy to detect with this imaginary device. On the ground, changes seem chaotic—forests remember, are chaotic systems—and slow.

4.5.3. *Forest Participation in Cycles*

In a mature forest very little material actually leaves the forest. It is held in cycles. Materials cycle above and below ground, between the atmosphere and trees, between trees and insects, and squirrels and fungus. Chris Maser is fond of saying that most of the cycling is invisible because it is underground or in the air. Many cycles can be investigated through ecosystem analysis, where energy and materials are traced through transfers through compartments in an ecosystem. For example in the nitrogen cycle, the compartments are nitrogen, atmosphere, vegetation, forest floor, and mineral soil, while the transfers are precipitation, throughfall, leaching, litter fall, mineralization, fixation, and denitrification. Each compartment keeps the nitrogen for a certain time, termed the residence time; for a hardwood forest floor, for example, residence time is about 17 years. Human interference in forest cycles can collapse the residence time; for example, clearcutting alder in Washington State causes very high nitrogen losses.

Virtually every material cycles through the forest: nitrogen, carbon, phosphorus, potassium, calcium, sulfur, magnesium, water. Some material cycles between other ecosystems or in larger patterns around the planet. Some of the cycles are daily; some are seasonal or annual; others are years or decades; a few, like the carbon cycle, are century or millennia long. Human beings do not pay much attention to very long cycles or to those we perceive as not affecting us.

Table 452-1. Global Changes to Forests

Human use of fire	45,000 BP ongoing—	Selection of fire adapted species. Reduced forests in Europe
Glacial maximum and warming	18,000-8400 BP	Squeezed or eliminated species; forests shift towards Equator
Human colonization of Americas	14,000	Shifted ecosystems to grasslands
Climate change Hunting stress	12,000 BP	Megafauna extinctions in N. America
Farming & domestication of animals and plants	9300 BP	Shifts in wild species. Conversion of forests to fields
Forest clearance	6000 BP on—	Europe, Middle east, Mediterranean
Climate change	5500 BP	Desiccation of Africa and Middle east
Polynesian colonization of pacific islands	2100 BP	Extinctions of endemic species, including palms
Tropical forest clearance	1750 AD	Desiccation of tropical areas
Fossil fuel use	1800 AD	Additions to atmosphere/energy systems
Industrial Forest clearance Extinction spasms	1940 AD	Interference with habitats

4.5.4. *Designing Global Forests within Cycles*

Because forests provide so many useful beings and things, such as mushrooms and wood, forests are intensely used by humanity, without regard to the limits of forest ecosystems and or to the minimum cover that they provide. Crises sciences, such as Conservation Biology and Ecoforestry, and crises philosophies, such as Deep Ecology or Radical Philosophy, are dedicated to protecting forests as well as restoring large areas of forest cover. These approaches can ask important questions about forests and forestry. For example:

- When does clearcutting increase the health of a forest, if at all?
- What is a minimum, optimum or maximum forest cover for various watersheds? Science might identify minima or maxima but philosophy can aim at optima.
- How much wood can be taken from a forest? How much biomass can be taken before the system collapses?
- What kinds of stability should we encourage or maintain: persistence, resilience?
- What is the character of nature undisturbed by human beings (asked by Dan Botkin)? Or what is the quality of nature with limited disturbances? (These are bad questions—there is no single state anyway. There is no nature undisturbed, but the

kinds and rates of disturbances have changed)

- What is the difference between exploitation in a forest and disturbance or interference?
- How much disturbance can a forest take? Is clearcutting a natural-enough kind of disturbance?
- How can we manage with unpredictability (after Chris Maser)? Science can deal with unpredictability to some extent, but philosophy can provide other analytical and synthetic tools.
- At what level should management take place? Individual? County? National? Global?
- How can we design forests for the long-term and high diversity? What are the limits of biodiversity? How much of the forest can we design?
- How can we design forests for neutral elements in interrelated processes in a landscape?
- What are we restoring when we restore an ecosystem without all the parts or good knowledge about the ones we have?
- Can we limit our take so the forest is still self-sustaining and self-repairing? Philosophy can provide images of rich frugality.
- Why do we need old growth? We can support it ecologically in terms of nutrient flow and diversity, but we should also recognize what part it plays in human psychology and myth.
- How can we apply ethics to the forest in our current sociocultural situation that emphasizes short-term profits?
- What kind of certification should we promote? Third-party only? What are the implications of certification?

These questions highlight the uncertainty we face in dealing with large, wild, complex, long-lived entities like forests. Forest managers have to live with uncertainty; this means that management decisions are essentially gambles. Gambling is a profession that acknowledges the operation of chance and makes conclusions in the absence of facts—few people are successful at it. This is an important admission, that we do not have facts to base our actions on, that nature is a stochastic process, and that ecosystems always changing. Furthermore, we do not know for sure what effects our actions will have on the forest, which used to live so long, in such diversity, in so many places. Successful gambling suggests that the proper attitudes for gambling with nature are awareness, humility and courage, not arrogance, fear and maximum use. Assuming those attitudes, we can take actions to restore forests at the global level.

4.5.4.1. *Design Goals for Extents for a Forest Planet*

Over 50 percent of the planet was forested at one time—down to about 28 percent now. We could restore at least 20 percent in the next decade, leaving all old growth untouched and the last 2 percent for tree plantations.

On the other hand, how much forest cover do we need to keep the atmosphere functioning the way we like it? Carbon dioxide (CO_2) accumulates in the atmosphere at the rate of 4×10^6 tons annually. Deforestation possibly releases about 2×10^6 tons of carbon per year (only a third as much as from fossil fuel combustion). Reforestation could remove carbon from the atmosphere. We need about 7×10^6 square kilometers of new forest to store

4×10^6 tons of carbon annually (after George Woodwell's estimates).

Estimates of the minimum forested area for the planet are more difficult to arrive at. R.A. Houghton et al. (1990) suggest that the minimum should be about what remained in 1990: about 5.3×10^9 hectares, or 40 percent of the land area, although the area remaining that year is not definitely known.

4.5.4.1.1. Local Goals

Local goals are appropriate for watersheds and habitat types. Educational and manufacturing are presented on the local level, along with measurement, monitoring, and protection of forests. The health of human communities is linked to that of forests, so goals have to address those as well. Finally, resacralizeing forests is an important goal.

4.5.4.1.2. Regional Goals

Regional goals are appropriate for bioregions and isotopes (similar places). Notice that the number of goals decreases as the scale gets larger.

- Zone forests at the landscape level for preservation, conservation, or selection use
- Maintain ecological and evolutionary processes in healthy forest landscapes
- Preserve all old-growth—none of the new forestries can be a substitute for keeping the remaining old-growth, and no secondary forest can match old-growth for biological richness or ecological importance
- End logging in national forests; Clinton's 1993 FEMAT reported that the only way to ensure a chance of maintaining viable populations of all species in PNW coastal forests was to halt all logging—Option 9 (from outer space? An Ed Wood movie?) allows for extirpation or extinction of 800 species.
- Diversify the institutions that deal with forests; relate people diversity to forest diversity
- Eliminate government subsidies for timber harvesting
- Reduce fragmentation of landscape patterns with responsible selection harvesting on a smaller scale
- Accept and plan for natural change, disturbance, uncertainty, ambiguity—it's part of the process
- Restore forest cover in North America to pre-European levels
- For the US, replant 142 million hectares of forest lands—up to 438 million hectares (the approximate level of cover in 1600)
- For Canada, replant over 80 million hectares of forest, up to 530 million hectares
- For the Northwest (Pacific NW coast forest, US and CND), replant up to 47 million hectares
- For the Northeast (northern hardwoods), replant up to 11 million ha
- For the Southeast (Oak-pine forest), replant up to 129 million ha
- For other ecoregions, replant to a high percentage of 2000 BC levels, especially around the Mediterranean
- Relate (or limit) population and consumption to the productivity of ecosystems—without such limits, forests will eventually be destroyed

4.5.4.1.3. Global Goals

Global goals apply to the planet as a whole, for Gaia as a metaphor for the living planet. They are not simply the sum of local and regional goals.

- Reimplement international initiatives to slow deforestation—the UN notes that previous initiatives *accelerated* deforestation, as in Cameroon, where log production is to double in the forest, home to 50,000 Pygmies with a unique and valuable cosmology and life-style
- Plant and maintain forests sufficient to guarantee indefinite support of known and unknown global biogeochemical cycles
- Protect fragile ecosystems with global importance
- Reduce threats to forests from acid rain and other nonpoint-source pollutions
- Reforest nations such as Haiti (economically, the poorest countries in the world are those with the least remaining forests). Reforest the Sahel south of the Sahara, and the coast and inland north, to keep that desert from spreading.
- Plant 9 million ha of trees each year to meet current demands; for soil and water conservation, plant another 6 million ha (at an estimated cost of $6 billion dollars); and plant 110 million ha just to catch up with cutting
- For the planet, reforest 1.4 *billion* ha to restore the 30-40% forest cover removed in the past 3000 years.

These goals have to be expanded.

4.5.4.2. *Design Considerations for Forests*

Shapes are as important as coverages. Location is critical, as soils are important. To restore the extent of forests before a nonarbitrary time, e.g., before 40,000 years before the present (before extensive fire use) or 10,000 years before the present (before extensive agriculture) or even 500 years before the present (before industrialization), decisions about replanting, or even relocation of cities and roads, have to be made.

4.5.4.2.1. *Location*

Forests thrive on good soils; some forests can do well on fragile, unproductive soils that are too thin, cold, wet, or rocky, if they have time to develop. Unfortunately, many cities and other human habitations have replaced forests on good soils. By building cities on poor, rocky soils, and by expanding agriculture into cities, especially rooftops, a greater area of good soils could be left for the former native forests.

4.5.4.2.2. *Shapes*

The shape of a forest can influence the numbers of tree fall from storms, the amount of active interior space, and many other parameters. The shape can determine the total area. Currently most shapes are the result of cutting and conversion; even plantations seem to be rectangular to simplify future harvests. Designing the shapes according to the topography and with regard to the goals of the forest could improve the health of forests. The space between trees influences the kind of wood growth and branch patterns. The space between forests influences the amount of genetic exchange.

4.5.4.2.3. *Restoration*

Many of the local and global goals require restoration. But, is that a good idea? What is weak about restoration? What are we restoring? An ideal? Richness? Context? Function? Patterns? The past configurations? Are there too few parts? How large an area is needed? Do we need places for DNA, zoos, parks, and cryogenic labs, if we cannot save the entire forest?

We need to start to plan for future biotas that may be less beneficial for humanity and more necessary for forest and planet health. Many of these will be restored or assembled from exotics, reintroduced natives, or engineered species. What are we restoring when we restore an ecosystem without all the parts or even good knowledge about the ones we have? Ecosystems are not built by selection in the same way that organisms are. Their irregularities are be caused by external forces and constraints. Although the components of ecosystems may be erratic, they seem to be organized in predictable overall patterns. So, we can guide restoration.

Restoration projects have the potential to save entire ecosystems. The intensive management of (usually) small areas could restore sets of species critical for forest functions. Landscape ecology and island biogeography can identify candidate ecosystems for restoration, and candidate ecosystems for preservation, conservation, or reservation. Conservation biology and ecoforestry recommend how to restore clearcut areas: Replant with native species; restore damaged streams and wetlands; restore natural corridors.

Radical ecology can calculate the optimum amount of wilderness to preserve the natural cycles indefinitely. If the current wild area is less than the calculations, restore the difference and set it aside as a preserve. Restoration areas, which are set in a pattern by human activity, but may not need further intervention.

Forests start from bare land or reestablish their range at various scales (after an ice-age for instance) or continue through the death of individual trees or shift into different kinds of forests. Natural forests often contain small relatively even-aged stands of trees. This can be observed regularly with old-field restoration, where planting continues over several decades and, where a forest surrounds the fields, natural regeneration continues.

Part of any management scheme must be to improve local and global supplies of wood by replanting and caring for forests. Ecoforestry management could help re-establish forests on heroic scales. R.A. Houghton (1990), for example, has suggested that there might be as much as 3 million square kilometers of once-forested, now-degraded land in Africa, 1 million in South America, and 1 million in Southeast Asia. Even North America could probably benefit from a million square kilometers or two of restored forests.

Even industrial forestry is concerned with restoration. Management is now considered necessary to restore trees to previously forested areas, to preserve the genetic information in forests, and to iron out the boom and bust cycles of wild nature by controlling environmental factors, such as mineral deficiencies, as much as possible. Furthermore, federal management assumes that it must set standards for knowledge and development that local communities might not have.

4.5.4.2.4. *Design Cost Considerations*

Design may be costly. Restoration may be more costly. For example, grassland restoration costs about $1500 per acre per year, based on the first two years. Forest restoration costs more. The cost of the design itself could be significant, at $300-400 per acre. Design may take a long time—longer than human lifetimes. How does this cost compare to expenditures on ice cream, make-up or medication for erectile dysfunction?

The forest may be too complex to design. Consider a thought experiment about how to design a forest using artificial pieces, such as giant sponges or shade cards. The experiment could make people uneasy, possibly because it was absurd or too complex. How do we design a forest, a complex, self-making, self-sustaining wild forest? Management has to recognize the limits of design. Limits of ecological design include: Forests are wild, we have no real control; the scale of forests is too large to manage everything; the longevity of forests is too long, we will never complete the design in human lifetimes; the costs may be prohibitive—indeed, we have depended on the free goods of forests for economic advantages; and, other human limitations apply to our ability to see and understand the forest.

Most forest designs will not be restorations, because of the uncertainty about the kinds and associations of native vegetation. Furthermore, humans are now an large part, although not yet an integral part, of the system; therefore it could not be restored to a premodern or prehuman state (and even if it could, which state?). This design is not the biotechnological design of a new ecosystem, either; we cannot accurately control and predict ecological events in most ecosystems. However, we can steer some of the events in a known direction—known because we have historical records of the system, although not complete. We can also reduce those human activities that we know alter the conditions of the forest, such as overcutting and pesticide use.

Although ecological design attempts to restore some kind of balance, the balance does not exclude human activity. Rather, it integrates it into the larger community. A moderate number of human impacts can be absorbed by the system—too many interferences destroy the systems capacity for self-maintenance. The design should be open to evolution and to human technological and social development. The design should be based on a model of ecosystem functions, considering diversity, complexity, and the maintenance of natural process—natural here meaning a self-sustaining system composed of elements now lost through human disturbance.

The goal of ecological design is not to restore, but to revitalize and reinhabit forests. We do not want to live in the dead bones of a mechanistic failure. We want to live in a healthy environment with aesthetic appeal, which is a requirement for human health. Every forest has physical, biological, economic, and political characteristics. The design, planning, and management for a forest describes the system in a comprehensive interdisciplinary approach, using dynamic concepts such as feedback and stability, recognizing limits to change and sustainability with different levels and scales of structure and function in an anticipatory, flexible planning approach, recognizing human and nonhuman goals, and incorporating personal and institutional interests.

4.6. *Global Design Factors: Animals Species & Diversity*

Animals, including zooplankton and insects, are mobile organisms that survive by preying on plants or other animals. Each organism is inseparably related to a place; breaking the bond with place may mean death for the organism. Organisms and places shape each other. Even if individuals can be described in terms of vortices, as the poet E. Pound did before the physicist I. Prigogine, they do exist materially, and they participate in the field in which they exist. The organism must adapt to the environment, which implies having a memory and being capable of learning; the organisms must also reproduce, that is, duplicate its pattern in a separate being. Organisms are goal seeking, and often stability is sought above change or complexity. The individual is a subject centered in a milieu. Because of this implied point of reference, J. Rodman concludes that ecology is teleological. Often, organisms strive for well being beyond just survival. Their goal is to come into the fullness of being; A.N. Whitehead considered that all organisms have three urges: To live, to live well, and to live better. Living better is being more attuned, stimulated, receptive, flexible, and integrated into a milieu.

4.6.1. *Wild Animals: Individuals, Species & Ecosystems*

Each participant in a field creates an image of nature—or world— from what is meaningful to it. Jakob Von Uexkull suggests representing these unfamiliar worlds with a bubble model. The life-image, or *umwelt*, of an animal is what has perceptual and operational meaning for the animal. All animals are fitted to their unique worlds with equal completeness—simple animals to simple worlds and complex ones to well-articulated worlds. Each is optimally (or suboptimally) fitted to its habitat.

Animal populations vary according to cycles or unknown causes; they move and concentrate or disperse. Because animals fluctuate in such a cyclic manner on the tundra, for instance, management by the maximum sustained yield concept is even more difficult and questionable. Furthermore, the ranges of caribou and birds cover more than one ecosystem; wilderness designation for areas outside any one focus must be coordinated. Animals move between ecosystems, carrying their biomass and experience. Wolves, elk and other species use different systems for feeding, mating and sleeping. Other species, such as birds, can connect ecosystems separated by thousands of kilometers.

Microbes are vital to the environment because they participate in the Earth's element cycles like the carbon and nitrogen cycles. Microorganisms are involved in the production of oxygen, biomass control and 'cleaning' the Earth of remnants of dead organisms.

4.6.1.1. Evolution & Domestication

The process by which species reorganize their structures to adapt to their environment, as well as modify the environment for their benefit, is called evolution, an integrated, partly open process that selects whole individuals in whole environments. Evolution can be said to flow upward and outward, as well as inward and downward, from the simple to the complex, but also back again. For moths that mimic bark patterns, there are others in the same area that are conspicuous; for herbivores with complicated stomachs, such as deer, there are those with simple stomachs, such as elephants or horses. It cannot be shown that a particular evolution took place by necessity, only that an adaptation had value and the species survived.

The consideration of observations can lead to the conclusion that evolution is converging to a single end. Darwin himself did not want anyone to consider evolution a purposive movement towards a goal. Rather he regarded evolution as a bush, growing where it can. Evolution can be considered as a building up of complexity, or an unfolding of patterns. Evolution does not seem to be a hierarchical ladder or an up escalator, but a history of forms adapting to changing environments.

The adaptation of beings to a changing milieu cannot be perfect. Over-specialization reduces flexibility and the ability to change, but underspecialization reduces efficiency. Beings that survive tend to have a satisfactory level of specialization. Beings that are not optimally (or satisfactorily) adapted are eliminated through competition and stress. Evolution can increase the levels of complexity through the operation of natural events.

Species are defined by their position in the environment and thus are in internal relations within the environment, but it is also true that they define the environment through positive and negative feedback. While some species adapt to a niche, others create new niches. The species is much more than a passive group—it is intentional and flexible, sometimes stress-seeking and maladaptive. Species in their milieu are in dynamic relationships. While relationships are as real as the organisms, the relationships are not necessarily or logically prior. The whole part, or holon, creates the whole as the whole creates the part. The organism creates the ecosystem as the ecosystem creates the organism. The multiplicity of beings and relationships create and are created by the field.

Humanity created new niches for wild animals when people started to domesticate animals. However, candidate animals were distributed around the planet very unevenly. For instance, with mammals over 100 pounds (45 kilograms), Eurasia had pigs, five species of cattle (Aurochs, water buffalo, yak, guar, banteng), horse, and mouflon sheep. Africa had 3 wild pigs, buffalo, and zebras. And, the Americas had bighorn sheep, bison, and boars. In Eurasia, almost all the candidate animals were domesticated. In Africa and the Americas, only one in each region was domesticated.

Table 4611-1. Approximate dates for Domestication (after Diamond 1999)

Species	Date	Place
Dog	60,000-10,000 BCE	SW Asia, China, N. America, Australia
Sheep	8000	SW Asia
Goat	8000	SW Asia
Cat	8000	Egypt
Pig	8000	China, SW Asia
Cow	6000	SW Asia, India
Horse	4000	Ukraine
Donkey	4000	Egypt
Water buffalo	4000	China?
Llama, alpaca	3500	Andes
Bactrian camel	2500	Central Asia
Arabian camel	2500	Arabia
Guinea fowl	2500	Central Africa
Reindeer	1500 BCE	Russia, Scandinavia?
Rabbit	900 AD	Europe?

4.6.12. Wild Centers

The disappearance of wildlife and wild places to live is a problem for the whole planet. Many people do not miss wolves, for instance, but they are very important to keeping the deer populations adjusted and healthy. Pets and domestic animals also need to be considered as competitors for wildlife. But, they also need care, even when it means sterilizing them to keep them from breeding freely. The solutions to this are to save some habitat—do not convert it to tree farms, farms, or roads—using an ecological plan. Then, limit the takes of all wild species, not just wolves but also deer.

Except under rare conditions (such as heavy snow), wolves do not determine deer populations, whose numbers are limited by food supply. Instead wolves cull weak and diseased individuals that lag behind their herds. Wolves help strengthen herds by killing such animals. Wolves are also efficient scavengers of domestic animals that are sick or have died. Old or unhealthy animals can be a burden on a herd, for example, by eating browse that a healthy animal might need or by infecting young deer. By eliminating such animals, wolves perform an important natural function in wild ecosystems. Wolves are keystone species and an indicator of the quality of wildlife habitat. Their actions are crucial for maintaining the long-term viability of ecosystems. Other predatory species are also supported by wolf kills, including ravens, foxes, wolverines, vultures, bear, and eagles. Wolves contribute to an ecological 'balance' and prevent overpopulation in deer and other grazers. Wolves are evidence of the diversity that we value so much, from genetic diversity to the full spectrum of an ecosystem. Their persecution could reduce the complete functioning of ecosystems in immeasurable ways.

All of nature is not human nature, however. There are many other sentient species. All animals, 'two-legged and four-legged,' are equals in the view of Black Elk. Science is only beginning to support this idea in terms of ecosystem functioning. Adolf Portmann shows that every form of life appears as a gestalt, developing in a specific place. All living forms create an image of their environment. Genetics provides the proper image choices for some—frogs, for instance, focus most closely on objects that have the same size and trajectory as flies. Others must learn what is valuable. Von Uexkull implies that the human world is only one of the many possible. Animals are not suboptimal beings relegated by evolution to second-rate habitats. They are optimally fitted to places that humans are not.

The theory of life-images is a basis for a new, genuinely nonanthropocentric metaphysics. Natural processes take on an expression of significance of their own without reference to humanity. All things have an ultrahuman value of their own. There are other life-images that are measuring parts of habitats. There are other centers, which are equals. Humanity is not the center of all. The planet cannot be controlled for only human benefit.

Humanity is exploiting nature recklessly, without attention to the minimal health of ecosystems. Yet various societies are working to preserve animals, species, and habitats. Their efforts are described, according to three levels: individuals, species, and habitats. An ecological philosophy is outlined as a basis for the united effort of these societies. Ecology supports the uniqueness of individuals in their life-worlds and the interrelatedness of species in communities. Psychological and geographical studies support the importance of healthy places for human beings. The concept of earth as home is proposed as a metaphor for the development of appropriate attitudes and participation in appropriate ways of living.

4.6.2. *Global Design Factors: Domestic Animals & Species*—Agriculture, Biotechnology, Bioethics, & the Global Food-Drug-Agriculture Complex

By M. W. Fox, B.Vet.Med., Ph.D., D.Sc., M.R.C.V.S.

Food safety, quality and security are rising concerns both nationally and internationally. The hegemony of multinational agribusiness corporations promoting non-sustainable agricultural practices erodes both cultural and biological diversity; promotes cruel and environmentally damaging concentrated animal feeding operations (CAFOs or factory farms) supported by wholesale use of antibiotics, anabolic steroids, live vaccines, pesticides, and other veterinary drugs; and forces the planting of patented, genetically engineered/modified (GM) and hybrid crop varieties coupled with toxic agrochemical pesticides and fertilizers.

The validity of these concerns will be documented from a holistic veterinary, public and environmental health perspective. The bioethical basis for the adoption of bioregionally appropriate, sustainable, community supported and supporting, socially just, humane, and organically certified farming practices and marketing cooperatives will be established. In the face of climate change, rising oil and food prices, dwindling food reserves, and increasing world hunger, finding and applying alternatives to conventional, petrochemical-based agribusiness is one of humanity's most urgent priorities.

4.6.2.1. *The Transnational FDA*

The late President of the United States, Dwight Eisenhower cautioned, 'Beware of the industrial-military complex.' In today's global context, a new industrial complex needs to be confronted and dismantled, especially the transnational FDA (Food, Drug and Agriculture, which is actually agribusiness, including all farm-input providers, from seed-stock and breeding stock, to machinery and petrochemicals).

Poverty and hunger are exacerbated by the disenfranchisement of indigenous farmers and once sustainable communities by commodity crop developments and subsidized imports, including crops grown to feed livestock and poultry for the more affluent urban consumers. Landless 'peasants' become the urban poor, their indigenous wisdom, sustainable farming systems, and crop and livestock varieties being lost in the process.

The harmful socioeconomic consequences of Concentrated animal feeding operations (CAFOs or factory farms) in the US have been well documented. Once independent family farms have become extinct, either forced into bankruptcy or contracted into corporate serfdom by large, and increasingly transnational agribusiness conglomerates.

The global imperialism of such monopolists is assured when tax payer's moneys go to heavily subsidize commodity crops and animal feedstuffs. These farm subsidies help this agribusiness sector gain an advantage in the competitive world market place, but much to the detriment of America's once vibrant and productive nexus of family farms and rural communities, now decimated by this juggernaut of economism that is called progress and necessity. Trade agreements through NAFTA and the WTO, (the North American Free Trade Association and the World Trade Organization), with their transnational laws and regulations set up to facilitate the fixing of prices, supply, and demand, violate the sovereignty of nation states and the viability of farming communities world-wide.

4.6.2.2. *Conditioned Chemical and Drug Addictions*

We are all conditioned as children to take our medicine, and as adults to trust the good doctor and not question Aesculapian authority. In science we all trust. Anything that is called 'scientific' or 'science-based' is acceptable. But Aesculapian authority needs to be questioned, and the pharmaceutical industry held accountable for violating public trust with its rush to fast-track new drugs and vaccines for government approval, patent protection and world-market profits. Agribusiness' petrochemical industry claims scientific authority over the 'safe and effective' application of pesticides—agricidal poisons— to the land as well as to the food-chains of man and beast. This same industry lobbies against any restrictions on the use of antibiotics in livestock feed, and other food-animal veterinary biologics/ drugs that substitute for more humane, disease-preventing methods of livestock and poultry production; putting both humans and animals at risk in the process.

The food and drug industry complex with its pharmaceutical and petrochemical and 'life science' agribiotechnology components is not to be trusted. The public trust has been violated in countless ways in the rush for corporate profits and market monopolies. How can we trust the medical profession that condones the wholesale medication of even kindergarten children, with psychotropic, mood and behavior-altering pharmaceuticals? Or organized veterinary medicine that never opposed the use of antibiotics as feed-additive growth-stimulants for poultry and livestock? Neither the American Medical nor Veterinary Medical Associations opposed government approval BGH—genetically engineered bovine growth hormone, —the first product of animal production biotechnology to be rushed to market, before the rash of genetically modified live virus vaccines. (BGH is prohibited in Canada and the UK for cow heath and public heath reasons). Who can trust the food industry when it is public knowledge that the 'life science' biotechnology industry-government alliance allowed the planting and consumption of never-tested or authorized, yet patented (even by the US government) varieties of genetically engineered food and feed crops? (See Addendum for documented concerns). The enduring government alliance with the petrochemical pesticide and fertilizer companies that continue to poison our food and water, and contaminate our oceans and amniotic fluids, along with all the drugs consumed that we and livestock excrete, is a matter of fact.

Profits and pestilence aside, the veterinary and human medical advocates of conventional vaccines and drugs for a sickening society and sickly, stressed factory farmed livestock and poultry, can no longer ignore the price of success: Nor can the agribusiness food industry, squandering land, water and oil/fossil fuels to boost production and profits with its toxic petrochemical fertilizers and pesticides.

4.6.2.3. *Drugs & Farm Animal Health*

Concentrated animal feeding operations, (CAFOs or 'factory' farms) are a bad investment in the long-term. Notably, they are pathogenic, spreading agricologenic and domestogenic diseases—new crop and animal pathogens and the chronic human diseases associated with the Western diet. They are also a major source of diseases of food-born origin, often epidemic in scale, and other diseases like Avian and Swine 'flu. New zoonotic diseases, and more virulent strains of existing zoonotic pathogens, are likely to evolve because of the pathogenic environments and condition of the animals incarcerated in CAFOs.

Like agrochemicals, not all vaccines are bad. But like many drugs they stimulate populations of pathogens and harmless organisms to mutate and become more harmful. So we need new, more costly—and highly profitable—mutation and serovar-specific vaccines and ever stronger antibiotics and other drugs. The same is true with the application of agricultural, food industry pesticides, a global industry, along with genetically engineered crops, that stimulate populations of resistant weeds, insect pets, and crop diseases. And both human and veterinary drugs and agrochemicals cause serious water contamination.

Human and veterinary vaccines and drugs give us a false sense of security and put us on the treadmill of addiction/dependency to prevent and treat diseases in essentially pathogenic environments, notably those where there is human over-crowding, poverty and malnutrition, and where virtually genetically homozygous farmed animals are crowded together in CAFOs, mirroring the genetic uniformity of commodity crops grown in disease-promoting monocultures.

Ideal substrates/environments for the proliferation of pathogens have been created in CAFOs with the commercial hybrid livestock and poultry lines being virtually homozygous—and now even being cloned—. This calls for more drugs and vaccines, -what I call domestogenic diseases of animal production—that mirror the agricologenic pest and blight problems of crops that are also raised in homozygotic monocultures on nutrient-and micro-organism deficient, agrochemically intoxicated soils.

Factory farmed animals are made genetically as uniform as possible in terms of growth rates/productivity, in order to maximize profits. The more so when they have been cloned, a biogenetic engineering process now in full swing. Genetically similar lines of pigs for example, make similar weight gains and reach slaughter weight at the same time. This uniformity mirrors that of commodity food and feed crops grown in monocultures. Both provide ideal substrates/environments for the proliferation and evolution of increasingly virulent and highly infectious and contagious organisms. Coupled with husbandry factors such as over-crowding stress, soil nutrient deficiencies etc; this lack of genetic diversity increases the virulence of organisms, even making harmless ones, (so called commensals and symbiotes) into pathogens and pests. Those pathogens that can rapidly mutate or acquire genetic material from other organisms can soon develop resistance to antibiotics, pesticides, and other drugs, in some instances even thriving on them.

Deliberately infecting already immuno-compromised animals in CAFOs with modified /attenuated, yet still live, viral vaccines is problematic and counter-intuitive considering the zoonotic, public health risks, manufacturers' profits not withstanding. The various antibiotics, antihelminthics, and other veterinary drug residues, including anabolic steroids and growth hormone implants, and feed additives and contaminants like copper, arsenic, cadmium, lead and dioxin that go into the environment in animals' nitrogenous and phosphate-loaded excrement, pose a challenging management and containment problem, (especially to surface and ground water) that few if any CAFOs effectively address.

Recycling slaughtered livestock and poultry remains, and food and beverage industry by-products, into livestock and poultry feeds that are not organically certified and therefore can contain pesticide residues, dioxins and heavy metals, and various pathogens, compromise animal health and welfare. Manufactured livestock and poultry diets can be deficient in essential nutrients, and being formulated to increase growth/productivity at the lowest possible ingredient cost to maximize profits, can result in production-related diseases, notably metabolic and liver diseases in cattle, arthritis/lameness in pigs, and lameness, obesity and heart attacks in broiler chickens. . Feeding livestock and poultry GM herbicide and insect resistant crops and byproducts containing endogenous toxins like Bt, and absorbed herbicides, and conventional feed from nutrient deficient soils and hybrid 'Green Revolution' crop varieties, pose further animal and consumer health issues.

One of the most limiting factors in establishing CAFOs is the diminishing supply of water world-wide, and the vast quantities demanded by such operations. The amount of land and resources used to raise feed and fodder for intensively raised, confined livestock and poultry has a major impact on biodiversity. The negative impact on wildlife habitat is compounded by the adverse wildlife and habitat impacts of extensive livestock husbandry systems of grazing/ ranching/ pastoralism where there is over-stocking/over-grazing, and indiscriminate predator control. The adoption of sustainable livestock production systems linked with organic food, feed and fodder production appropriate to the natural resource availability in given bioregions would do much to help advance the conservation-based agriculture approach to wildlife protection and habitat restoration.

4.6.2.4. *Population & Consumption Issues*

The price of success in maintaining and promoting human population growth with decreased mortality rates and arguably longer life expectancies means more hungry mouths to feed and potential disease outbreaks to fend off. In more affluent and consumptive socioeconomic sectors around the world the diseases of affluence like obesity-diabetes/ metabolic syndrome, and cancer, are part of the price of success. But the ever more impoverished and landless survivors of averted epidemics and famines, and the more affluent but disenchanted, together make the kindling of inter-tribal conflicts, war and acts of terrorism inevitable.

Uncoupled from any family planning and concerted population control, effective resource management and conservation, pollution control, sustainable agricultural practices and economies local and global, poverty, sickness and famine will be the legacy of the human condition, passed on with increasing virulence from one generation to the next. Look at our history since the beginning of the Industrial Revolution, the Age of Reason, and the epoch of colonial imperialism, once nationalistic, now corporate and transnational. The fear- based progress and the success of the modern age envisioned by the military-industrial technocracy generations ago, to essentially find ways to profit in the name of fighting famine and pestilence, two of our primal fears, by selling more drugs to save more people—for what? And by selling more toxic chemicals to produce more food—for why, but mainly to fatten the cattle of the rich as Gandhi observed, now mean that there are ever more moths to feed and souls to suffer.

The price of success in maintaining unhealthy concentrations of animals for human consumption and for other commercial purposes, made possible by the use of veterinary vaccines, antibiotics and other drugs, has meant more resistant and harmful pathogens, more and more being harmful to humans, the so called zoonotic diseases. When computed along with the environmental impact of extensive livestock herding and grazing, CAFOs are the number one contributor to climate change; and a leader of the pack in ground and surface water pollution and topsoil waste.

Corporate profits not withstanding, the misguided altruism of philanthropic agencies and individuals playing into the FDA system, giving $ billions in drugs, food aid, and seed and livestock varieties unsuited for sustainable farming, is a major impediment to real progress in the human condition that is inseparable from environmental health and quality, and from the protection and restoration of both cultural and biological diversity.

4.6.2.5. *Western Diet & Health*

It is argued that without the use of the petrochemical industry's fuel, pesticides and fertilizers, and the genetically engineered commodity crops of its agribiotechnology affiliates, commercial, high-volume crops like cotton, corn and soy could never be produced in the amount that is needed to clothe and to feed people ever more beef and cheese, rather than whole wheat and organic rye, and more pork and chicken rather than lentils and beans. The Western economy, and the middle class in particular that has been raised on this diet (of the affluent), rather than on the healthier, high cereal/grain, legume, fruit and vegetable-based diets of the materially poorer indigenous peoples around much of the world, are being crushed by the rising drug and health care costs, primarily arising from a meat and processed 'junk' food- based diet. While informed Westerners adopt some of the more healthful diets of indigenous peoples, their own governments, and donor, 'philanthropic' agencies, like the UN's World Bank, are working to implant their own industrial agriculture and the Western diet in developing countries to sate the rising demands of the affluent, and the tourist industry, for beef, chicken, cheese, ice cream, and in non-Muslim countries, more pork instead of lentils, chick peas and beans.

The irony that the Western diet is now being associated with not only such epidemic problems as obesity, stroke, heart attack, diabetes and chronic degenerative diseases like arthritis as well as a range of cancers and birth defects and brain damage, but also with behavioral changes in the consumer populace. Most notable is the epidemic incidence of anxiety and obsessive compulsive, addictive, and depressive disorders, and various psychoses, violent and delusional. These behavioral abnormalities are associated with disrupted brain, neuroendocrine system chemistry, like the neurochemicals serotonin and nor-adrenaline. While social and emotional stress contribute to these complex and widespread mental health problems, radical dietary changes that are the antithesis of the Western diet and that embrace some of the nutritional wisdom of earlier times and indigenous traditions, have been shown to greatly help many of these neurobehavioral, psychological, and psychosomatic disorders, especially in children.

We may never know to what degree we have harmed ourselves, even for ever, genetically, with petrochemical pesticides that are lipophilic, being selectively absorbed by fatty tissues, as in the skin of oranges, the breasts of women, and the brains of all.

More and more people, along with their pets, make dramatic recoveries from a variety of health problems following a change in diet that includes the exclusion of almost all the conventional human and companion animal (cat and dog) prepared and processed foods.

That highly refined, denatured, and bleached wheat flour was sold as 'Wonder Bread' for decades in the US, while the more nutritious ingredients were either put into livestock feed, or used by other food industry sectors, including the 'health food' industry that sold at premium prices the bran, gluten and vitamins that was taken out of Wonder Bread, as essential dietary supplements. Wonder Bread is the Asian and Middle and Far Eastern equivalent of polished white rice, the essentially denatured, nutritionally deficient staple food of billions of uninformed people.

Much of the food we consume today and that goes in to pet foods and livestock feed are from 'high performance' patented hybrid seed varieties that were developed in the 1960s and 1970s as part of the much hyped 'Green Revolution' to feed the hungry world and end famine and malnutrition around the globe.

4.6.2.6. *Harms & Costs of the Green Revolution*

The failure of the Green Revolution was underscored in a report from the UK's Global Environmental Change Programme, funded by Britain's Economic and Research Council, and published in April 2000. Green Revolution crops, introduced in the late 1960s and early 1970s increased agricultural output and profits, and provided much needed and affordable calories for the poor. But these crops failed to take up minerals such as iron and zinc from the soil. The report states: "High yielding Green Revolution crops were introduced in poor countries to overcome famine. But these are now blamed for causing intellectual deficits, because they do not take up essential micronutrients." Iron deficiency disease contributes to increased infant mortality, impaired brain development and learning ability, affecting an estimated 1.5 billion people in one quarter of the earth's population, according to the author of this report, Dr. Christopher Williams.

It should also be added that micronutrient deficiencies, also a nutritional problem in the West from deficient soils and crops, can impair the immune system, and related nutritional deficiencies and imbalances in various animal products, especially in the omega 3 and 6 polyunsaturated fatty acid ratios can impair brain development and cognitive functions.

Recent studies in Canada, the U. S. and the U. K. have shown that fruits and vegetables are less nutritious than 30-50 years ago, showing often marked deficiencies in iron, copper, zinc, calcium, sodium, phosphorus, protein, vitamins C and riboflavin, a disturbing finding attributable, in part, to the fast-growing and large-yielding varieties of crops being grown today for human consumption: And to the use of chemical fertilizers, potassium fertilizer, for example, interferes with plants' magnesium and phosphate absorption. Herbicides like Monsanto's Roundup can interfere with plants' uptake of iron and manganese. Widely used nitrogenous fertilizers can increase harmful nitrate levels in conventionally grown crops, lower the plant's vitamin C content, and while increasing total protein content, the quality of the protein is inferior to organically grown crops, lacking in essential amino acids like lysine, which means lower quality food, and livestock feed.

4.6.2.7. *Organic is Superior*

Studies comparing the nutrient content of organic versus conventionally grown crops report significantly lower levels of potentially toxic aluminum, mercury and lead in the organically grown, that also had higher levels of many essential trace minerals and other nutrients, notably boron, calcium, chromium, copper, iodine, iron, lithium, magnesium, manganese, molybdenum, phosphorus, potassium, selenium, silicon, sodium, sulfur, vanadium, and zinc. Also more vitamin C, bioflavinoids and other antioxidants, and less nitrate. Produce from animals fed organically grown feed are more nutritious than from CAFO raised animals fed manufactured food-and beverage industry byproducts and synthetic supplements and drugs. Organic beef has more healthful Omega 3 fatty acid content; organic chicken has more Vitamin E, Omega 3 and beta carotene, as has organic milk, that has also more antioxidants, lutein and zeanthine.

Animal studies have shown that such functions as reproduction and resistance to infection may be adversely affected by conventionally produced foods as compared to organically produced ones.

Studies around the world of organic farming methods found that they contributed more to biodiversity and wildlife conservation than do more harmful conventional farming practices. Organic agriculture increases biodiversity at every level of the food chain, from soil bacteria to wild mammals and raptors.

University of Michigan professors Catherine Badgley and Ivette Perfecto have completed a three-year study of worldwide organic vs. conventional farm yields and found that organic farming could produce three times as much as low-intensive methods on the same farms in developing countries, and to produce almost equal yields to conventional farms in developed countries.

Like holistic medicine, organic farming is systemically integrated within the physical parameters of general systems theory and quantum mechanics as they relate to dynamic living ecosystems, with the overlays of ethics, esthetics, and metaphysics. As 2008 President of the Pennsylvania Sustainable Agriculture Association's annual conference, dairy farmer Kim Seeley advised in his opening address, that we must all "Obey Nature's laws first before we accept man's laws."

That more holistically-oriented physicians, veterinarians, and agronomists are at last beginning to put such wisdom in to practice is a clear sign that a paradigm shift or change in our worldview is taking place and that the status-quo of conventional medicine, agriculture, the economy, and other social institutions is no longer acceptable and most certainly not viable without further violence and suffering. As more medical and veterinary scientists are becoming real healers, so more farmers are becoming real land-stewards.

Their paradigm is based upon the following bioethical principles: compassion, service, humility, ahimsa (avoiding causing harm), and reverential respect for all life; social justice; eco-justice, and the precautionary principle. These are the cornerstones of a healthy community and of a sustainable economy. We have all but eliminated the Meadow lark from our fields. We have many wrongs to right, and much to atone for what our ancestors and civilization have done to harm through fear and ignorance, arrogance and greed.

Advances in the science and bioethics of alternative human and veterinary medicine and organic agriculture that are based on this new paradigm hold much promise and should be supported by the corporate sector as well as by the consumer-populace and governments around the world.

4.6.2.8. *Reducing Animal Consumption: A Bioethical Imperative*

The singularly most damaging environmental footprint upon this planet is caused by our collectively costly and damaging appetite for meat. Some 3.2 billion cattle, sheep and goats are now being raised for human consumption, along with billions more pigs and poultry. These extensively and intensively farmed animals produce less food for us than they consume, and compete with us for water. Their numbers and appetites result in an increasing loss wildlife and habitat, and of good farmlands and grazing lands. Linked with deforestation, loss of wetlands, over-fishing and ocean pollution, our appetite for meat is the number one cause of global climate change.

We can no longer continue to regard meat and other sources of animal protein as a dietary staple because of the enormous costs and harmful consequences of such a diet. Vegetarianism is an enlightened choice, and all people should at least become 'conscientious omnivores,' treating food of animal origin more as a condiment than a staple. According to figures from the UK's Compassion in World Farming, reported in *The Economist*, (Dec 2' 2006, p. 88), over 50 billion animals are killed for food every year, which comes to almost 100,000 a minute 24/7. In the past 40 year meat consumption per person has risen from 56 kg to 89 in Europe, from 89 kg to 124 in America, and from 4 kg to 54 in China, in spite of the nutritionally inefficient conversion of grass or grain to meat, some 10 kg of feed being needed to produce 1 kg of meat.

It is surely a bioethical imperative not to kill animals for their flesh when no less nutritious foods of plant origin are readily available, more affordable, and more sustainably produced. Ironically, the shift toward 'improved' animal-based diet correlates with increased incidence of so called Western diseases, and with an increasingly dysfunctional, unhealthy environment.

These correlations support the karmic truism that when we harm others—animals and the natural environment—we harm ourselves. Hence obedience to the Golden Rule—of treating others as we would have them treat us, is enlightened self interest. This core bioethical principle is embraced by the animal rights and environmental/deep ecology movements that have been demonized by antidisestablishmentarians who have succeeded with the Bush administration to identify both movements as potential terrorist organizations liable for prosecution under the Bioterrorism Preparedness Act of 2002. Homeland Security and the protection of vested interests are one and the same, the continued, economically justified exploitation and suffering of animals, and environmental desecration, being protected under the law. U.S. animal industries have gained additional protection with the so called Animal Enterprise Protection Act that criminalizes certain conduct aimed against companies engaged in animal production, research and testing.

The economy of the Western industrial consumerist paradigm is non-sustainable, and because of its global reach, is wreaking global havoc, as predicted by Jared Diamond and many other critics. For instance, much livestock feed is imported by the multinational food industry oligopolists from the impoverished third world, thus contributing to mass malnutrition in poorer countries. This problem is compounded by what is called 'dumping' of surplus, heavily subsidized, animal and other agricultural products/commodities on the third world, from chicken legs and powdered milk, to corn and wheat, often under the guise of emergency food aid. This only serves to enrich a corrupt few, and undermines the economic viability of indigenous farmers and once sustainable rural communities.

In sum, we can no longer continue to regard meat and other sources of animal protein as a dietary staple because of the enormous costs and harmful consequences of such a diet. Vegetarianism is an enlightened choice, and all people should at least become 'conscientious omnivores,' treating food of animal origin more as a condiment than as a staple.

4.6.2.9. *Conclusion: Glory & Desolation*

From the above review, it is evident that organic agriculture and holistic human and veterinary medicine have major roles to play in the 'end of days,' as some call the collapse of the dominant culture of industrialism and consumerism, to help save humanity and the life and beauty of the natural world. They have major roles to play because they are of a different world view and bioethical basis than the dominant one of today—that ignores the insight of Albert Einstein that the problems of the world cannot be solved at the same level of consciousness that caused them. This major role is not simply in better nutrition and health for all, but in the evolution of human species from a killer ape and global parasitic infestation to one that strives compassionately to establish a more symbiotic and co-creative relationship with the entire biotic community of this living Earth where peace, justice and respect for all life unify us in our sufferings and joy.

In the light of current trends—from climate change and its catastrophic global socioeconomic, environmental, agricultural and public health consequences, to the devastation being caused by a foundering WTO in these times of escalating conflicts, failing economies, resources, and markets, and rising populations and epidemics of disease and violence—the bioethical imperative of humane, sustainable, socially just and organically certified agriculture is enlightened self-interest. It is the highest form of altruism if we care not only for our own health and that of the planet, but also for the rights and interests of indigenous peoples, endangered species like wolf and whale, elephant and albatross, and the last of the wild: And conserve and preserve our native seed stocks and animal breeding stock for that more enlightened future. As the Pennsylvania Dutch farmers say, "We do not inherit the land from our ancestors, we borrow it from our children."

There will be no tomorrows for today's good seed-savers unless everyone awakens to Earth's sorrows and reverence all Creation. Some sage once said, 'Until we suffer the earth as we suffer for ourselves and for our own kind, there will be no end to suffering." And as the late Loren Eiseley observed, "We do not find ourselves until we see ourselves in the eyes of those who are other than human." My friend Thomas Berry wrote "The glory of the human has become the desolation of the earth." This I would consider an appropriate way to summarize the twentieth century.' But for me, I find seeds of hope in the practice and bioethics of humane, organic, and sustainable agriculture that can see us through the next century to a more enlightened and viable future.

Figure 4629-1. Dr. Fox forms the axis of a dog pyramid

4.6.3. *Interactions in Nature: Disturbance, Exploitation, and Interference*

This section examines the parallels between the interactions of processes, of animals and of humans in ecological systems. It concentrates on disturbance and exploitation behavior and contrasts them with the interference behavior that characterizes the nonecological activities of the dominant human, industrial culture. Examples of each will be taken from wild ecosystems, forestry, animal cultures, archaic human cultures, and industrial culture. The word interactions is used, instead of words like 'events' or 'catastrophes,' to describe the feedback and cyclic nature of actions.

Humanity is exploiting nature recklessly, without attention to the minimal health of ecosystems. Many ecologists, such as Eugene Odum, have observed that complex communities have existed for thousands of years in relatively stable environments, even though these environments are characterized by regular disturbance and constant exploitation. These environments are now vulnerable to human interference, which is a different thing from disturbance or exploitation. Disturbance, by definition, is an event that can be caused by climate, biological entities, or other actors. Exploitation is the normal use of a resource or of a species by another species, including the human species (this ecological definition differs from a sociological definition, which means 'selfish or unethical use,' although it may suffer from negative connotations due to the latter); in fact, ecological exploitation has a rejuvenating effect on populations. Exploitation is contrasted with interference, an activity that can degrade, destabilize, or destroy entire ecosystems. Interference is not a form of disturbance, exploitation, or competition; it is destruction without gain to any species; sometimes it is caused by planetary events, but in the case of human interference, it is the destruction of the structures and processes of evolution for large-scale, one-species, short-term gain.

The interactions of living beings in ecological contexts may have positive and negative effects on themselves and other species, as well as constructive and destructive effects on ecosystems and the operation of biogeochemical cycles. Human interactions are also considered. The pandominance of ecosystems by humanity is related to the biological and cultural characteristics of the species. Ignorance and indifference are identified as major reasons for continued interference.

4.6.3.1. Interactions

Living organisms in a given area interact with the physical environment so that an energy flow leads to the defined trophic structures and material cycles that comprise an ecosystem, according to Eugene Odum. An ecosystem can be analyzed into parts, including organisms, energy circuits, food chains, diverse patterns, nutrient cycles, development and evolution, and control. No organism can exist by itself or without participating in an ecosystem.

Organisms interact in a number of ways. Interactions can be positive, negative or neutral in effect. In 'neutralism,' for instance, neither population is affected; in 'competition' each group adversely affects the other for resource use; in 'parasitism' one benefits and the other is adversely affected; and, in 'mutualism' both benefit in a necessary relationship (See Section 4.7.1.1.). These kinds of interactions are basically forms of exploitation. Disturbance or interference are also possible.

4.6.3.1.1. Exploitation

Animals and plants, algae, bacteria, fungi, live together in ecosystems. Living together involves many kinds of interactions, from competition and conflict to cooperation and mutualism. Interactions may be reciprocal or complementary. They may dominate or control. Interactions are multidimensional. A wolf, for instance, may howl to communicate, or to restore proximity with a mate, or for simple pleasure. Many animals, such as wolves and caribou, develop together over time, adapting to each other's strategies. Paul Ehrlich and Peter Raven refer to this mutual adaptation as coevolution. Coevolving systems never completely adapt.

Every species uses some part of other species or of the environment. This use is termed exploitation. Insects, diseases, and animals, more than being simply agents of mortality, are native components of complex food webs in ecosystems, and they contribute to the selection of species. In a Ponderosa pine forest in the Pacific Northwest, insects exploit trees; they pollinate some trees and overwhelm others, but rarely more than 1 percent of a forest. Diseases exploit trees; they remove stressed trees—also probably a low percentage on the order of 1 percent. Their effect on the long-term health of a forest, however, is positive.

Birds and mammals eat foliage and seeds; they also disseminate seeds. Mammals, the best regulated of more recent species according to Frank Golley, change their habitats to suit themselves by chewing, digging, and burrowing. Rodents can dislodge earth at a tremendous rate. In many cases, these activities improve the conditions for the growth of vegetation. Mammalian grazing promotes vegetative regrowth and the movement of seeds. Bison and prairie dogs were responsible for much of the character of the American plains. Rodent caches may account for a good percentage of pine seedlings; possibly 15 percent of a Ponderosa pine forest rises from such seed caches. Beavers and other rodents create their own microsystems. Wide-ranging caribou and wolves transfer energy between systems.

Predation increases the survivability of a prey species. Predation also increases the diversity of species, according to Steven Stanley, by limiting the most populous prey species. Rarely do predators kill all of the prey. Rarely do animals interfere with the operation of the biogeochemical cycles in the environment. The exploitation of the system by plants, insects, and animals contributes to the health and continuity of the ecosystem. Exploitation is not chaotic; there are limits and rules.

4.6.3.1.1.1. *Rules*. Animals obey rules of behavior. Many animal communities have codes of behavior that regulate interactions. In birds and less complex mammals, these rules may be very rigid and predictable. With increasing brain complexity, however, learning takes a larger role. For example, young white-tailed deer in Idaho have to learn to cross highways in Idaho and Washington They appear to use rules of thumb (not the best phrase), finding a proper balance between safety and reasonable progress, between no traffic in sight and bumper to bumper congestion.

Animals like wolves have behavioral inhibitions against killing too many prey or killing their own kind, against coupling with a mated or disinterested female, or against attacking nonprey species. Animals that break such inhibitions are usually sometimes attacked or ostracized. In general, food is shared by all members of a wolf pack. Adults will regurgitate part of their food for adults who stay behind with juveniles. The members of a wolf pack cooperate bringing down an elk, but then compete for the choicest parts of the prey. Rules are not always strict; wolf mates raising pups may consciously deceive one another to get a break from the responsibilities, according to Michael Fox.

The social structure of a wolf pack is most important. Breeding, playing, hunting, feeding and territoriality are tied to social structure. Wolf pups are taught how to behave and how to hunt. Much of the behavior of wolves is directed to keeping the animal's status in the pack or to raising it. Quarrels take place often and the entire pack seems to take an active part. Actual battles, however, are rare. Ritualized squabbles result in few physical injuries. Wolves do kill each other, however. Wolves that behave strangely, such as epileptic pups or adults crippled in the chase, are sometimes killed by the pack. Disputes over the alpha position may end in death. Foreign wolves may be killed if they do not flee. Prey may be killed in excess during times of denning. Rules of encounter are complex and the outcome depends on numerous circumstances, such as the abundance of prey, the size and health of the pack, and stress; that is, the rules often depend on limits.

4.6.3.1.1.2. *Limits*. Mammalian behavior is controlled and population regulated through the use of space in general. Most mammalian populations, wolves for instance, regulate their density well below the limits of the food supply, often by as much as 50-70 percent. Territoriality limits populations, but populations can also be limited by specificity of prey or plant source, size of prey or plant populations, predators, natural events, or even individual tastes.

Wolves in the Arctic disperse with the migration of the caribou. According to David Klein, they prefer Caribou to other often more easily obtained species, such as mice. This preference reduces their hunting efficiency, however.

The goals of an organism are limited by the life-images of its species. Each animal is a participant in a field of existence. Using its senses, each participant creates an image of nature, or world (*umwelt*, life-world, is the term used by von Uexkull), from the sensations that are meaningful to it. Each animal fits itself to its unique world as completely as it can—simple animals to simple worlds, complex ones to well-articulated worlds. Each fits its place as well as it can. Konrad Lorenz, Michael W. Fox, and others have elaborated this kind of fitness in more detail.

Each organism is inseparably related to a place; breaking the bond may result in death. Organisms and places shape each other. This is true of archaic human cultures as well.

4.6.3.1.1.3. *Traditional Ways of Archaic Societies*. Most human cultures are located in a particular territory. This is especially true of the Campa, who live in a tropical forest in Peru, and for the Ituri pygmy, who live in a tropical rainforest in Africa. The features of their cultures are unique to their place. They literally could not live with images of desert or ocean, like the Taureg of the Sahara or the Samoans of the Pacific. The very circumstance that makes each culture unique—being in a unique place—ensures that it can fit a place. This fitness ensures a limitation of exploitation.

Particularly in agricultural societies, cultures are gauged closely to seasons. The culture makes the world manageable by limiting it. A local culture is also tuned to the limits of the local ecology, within the knowledge of interactions—the long-range ecological consequences of drainage, irrigation, or overexploitation can contribute to the success or failure of a culture. Many, but not all, archaic cultures are a form of fitness and limitation. Most archaic groups try for adaptation before domination. For instance, according to Gerardo Reichel-Dolmatoff, the goal of the Desana Indians is the cultural continuity of their society in its place in the rainforest.

The Chipewyan people in Northern Canada occupy the same territory as wolves and compete for the caribou, although their niches are not identical. Both social systems are adjusted to the hunting of barren ground caribou. Chipewyan hunters depend on animals other than caribou, which migrate out their Indian grounds. The cultural decision to hunt caribou as the primary item of subsistence, however, has produced many similarities between the two species in their utilization of land and in the formation and distribution of social groups. The cultural decision to hunt caribou results also in a population density lower than what would result through other decisions regarding the utilization of resources.

For hunting, Chipewyan use dog teams, snow shoes, and boats to increase their mobility and rifles and bows to supplement the traditional spears. The strategy of the Chipewyan, according to Henry Sharp, is to kill caribou at any opportunity. They increase their opportunities by walking aimlessly, watching, and driving the caribou, although the Chipewyan expend less energy by watching and ambushing. Wolves follow the more active strategy because of their increased and superior mobility. Both species adopt a pattern of dispersing and concentrating with the caribou. The basic choices regarding subsistence patterns, social organization. demography, terrain usage, and yearly cycles are made on the basis of the internal logic and structural characteristics of the two cultures (wolves do have culture, in the general anthropological sense, according to Sharp and Fox).

Although the two species do not compete directly, both Chipewyan and wolves are predators that put pressure on caribou populations. Sharp suggests that the commitment of both to caribou hunting is ecologically inefficient, since both species could spend more energy on secondary sources of food. For the Chipewyan, a deliberate "underutilization" of moose, rabbit, grouse, birds, and fish, is the result of their cultural values, including their willingness to live below the carrying capacity of the local environment—a characteristic of most hunting/gathering societies—the complex practice of drying caribou meat, and the reciprocity of their kinship system, i.e., caribou is a better basis for future relationships. The cultural decision to hunt caribou as the primary item of subsistence has produced a unique pattern in the utilization of land and in the formation and distribution of social groups. Wolves also underutilize their resources.

Regardless of cultural order or cooperative interactions, part of the process of life is uncoordinated, unfitting, disorderly, unbalanced, and destructive. Therefore, suffering often occurs. Suffering is an unavoidable part of disturbance or exploitation. We cannot intervene in every case, nor can we eliminate the possibility of suffering. We cannot maximize the self-realization of every being, and we cannot make evolution into a perfectly functioning machine; the functionless features of evolution are part of the process, but, we can protect the process. The mode of operation of nature consists of a rhythm of dissolution and reformation. The extravagance and beauty of the natural world features many more species in an ecosystem than would be necessary if exploitation alone were its organizing principle.

4.6.3.1.2. Disturbance

Disturbances in nature are regular but unpredictable events. Disturbances are caused by geological events, climatic events, physical processes, and biological agents. Hurricanes, for example cause disturbances, as do volcanic eruptions, windstorms, tidal waves, disease outbreaks, and acid rain.

Disturbance is one thing that causes change in an ecosystem. On a small scale, a single tree falling over is a disturbance. Although an individual dies, species continue. Mortality is a normal part of the life cycle of the forest. The disturbance may be necessary for the ecosystem to continue to mature; for example, according to David Perry, without windthrown spruce that expose mineral soil seedbeds, the northern forest ecosystem would shift to bogs.

Disturbances, if sufficiently regular, become a 'known feature' of the ecosystem. In Florida, some species such as Cypress, need the complete inundation provided by hurricanes to remain healthy. Yet, even catastrophic disturbances like hurricanes rarely damage more than 5 percent of a forest; for instance, the 1938 hurricane in the eastern US blew down less than 4 percent of the trees.

As the frequency of a disturbance increases, the forest becomes adapted to the disturbance; even pine plantations in the southeastern United States that are managed with controlled burns are less damaged by lightning-caused wildfires. Many disturbances in forests, such as insect explosions or fires, kill low percentages of trees.

After long periods without a major disturbance, however, a catastrophic disturbance becomes more likely. Where wind and fire are absent, for example, the probability of insect and disease outbreaks increases. By trying to prevent one kind of mortality, ecosystem managers often establish conditions for another kind.

Fire is regarded as catastrophic. In some ecosystems, for instance tall grass prairies in Illinois, fire is required to suppress competition from trees. In some forests, such as lodgepole pine in Washington state, fire is required for the cones to open and the trees to regenerate. Forest fires rarely damage more than 10 percent of the whole forest. Even the Yellowstone fire of 1988, still regarded by some as a tremendous disaster for "Smoky the Bear" policies of prevention (resulting in dead material forming fire ladders), caused limited damage as it leapfrogged along, leaving healthy untouched stands that became the source for the regeneration that is now being observed.

A typical percentage of death is the normal condition of an ecosystem, necessary for its renewal. The rate of death per year in an old forest is remarkably consistent at about 1-2 percent, even with wind storms, fires, disease outbreaks, and animal damage. In some cases, a larger percentage of the forest is affected. For instance, high elevation balsam fir forests are subject to bands of dieback that progress up the slopes parallel to the contours of slopes. These "fir waves" seem to be triggered by cold winds striking exposed forest margins. A new stand regenerates where the trees have been killed.

Disturbance may change the direction of maturity in an ecosystem, but it also is stimulating for those species adapted to it. Disturbance may continue succession or it may deflect it, according to Bormann and Likens. Because of the range of scales and intensities with disturbance, it is a complex concept.

Disturbances that are not part of the history of an ecosystem may cause irreversible changes to the system, because the system has not evolved a defense or response mechanism to such a rogue disturbance. A meteor strike would be such a disturbance, especially if the landform was altered by a crater. Human disturbances, in the form of acid rain or clearcutting, are both novel and threatening. If they are small enough or rare enough, however, the ecosystem may rebound.

Very large scale disturbances, such as volcanic eruptions or meteor impacts, can destroy entire ecosystems or disrupt global biogeochemical cycles. However, such very large-scale disturbances are rare, and the ecosystems often have thousands or millions of years to become reestablished, although changed.

4.6.3.1.3. Interference

Although rare large-scale or novel disturbances can interfere with ecosystem processes, the term 'interference' is reserved for constant large-scale or novel effects. The destruction of ecosystem processes in nature by the action of one or more species is rare; any species that did so would become extirpated or extinct, unless it was not dependent on a single ecosystem, as is the case with wolves. Many commentators have accused mammals, wolves for instance, of overkilling their prey. It is fairly well established now, by David Mech and others, that wolves will take prey in excess of their immediate needs. This behavior has been interpreted as useful in maintaining not only the wolf but also secondary predatory and scavenging populations, for example, foxes and ravens. Indian informants are aware of this aspect of the wolf's excess kill, but they attribute to the wolf sufficient foresight to kill an excess of caribou near the den site in order to have an adequate food supply when the caribou are absent. Regardless of the wolves' intent, excess kills of caribou by wolves seem to be linked to the pup-rearing part of the pack that follows behind, as well as providing some food for the reverse seasonal migration—wolves can eat the remains of kills that are up to a year old.

Like wolves, human beings, as part of the process, interact with the individuals of other species or with entire species. Human beings are mammals who, as George Woodwell put it, live in a biosphere whose essential qualities are determined by other species. Mammals are bound by biological requirements that must be met for a population to survive.

Like other mammals, humans change their habitats to suit themselves. Humans have modified animal and plant associations in a different way from other mammals, simplifying patterns of energy and chemical exchange and solidifying themselves at the end of many food chains as a dominant species (a dominant is a species with greater influence than others in its biotic community, changing the lives of other species and the character of the habitat.)

Human populations have increased exponentially, with billions in giant urban ecosystems. Agriculture has produced monumental yields, but only at the cost of tremendous erosion and great subsidies of fertilizers and pesticides. Dams have been built all along rivers, and riverine forests have been cut, altering rivers and fishing grounds. Changes have been made without regard to the long-term impact on the ecosystem or on its human population. We dominate entire ecosystems.

By its influence of all ecosystems, humanity has become a pandominant species. As such, humanity reclaims, overgrazes, clears, depletes, and wastes at a scale that interferes with the stability, processes, and existence of many systems. One of the ecological consequences of human activity is the degradation of wild habitats for human developments and the introduction of novel elements into the biosphere—elements that have not been added slowly over time as the result of natural processes.

The biomass of the human species probably exceeds the biomass of any nondomestic mammalian species, and that biomass is supplemented by the tremendous biomass of domestic animals, which is far greater than the human biomass and consumes much of the same food as humans, including milk, fish, and grain. The domination of humanity is related to other characteristics as well, its large annual population increase (over 2 percent), high structural organization (of information and matter), and high energy use (globally 13 times the total of all other mammal equivalents).

This dominance has major effects on ecosystems: Transient perturbations in energy relations (from oil spills and burning); chronic changes/shifts of systems (from dams, irrigation, and chemical wastes); species manipulation (from the import and export of exotics); and interference competition with wild species. None of these effects are exclusive to humans as a species, but they are excessive, rapid, compounded, and very large-scale. Humanity has upset the balance of nature in favor of its own needs. Animals, plants, and habitats are being destroyed because of short-sighted, short-term economic interests.

Human beings have contributed to the extinction of species and to the destruction of ecosystems. Human hunters are hypothesized to have wiped out the most of the large mammalian species of the Pleistocene through overhunting—not for future food, but rather from the style of hunting—by driving herds over a cliff. There are other instances. In the 1880s, soldiers and cowboys slaughtered buffalo as a political strategy to reduce the resources of native peoples. Farmers and loggers destroyed the dense forests of Ohio and other states. Settlers and industrialists in the Amazon are destroying vast tracts of rainforest, as part of a political strategy to move peasants out of cities. Industrial forestry in the Northwest is content to take a high percentage (well over 90 percent) of a forest for wood and pulp, destroying the basis for the continuity of the forest, as well as all beings that depend on the old-growth, fungi, and physical properties of the forest to live.

Human exploitation at the tremendous physical scale that occurs in industrial states is different from exploitation by other species, because it results in the destruction of the entire system, the very basis for renewal of a system that human beings (as well as other species) need for life. Human actions are damaging global biogeochemical cycles, such as the carbon or nitrogen cycle. For instance, deforestation, burning, wetland loss, and industrial processes are releasing massive quantities of carbon dioxide into the atmosphere, which disrupts the carbon cycle. Although the destruction of large species, from whales to frogs, has a dramatic effect on ecosystems, the destruction of microbes, which generate oxygen and recycle nutrients, has a critical impact on the entire food web. These actions are global, like a large volcanic eruption, but, unlike a volcanic eruption, they are constant and hourly. These human activities are best referred to as interference.

4.6.3.1.4. Dealing with Interference

Interference has been a rare phenomenon on earthly ecosystems; it has happened in the past as the result of global catastrophes, such as meteor impacts. Now, interference, as opposed to more limited and predictable disturbances or exploitations, is threatening the stability of all ecosystems. It is dangerous to interfere with the processes of ecosystems because it disrupts the communities on which other species, and ultimately human communities, depend. Furthermore, in the deepest sense, it violates the idea of living together with other species on the planet. The proper relationship of humanity with nature includes competition and exploitation and mutualism, but not interference.

We kill millions of animals in laboratories to insure our safety, we kill billions of plants and animals for food and clothing and products, while indulging in the sentimental preservation of some individuals of other species. Animals do not need to be saved from natural death, a great regulator of life, but from unnecessary suffering, experimentation, and premature extinction. The world would not be a better place without sharks, silverfish, rats, cockroaches, or hyenas. They need their own places. The places, entire ecosystems, need to be saved. If we diminish variety in nature, we debase its stability and wholeness. To save ourselves, we must preserve and promote the variety of nature.

How do we incorporate this variety of interactions into design? Should we ban interference activities entirely? What do we design for? Wild animals in place, good domestics? Many original ecosystems supported good numbers of mammals, from mice and coyotes to deer, antelope, and elk. To some extent they have been replaced by domestic species: Dairy and beef cattle, swine, sheep, and poultry. Livestock often outnumbers the human population. Over 60 percent of the cropland production is devoted to feeding them, and over 30 percent of raw materials to housing and transporting them (for example, it takes 5 to 20 calories of fuel to produce 1 calorie of meat). Should design consider the numbers of feed animals. Should it arrive at an optimum? Would the optimum be determined by dietary preferences or by the amount of land available for raising healthy free-range domestic animals?

Although many animals, such as cattle and sheep are raised on ranges, they often spend months in feedlots being fattened with grain for human consumption. About 95 percent of this food goes for respiration or ends up as manure. The 95 percent loss is acceptable when an animal is raised on rough ground or when native populations, antelope for example, are used for food.

Harvesting some wild animals may be a better alternative than agriculture; this would be cheaper than improving the pasture degraded from overuse. Wild species might be more appropriate on marginal soils. The husbandry system whose forms underlie the foundations of modern thought, excludes wild nature as chaotic and other. We commit biocide on the wrong (or not 'our') animals. The living world faces a massive failure of interspecies dynamics, with great destruction of life and devastating psychological effects.

Pets, as domestic animals and a few wild but caged birds, reptiles, and mammals, need to be considered for fitness into nature. Because of pets, it could be argued, we are less concerned with wild animals and allowing them to slip into extinction. Then, too, we maintain our pets out of context; they are fed food from cans, kept indoors or in cages, and taught to defecate neatly. Zoos, aquaria and aviaries keep animals alive out of context, out of the conditions that shaped them. Denied the possibility of biological meaning, many of the animals may go mad. We will never understand why they are the way they are if we only study them in our homes or their prisons.

Aldo Leopold's chief concern was the need to reestablish the personal coexisting relation with nature, rather than large-scale impersonal management of resources by a professional elite. What the preservation designer wants is to preserve natural cycles, not a frozen state of habitat like scenes from a Disney movie. As civilization staggers, we can find an ecology of the psychological environment that can be trusted to find balance and compensation; it is part of life-support system.

4.6.3.2. *Practicing Noninterference*

Exploitation, in the ecological sense, is necessary and beneficial to biological populations. A machine metaphor approach, with its assumptions of interchangeability and quantity, apparently has difficulty distinguishing between exploitation and interference. An ecological metaphor, that is more receptive and reverential, may be more appropriate to understanding organisms and nature in general. Such an approach stresses noninterfering observation rather than controlling manipulation.

Applied to nature, human intelligence discovers the significance of natural rules of interaction and exploitation. The reverence for beings as they are results in the rule of noninterference (Wittbecker 1984). A rule of noninterference states that human beings ought to avoid behavior that disrupts essential ecological processes or destroys biotic communities. As Paul Taylor states his rule of noninterference, it requires a "hands-off policy" for whole ecosystems and biotic communities; the rule stated here is concerned with limited and sustainable exploitation of ecosystems already shaped to some extent by human activities. Many other ecosystems, perhaps covering 50 percent of the land area of the planet, would be reserved by law for predominately natural ecosystems or adapted first nations. Noninterference also means "letting be" (after Martin Heidegger), or "letting alone" in the words of E. O. Wilson. Noninterference is not indifference, which is diffuse. It is caring. Noninterference will not lead to chaos, poverty, or stagnation. It can permit the rational exploitation of resources.

We need to practice the rule of noninterference so that all beings can enhance their lives and habitats. Noninterference can be derived from nonviolence (or taoistic nondoing, a metaphoric expression for the nonbeing of nature) or even from English Common Law, which is well-established in Western law; it includes a precept: "Use what belongs to you in such a way as not to interfere with the interests of others" (*Sic utere tuo ut alienum non laedas*). This rule could be defined by positive laws and by negative restraints on behavior. This attitude would entail using what is necessary, exploiting some ecosystems completely, changing a place to fit human aspirations, and killing plants and animals for sustenance. But, it would also mean limiting humanity and its technological effects, limiting human use to local impacts, and letting other beings live without interference. It is not necessary to dominate or terraform the earth completely. Humanity could contain itself to a small percentage of the planet's surface and ecosystems and only visit or ignore the remainder.

4.7. *Determining Planetary Wilderness Designs*

The scope of this section is to determine how much wilderness needs to be saved, on a global level, to prevent, or reverse, increasingly significant annual losses of biodiversity, species and ecosystem services. For the moment wilderness is pragmatically defined as areas necessary for global maintenance that have minimal human industrial or technological impacts). In his previous studies (1970, 1972), Eugene Odum suggested that forty percent of ecosystems needed to be set aside to provide ecosystem services for human populations. In his lecture just before this one (at the IV International Congress of Ecology, 1986), Odum emphasized the importance of wilderness for the planet, as well as a general knowledge of ecology by the people living on the planet.

There are significant problems in dealing with wilderness, however. To begin, we are not sure how to define wilderness. Nor do we know exactly how much of it remains anywhere. Next, we are saving wilderness from the bottom up, as separate species or habitats, rather than from the top down, which would identify entire wild areas to represent each kind of ecosystem, especially those that do not have grand viewscapes or charismatic animals. Furthermore, we are losing wilderness faster than we can understand it, and the more endangered the wilderness ecosystem is, the faster it seems to be declining or disappearing. Finally, we are not even identifying wilderness fast enough, and we do not have plans to survey and monitor all wilderness ecosystems. We know that most wilderness is not protected, but we have not studied the missing pieces of wilderness, such that we can save the processes that create and maintain the great diversity of wilderness.

This discussion of wilderness will expand two points: Wilderness definition and the idea of a minimum—or an optimum if we prefer to be safe and thoughtful—area of wilderness for the entire planet. First, wilderness definitions have tended to be restricted to banning human activity in mountainous areas. This kind of definition needs to be expanded to include every kind of ecological system, including those shaped by traditional cultures, as well as ecosystem dynamics of all systems.

Second, the idea of a minimum needs to be refined. A static minimum is easier to calculate, but a dynamic minimum is necessary to consider. The idea gets fuzzy because of the variables. Therefore, it is better to try for an optimum, rather than risk missing variables and adhering to a figure that is relatively meaningless.

4.7.1. *What is Wilderness Again?*

Wildernesses are ecosystems that are self-creating and self-maintaining. An ecosystem itself can be defined several ways, as a community, as a place, or as a process. As a special kind of ecosystem, wilderness is a human classification of an area (including air, water, land, and species) that recognizes that the content is determined by natural physical and evolutionary processes. Of course there are many classifications of wilderness and other definitions. This article does not address the definitions of wilderness that refer to human inspiration, recreation, purity, separateness, fiction, or myth. We have placed so much baggage on the word that it may not be useful. Wilderness is not a pure ecosystem. There never has been, for the past ten thousand years or more, a pure, humanless nature. Nor should wilderness be considered a simple playground for human needs for entertainment or therapy. Here, wilderness is simply a designation of natural systems that are not dominated or significantly modified by human processes.

Wilderness is a metaphor, after all, an invention of city people to describe the kind of nature existing outside their walls. This definition anticipates that nature was being converted to human nature rapidly. The metaphor has a psychological dimension. For instance, the forests of Greece were wild. But, the contemporary degraded landscape is also considered wild. No definition can be completely objective, due to this psychological dimension. Wilderness is a state of mind combined within a state of nature.

Wilderness is designated by boundaries, usually formal ones where governments have set aside wild lands. But, the boundary does not have to be formal, as long as there are rules. It could be recognition of places left alone because they are cold or remote. The boundary can be a limitation on interference or conversion, and perhaps a limit on the number of people or on their use of technology.

At least eight kinds of wilderness can be distinguished: Sacred areas, Foundation areas, Reservation areas, Preservation sites, Restoration areas, Neopoetic communities, Conservation parks, and wild agriculture and forests.

4.7.1.1. *Sacred landscapes* are those areas set aside out of respect, for habitats for others, where humans do not belong, and for species that cannot coexist with humanity. Examples of sacred landscapes are mountains, fisher/marten habitat, and large areas of tundra. In many archaic cultures, significant parts of the landscape are regarded as sacred (and, although not used, the wilderness is considered a part or center of their territory). This may be a mountain at the center of the world, a burial ground, or the portion of a river that belongs to the fish gods. Sacred spaces are highly valued locations, with limited access and usage. Such spaces have great symbolic value to societies where they are associated with significant events (or divine manifestations). The assignation of sacredness may result from functional necessity, to prevent flooding, limit population, or to balance the economy. In sacred landscapes no direct human impact should be permitted; mapping would be possible from satellite.

4.7.1.2. *Foundation areas* are zones that contain active wild communities where the integrity of nonhuman life is not challenged by human interference. Foundation Areas house the depth of wilderness. The depth of wilderness is what allows recolonization after disruption or human influence. Foundation areas could include common lands, that is, one of each kind of ecosystem on the planet, regardless of aesthetic value. Some visitation could be allowed, but without permanent residence or machinery. Human impact would be limited to noninterventive science (perhaps based on Goethe's method of contemplative nonintervention). Foundation areas would include large areas of the Amazon.

4.7.1.3. *Reservation Areas* are zones for the support of nonindustrial native cultures expressing traditional ways, that is, natural systems in which humans play a limited role—limited by a percentage of net ecosystem productivity, for example, the Miskito in Central America. Many traditional or archaic human cultures play a large part in the design and maintenance of these areas, not only by using fire, but by their traditional hunting practices. Limited human use often increases the diversity of a system, although the diversity tends to flow from human preferences for some plants and animals. Removing humans from this kind of wilderness would alter it and perhaps diminish it, so human use is retained.

4.7.1.4. *Preservation Sites* are places where the system is maintained by human activities, such as burning or planting. Specific kinds of preservation areas could include:

Boundary areas, ecotones or lands bordering agricultures, small patches influenced by human activities, or corridors. Human impact could be limited to traditional, experimental science. An example could be the central long-grass prairie in the United States. In these areas, human activity is consciously limited to maintaining the desired state of the system, where the system has lost keystone species or where the area is too small or oddly shaped for the large-scale processes of an ecosystem to work independently.

4.7.1.5. *Restoration Areas* are zones which are set in a former native pattern by human activities, but which may not need further intervention. This may include the experimental restoration of ecosystems disturbed by human activities or natural events, for example, Lake Shagawa or larger restored areas of Tall-grass Prairie. Once the system has been reestablished, it would be allowed to develop on its own. This zone requires large enough areas for the natural processes to continue.

4.7.1.6. *Neopoetic Communities* are areas that have been created through the introduction of exotic species over time, but have become naturalized. Most of these recent areas have been started by human activities, but saved as self-regenerating systems and not built up or interfered with, for example the California grasslands, which have been changed with Mediterranean plants, e.g., wild oats, wild mustard, wild radishes, and wild fennel, or the *Stara Planina* of Bulgaria, modified by grazing over thousands of years, so that grasses replaced the shrubs and trees.

In a sense, every ecosystem and community is neopoetic. North America once boasted a wide suite of large mammalian species, including camels, horses, jaguars, and mammoths—a combination of circumstances, that may have included climate change and human hunting, resulted in their extinction. It seems these niches were never quite filled completely by the immigrant species from Eurasian continent. Species compete or partner for space in ecological systems. They are always making and remaking the assemblages, causing new combinations or new extinctions. Creating new wilderness in North America by reintroducing similar megafauna from South America and Africa would be an interesting experiment in community building. The Wildlands Network has been promoting such an experiment.

4.7.1.7. *Conservation Parks* are areas set aside for multiple use of resources without interfering with the operation of the ecosystems. Research may be conducted to answer questions as to whether the park is big enough and shaped correctly to constitute a proper habitat for its inhabitants. Human recreation would be permitted in temporary camps and with some light machinery, for example, the Boundary Waters Canoe area in the United States. These areas have been adapted to human presence and exploitation of many species.

4.7.1.8. *Wild Lands (*forests & fields), as well as other wild systems managed for the harvest of wild species, such as antelope or fish, are a final category. Although forests can be lightly harvested for wood and other products, they are predominately wild, and would be left wild, rather than being clearcut and replanted with a single species. This is an unusual category of wilderness, since we do not always consider forests and some kinds of agriculture as wild. In fact, wild species in wild systems have been shown to be more efficient in their use of resources and more resistant to other wild species that we humans consider pests. In fact, as regards forests, wild areas are preferred to agricultural areas such as tree farms, for many reasons, from automatic regeneration to the quality of wood. In this category, we recognize that areas of wilderness can be used without being destroyed or domesticated.

By just wilderness, the first three areas are included indiscriminately. They all have similar values, as mirrors of existence, examples of natural, complex processes, expressions of love for nature, and wild, nonhuman places. What they have in common is that they continue natural cycles without having to be supported by massive human intervention. In this discussion, all of these refinements are included under the umbrella term wilderness. In a complete zonagraphy, these categories would be a critical part of all separate (limited) areas.

4.7.2. *Do We Humans Need Wilderness?*

Human needs have been placed by the psychologist Abraham Maslow into five groups: Physical (food, shelter, clothing), Safety (law, order, security, freedom), Psychological (belongingness, love), Esteem (strength, self-sufficiency, competence, attention, prestige), and Self-actualization (achievement, creativity). I reason that wilderness provides the basis for each group.

We humans need wilderness physically. It is the matrix that is producing and supporting us. Even if we understood all of the intricacies of the process, and thought we could duplicate it in artificial environments, on spaceships for instance, we would still need wilderness—as a source of basic ecosystem services (that keep the planet functioning) and as a source for ecosystem and human health.

Wilderness, as an ambihuman ecosystem, provides safety through its intrinsic order. In fact, wilderness has provided security for people because of its resources and because by definition it has not been under cultural control. Traditionally it has been a source of freedom from the many kinds of human political tyranny.

We depend completely on the natural environment psychologically. Psychologists, such as D.O. Hebb, have conducted experiments that show the effects of a limited environment. Cut off from external stimuli, the mind becomes strange. The external world is needed to keep us alive and sane. This world is composed of remote occurrences, on polar icecaps and distant stars, as well as immediate personal events. Wilderness provides a constantly presenting environment. The human body links this exterior to a mental interior. The person is inextricably woven with the world; the body is a mode of presence to others.

Living within many kinds of wilderness, as do many foraging and horticultural cultures, allows the development of strength and self-sufficiency. And, this results in feelings of competence; although, this may be true also where wilderness is used for recreation by industrial cultures. In Archaic cultures, wilderness, as sacred space, is reserved as sacred; it confers more prestige on the sacred chiefs, e.g., Tonga or Samoa (where prestige is the power to influence others, due to success or status). Wilderness can provide sources of prestige that are outside of inheritance or social rank.

We need wilderness mentally and spiritually. Wilderness, basically as sets of places where nonhuman beings could continue, is necessary to the human psyche, where "otherness" continues to exist. It is a source for inspiration from the nonhuman. It permits creative expression and spiritual development, outside of the human cultural limits. Wilderness is the source for all human creativity. It is the experimental ground where forms are recombined.

4.7.2.1. *How much Wilderness do we need?*

Wilderness is an ambiguous and indefinite thing. It is a need like the sun is a need. But, we do not need to live in it or even visit it. It supports and cycles our human ecosystems. We need it because it is not us, not human and not human-made or maintained; it is the source of all nonhuman being.

It is one of those things that we need as much as possible of. We can not know exactly what the minimum is, either for the planet or for human physical or psychological requirements. Even if we could determine a minimum, we should consider a more conservative number, or an optimum.

For ecosystem services, that is, for clean air, water, food, shelter, we could calculate a minimum (or optimum), based on a number of criteria. To ensure the continuity of many habitats and species, we need to restore many systems that have been degraded; and save every one that is left. The hot continental region has been transformed for agriculture and little natural vegetation remains. Nevertheless, many of these areas could be restored as common areas, and support a suite of species that is adapted to the system.

Perhaps, there is enough wilderness for inspiration, but to inspire 10 billion people may take more than is left on the planet. Humans are inspired by different things, so a token wilderness will not likely serve as inspiration for every one who is part of the current or projected population.

There may be enough wilderness at this time, especially if we employ better technologies and more discipline in their use. For growing populations, we will require more wilderness. Without knowing how much wilderness we need, it may be possible to calculate an amount that might serve our needs, after considering a few more questions.

4.7.2.2. *Does the planet need wilderness? Do species?*

The planet, as a self-creating and self-maintaining system, needs a minimum volume of wilderness to continue the cycles necessary for renewal. Because the planet is a sum of local regions, a mosaic of different ecoregions, those regions need to be considered individually.

Diverse habitats form a mosaic on the landscape, e.g., patches. A patch is also a landscape element. Each patch contains internal habitat diversity. Disturbance in a patch is a major determinant of species number and size. For sustaining a species there has to be a Minimum Dynamic Area. Patches have different patterns. Squirrels for instance, may be found in small patches but be absent from or scarce in large ones, which may contain predators such as owls. The same situation may be true with land snails, which may be preyed on by wild pigs. There may be a patch size restriction.

The Minimum Dynamic Area is the smallest area for a reserve to have a complete natural disturbance regime in which discrete habitat patches may be colonized from other patches in the reserve. Larger patches are required to sustain a species indefinitely. Formann defines the Minimum Dynamic Area as the patch size required so that the natural disturbance will not eliminate a species.

Although area is one criterion of a landscape, ecosystems are not completely defined by spatial criteria. One reason that it is difficult to have area define an ecosystem is because of the watersheds and airsheds that are larger than one system. In many ecosystems, plants through transpiration cause precipitation in the larger airshed. The spatial boundaries of an ecosystem, dynamic due to changes, are more dynamic due to air and water. Of course, parts of the ecosystem are based in soil processes and the plants themselves.

The scale of other pathways contribute to the size of an ecosystem. So, when calculating a minimum or optimum size for ecosystems that need to be labeled wilderness, we have to be sure to increase the area to make sure that the largest extent of water and airflows are also self-sustaining on that scale. The pathways have to be complete within an area, a natural surface with a large number of limits (water catchments, nutrient deposition, nutrient limits, temperature limits); this includes biochemical pathways. The minimum critical size of ecosystems remains one of the central topics in conservation and is being dealt with in greater depth by Lovejoy and Oren.

Because the regions are the sum of plant, animal, and material interactions, it may be necessary to calculate some wilderness in terms of keystone species. All animals use environmental signals to time their life events. Day length or availability of food can trigger reproduction. These signals provide predictable information about conditions that are forming in their environment. Sometimes, however, unpredictable events, such as storms, can disrupt behavior. Animals therefore learn to cope with many kinds of unpredictable events. Human actions, such as pollution, introduction of exotics, or large-scale disturbance are also unpredictable events to animals. Population declines of animals can be accelerated by: Genetic change, such as a loss of variation; demographic fluctuations, due to changing birth or death rates; and environmental fluctuations and disturbances, such as fire or poisons. Wilderness is a way to reduce the number of unpredictable events so that animals can flourish.

D. Terborgh (1974-1975, in Lovejoy) demonstrated that very large areas on the order of 1,000 square kilometers are necessary for long-term survival of species (without those large areas, bird species loss has been reduced to 1 percent of the original avifaunal complement per century). Although this particular approach has been questioned, other considerations such as problems of population densities and the likelihood of extinction from random population fluctuations support the general conclusion that large reserves are necessary to keep ecosystems intact.

Thomas Lovejoy and Richard Bierregaard, ornithologists, started a Minimum Critical Size of Ecosystems Project in Brazil. Using a Brazilian law requiring rainforest tract owners to leave 50 percent of the land in tree-cover, and working with landowners to leave patches in size from 1 to 1000 hectares, they started to survey diversity. The purpose of this project is to answer the question: How much land is required to sustain 99 percent of all original species for 100 years?

The diversity of small islands decreased more rapidly. The extinction of species was also accelerated by day winds that were able to penetrate into interior forest, killing trees 100 meters or more deep. Edge species increased. Interior species, including ants and shade-loving butterflies declined. Large mammals, such as pumas and jaguars and peccaries, migrated away from smaller plots. Without peccaries to create wallows in forest pools, some species of frogs failed to breed and disappeared. Beetles needing dung or carrion became scarcer. Second and third order changes would continue down to mites and parasites.

Wildly fluctuating populations are also more vulnerable to other events. Below a certain threshold, a small population is in danger of extinction. Edward Wilson notes that a tenfold rise in population size may increase chances of longevity thousands of times. A modest increase in habitat size may put a species beyond the threshold. Animals may be vulnerable if they are specialists, or if they are large. Large-size predators means smaller populations, which are vulnerable to extinction.

While the general conclusion that large reserves are necessary is undoubtedly valid, the topic has not been dealt with in anything like the depth it needs, from the viewpoint of either conservation or theoretical biology.

The main purpose of their study is to determine the role of ecosystem size for primary productivity, autotrophic biomass and system respiration and their temporal stability in experimental mesocosms and natural ponds and lakes. In any landscape, productivity can vary over short distances, due to differences in topography, air temperature, water availability, and history. Therefore, regional averages are used.

We should create a Minimum Critical Volume for planetary wilderness, below which cycles would wobble or collapse. We are not sure about size or stability of planetary cycles or ecosystems. Worse, the delay time between instability and collapse is likely more than one human lifetime, so unless we start monitoring all ecosystems, we will have a hard time understanding which systems are dying and which are changing to new points of stability.

4.7.2.3. *How do we know how much wilderness the planet needs? Or how much an ecosystem needs? Or how much species or guilds of species need?*

It is thought that if we save a large percentage of the planet in wilderness that will be enough to automatically save both ecosystems and species. However, it will not save part of each kind of ecosystem. It is thought that we can save minimum viable areas of each kind of ecosystem, and that would save most of even the larger species. But, that will not save at least one population of each species. For that, we need to inventory all the species on the planet. Then we could calculate areas with Minimum Viable Populations (MVPs).

4.7.2.3.1. *How Much Wilderness Does the Planet Need?* That's hard to say, because there are so many human variables, not to mention evolutionary variables. The planet will continue, regardless of how we modify it. It may have fewer simpler ecosystems. What we are really concerned about, I think, is richness. How rich a planet do we want? Do we want cathedral-like tropical forest canopies that host millions of different species, each making a home there? Or will we settle for desert ecosystems, blasted by centuries of war and destruction? Of course, these ecosystems have their own stark beauty, even after the adapted species have been destroyed. I think the moon is beautiful, but I would not want to live there for long, even with the best technical support.

The vast number of species existing now have existed for over a million years. These species have proved resilient to all kinds of natural changes and disturbances, except for human ones, which can interfere with renewal.

4.7.2.3.2. *How Much Wilderness Should there be in an Ecosystem?* I am not sure how much area an ecosystem needs to be self-renewing. Of course, that depends on the ecosystem. And, the larger and more complex the ecosystem, the greater the likelihood it has dependencies and exchanges with other ecosystems. We know about exchanges, especially bird watchers, who follow the objects of their fascination for thousands of miles. Birds carry information, genes, viruses, and seeds to distant ecosystems.

4.7.2.3.3. *How Much Wilderness Does a Species Need?* For species, we can calculate minimal areas to maintain minimal viable populations. But, even then, there are many variables to consider, depending on the species. For example, some species, such as wolves, use nonbreeding individuals to help with education of the young.

Each species needs to keep a minimum number to be genetically healthy. Biologists have been attempting to determine Minimum Viable Population size (MVP), which is the smallest number of individuals to maintain a population indefinitely. How big should a population be to avoid extinction? Population viability analysis is a comprehensive analysis of environmental and demographic factors that affect the survival of a population.

Michael Soule has suggested 500 breeding individuals as the minimum. The 500 breeding individuals is the effective size; the real size may be quite larger, especially where the generations are shifted to elderly or where not all members mate. Long-lived species are also vulnerable, for example, the Pacific Ridley sea turtle or African elephant. So, we could safely use 2500 as the optimum number.

How big is the minimum size of area that will sustain a MVP? What is the minimum viable area? For a forest patch size in forest marsh grassland, a minimum area can be calculated for typical species:

• One to four hectares (ha)—amphibians, frogs, a very few common edge birds, such as Downy Woodpecker or Great Crested Flycatcher

• 10 ha—still dominated by edge species, but may have very small areas of interior which supports numbers of forest interior/edge species, such as Hairy Woodpecker or White-breasted Nuthatch

• 50-75 ha—still predominantly edge, but will support small populations of most birds except those with very large home ranges. Least Bittern may be present in marshes of this size - more bird species (Northern Harrier, Short-eared Owl)

• 100-400 ha—all forest-dependent bird species diving ducks (Redhead, Canvasback, Ruddy Duck)

• 1 000 ha—suitable for almost all forest birds. Some forest-dependent mammals present, but the size may still be inadequate for Sharp-tailed Grouse and Greater Prairie-Chicken

• 10 000 ha—an almost fully functional ecosystem, but may be inadequate for a few mammals such as Gray Wolf and Bobcat (100,000 ha has been suggested as a minimum)

• 100000 ha—a fully functional ecosystem. It may be a minimum size for a functional ecosystem but some species may still be below or near their MVP level.

It might be best to use a strategy that combines all three approaches: a percentage of the planet, in addition to special ecosystems and then special species. Without knowing how much wilderness the planet, ecosystems or species need, it may be possible to calculate an amount that might serve those needs.

4.7.3. *If we don't know how much is needed, how much should we save?*

Obviously, we should be cautious and save as much as we can of every habitat. If the area is large enough, then probably the top predators will survive and keep the system diverse and healthy.

The current reserves are inadequate; wild species decline on limited reserves. Designing reserves requires a biogeometry, knowledge of the shapes of ranges. Left to themselves, in an adequate preserve, species may be dropped or generated. Human progress deprives many species of existence, simplifying ecosystems of which we are still greatly ignorant. Industry destroys billions of creatures more than unscrupulous hunters or multiplying homesteaders. The rate of extinction of species exceeds our rate of learning about them. Humanity as a species must develop an awareness that it is infinitely enriched by the organic world, and is poorer each time a species is eliminated or natural community degraded.

There are many ways to approach minimum (or optimum) wilderness areas. Some ways are simple, and others are complex, perhaps too complex. Some simple ways are probably unacceptable to the human populations. Several approaches can described as follows:

1. The Remainder method (*What's left?*)
2. The 50 percent rule (*Best guess?*)
3. The Acreage method (*After Eugene Odum*)
4. Minimum System Method (*Processes, after Lynn Margulis*)
5. Key Species: Top predator home range (*With genetics/ecoregions*)
6. The Mixed Method (*Appropriate for various areas*)

These approaches are expanded in the following paragraphs.

4.7.3.1. *The Remainder Method*

This method works by calculating how much wilderness is left and not critical for human needs. This would result in about 30-36 percent of the planet, according to satellite information. Early satellite information revealed that 32 percent of the land area was not being used in a way that compromised the systems self-renewal. A 1987 survey by the Sierra Club revealed that about 34% of the land area is undeveloped wilderness in blocks of 400,000 hectares. The Wilderness Society estimates that a wilderness area should be at least 400,000 hectares (1 million acres or 1600 square miles). Presumably, this would permit minimum cycling. Only about 20 percent of that is protected. Including Alaska, wilderness in the US occupies only 4 percent of the land area (and two-thirds of this is in Alaska). The US has 233 distinct ecosystems; very few of them are protected. But, 40 million hectares of public lands could be designated wilderness in US.

Wilderness remaining by continent has been calculated by J. M. McCloskey (Sierra Club, see Table 4731-1). This could form the basis of saving the remainder.

Table 4731-1. Remaining Wilderness by Continent

Antarctica	100%
North America	36%
Africa	30%
Oceania	30%
Asia	27%
South America	20%
Europe	7%

In "Wilderness: Earth's Last Wild Places," a publication by Conservation International and Agrupación Sierra Madre, the authors found that "wilderness areas" still cover close to half the Earth's land, but contain only a tiny percentage of the world's population. Over 200 international scientists identified 37 wilderness areas that represent 46 percent of the Earth's land surface, but are populated by just 2.4 percent of the world's population (excluding urban centers). To qualify as "wilderness," an area must have 70 percent or more of its original vegetation intact, cover at least 10,000 square kilometers (3,861 square miles) and must have fewer than five people per square kilometer. Five of the wildernesses are also biodiversity hotspots, home to thousands of species found nowhere else. These are Amazonia, Papua New Guinea, the Congo, the North American desert and the deciduous woodlands of southeastern Africa.

However, this does not tell us if it is enough to guarantee the functioning of representatives all ecosystems, for minimum function. Nor is there any way to tell if it is enough to support human populations at any level of luxury.

4.7.3.2. *The 50 percent rule*

The land area of the planet is over 149 million square kilometers (over 57 million square miles). Using the 50 percent rule, we should set aside 74.725 million square kilometers (over 28 million square miles). The oceans would also be protected at the same rate. Water area is over 360 million square kilometers. So, 180 million square kilometers would be preserved from extreme fishing, dumping or other use, especially those areas close to shore and upwelling zones.

It is possible to arrive at this rule as a result of exponential change, 50 percent of lake is covered the day before it is entirely covered, if algae is doubling every day.

The problem with this method is that a growing population has to be kept within the remaining limits, and those limits have to be exceeded to provide sustenance for those people. This might be possible with an increase in urban agriculture and with more appropriate technology, but it would wreak havoc on traditional diets and traditional agriculture.

4.7.3.3. *The Acreage Method*

Eugene Odum (1970) suggested using land area as a measure of human carrying capacity. Odum was one of the first to consider the implications of such limits. The minimum per capita acreage requirements, with a temperate area like Georgia as a model for a quality environment, is 2.02 ha (5 acres). The percentage of basic areas is shown in Table 4733-1.

Table 4733-1. Acreage Per Capita (after Odum)

Food-producing land	30%	.606 ha
Fiber-producing land	20%	.404 ha
Natural support areas	40%	.808 ha
Artificial areas	10%	.202 ha

The state of Georgia has a mean Net Primary Productivity (NPP) of 1200 grams per square meter per year ($g/m^2/yr$). Most of the state is a temperate deciduous forest. By comparison, the mean NPP of the entire planet is 782 $g/m^2/yr$—this includes desert and prairie areas—and this is only two-thirds as productive as temperate forest areas.

Using this figure for wilderness of 40 percent per person, and considering the difference between mean productivity, we can calculate an optimum wilderness area for the planet, using the current population (as of 9/2003, see Table 4733-2).

Table 4733-2. Calculation of wilderness percentage

6,301,400,000 x .808 ha x 1.53 =	8,484,204,960 ha
Convert to square kilometers	84,842,049.6 km^2
World land area	149,450,000 km^2
Percentage of world area	56.77%

This calculation results in a figure of just over half of the area of the planet for wilderness. Of course, as the population increases daily, then the amount of wilderness required also increases. This is not happening; wilderness is not being created or restored at the same high rate as population growth. Wilderness needs to be increased to provide the ecosystem services that more people need. At the same time, we might find it prudent to decrease our populations.

If we use Odum's whole figure requirements, not just the natural areas, then the situation is revealed to be more critical (see Table 4733-3, from 2000).

Table 4733-3. Calculation of total percentage required for current human population

6.301,400,000 x 2.02 ha x 1.53=	19,532,728,389
Convert to square kilometers	195,327,283.89 km^2
World land area	149,450,000 km^2
Percentage of world area	131%

This current area calculation is greater than the surface area of the planet. The only option in this case is to reduce the human populations over several generations—perhaps by lottery, or reverse incentives, or allowing cultural autonomy.

4.7.3.4. *The Minimum System Method* (Process)
When the ecosystem is the smallest unit capable of recycling the elements of its membership, then for each type of ecosystem, a minimum area can be calculated that would permit the processes to continue to function. For example, organic carbon can be expired, fixed, reacted, or transformed. This method requires intimate knowledge of an ecosystem. For most ecosystems, we do not have that knowledge. Until we do, we should use a more conservative approach to determine a minimum or optimum.

4.7.3.5. *Key Species Method* (Top Predator and Genetics)
By calculating the minimum viable area for each kind of ecosystem, using the largest habitat of the top predator, and summing for all ecosystems, a figure can be calculated for a wilderness area for the planet (if wilderness is equated with ecosystems MVAs). Predation is a key to initiating and sustaining the diversity of ecosystems. Humans, by wiping out the predators have made the systems less healthy. The predator serves as a top-down limit for prey species, keeping them healthy by altering their behavior, and by removing young sick and old individuals. Of course, in the system, there are bottom-up limits also, as plants change their chemistries to attract or avoid predators of their own.

The idea of saving wilderness now is the idea of saving ecosystems complete with predators, most of which cannot compete with humans. Yet, the systems are crucial to human survival. The conclusion then is to save large systems, as wilderness, complete with predators, not only to keep the biodiversity strong, but to allow those systems to provide those things that humans cannot do without, such as clean air and ecosystem services. The ecosystems have to have viable populations to be stable.

The size and geometry of reserves can be approached from considerations of large predators such as Grizzly Bears and Mountain Lions. It is possible to determine the minimum home range of such species by means of radio telemetry and to calculate a minimum critical area by making some assumptions about the minimum population size needed for genetic considerations. But such a procedure does not take into consideration the problem of dispersal of the young, who may not be tolerated within established areas. To remedy this situation, some have suggested reserves linked by corridors of similar habitat for dispersal so that there would be essentially islands of habitat for people rather than islands of habitat for wildlife .

Maximum population density scales as mass, therefore the requirements of individuals for space increases more rapidly with size than the space available. There is an overlap in the ranges of large mammals and birds. Large mammals that are grazing herbivores are not territorial. As species decrease in size they tend to be more patchy in their use of the environment (but many carnivores having a healthy population size also exhibit this tendency), which leaves a lot of space unused. However, those populations may shift territory, so it would be difficult to fence off only the territories they use currently.

We can calculate the areas for a few keystone species for instance, using their home ranges. Home range is the area around the home of an animal, used for feeding or searching for mates, commonly shared by mated animals with offspring. Defended territory is usually a smaller area that an animal will defend actively. Animals also disperse and migrate, both vertically and horizontally. Keystone species can be top predators, such as the Sea otter, who preys on sea urchins, which graze on algae and kelp, the dominant food source, e.g., fig trees, a connector, such as mycorrhizal fungi, a habitat modifier, such as the beaver or African elephant, a mutualist, such as cellulose-digesting microorganisms. Co-evolving species appear to alter the structures of landscapes over which they evolve. They then tend to have the highest fitness and survive the longest in their physical landscapes.

Predators have different sizes of home ranges, and the shape of their ranges reflects various habitat needs. Some predators have relatively small ranges that have a linear shape. For instance, the skunk, an omnivore that digs subterranean dens along hedgerows, has a home range of 1 km^2 per animal; the range is linear around edges. The red fox, a nocturnal carnivore that also creates subterranean dens, has a home range of 10 km^2 per animal; that range is also elongated rather than round in shape. River otters, piscovores living along rivers and valley streams, have a home range of 160 km^2 apiece, whose shape is guided by water courses, but also changes by seasons.

Other predators have larger ranges with other geometric shapes and may use several ecosystems. The Canada Goose requires numerous landscape features for summering and overwintering, roosting on open water, feeding in fields by day, resting on shorelines during day, and staying in protected coves in bad weather. Migratory birds are declining as a whole because not all of their territories are protected. In many cases, wintering grounds are being destroyed by logging and burning. These species need several habitats to avoid extinction.

Owls are also vulnerable to habitat destruction, although they reside in one ecosystem. The Spotted owl requires 1000 hectares (10 km^2) of old-growth forest for each mated couple.

Other owls have less stringent needs. The pygmy owl requires half the territory and survives in second-growth forests. As a key species the minimum area for a viable population is 250,000 hectares (2000 km^2).

Coyotes each require a minimum area of 700 ha (7-10 km^2) for a home range; although the range follows natural features, it tends to be much less linear in shape. An effective population of at least 500 individuals may be needed to maintain genetic viability of each animal species (Frankel and Soule, 1981). Since not all coyotes in a group breed—some become aunts or uncles and help care for pups—it is necessary to assume 3 coyotes per breeding unit. Using coyotes as the key species, the minimum area for a viable population becomes at least 525,000 hectares (or 5250 km^2).

With wolves, it is necessary to assume at least 3 wolves per breeding unit. Assuming a minimum viable population of 750, and a requirement of about 80 km^2 per wolf, the minimum area for a viable self-sustaining wolf population would be 60,000 km^2. Many species, such as wolf, use clusters of ecosystems, including corridors, such as roads or frozen streams, as well as fields and forests; they avoid wetlands and human cities. Larger carnivores, such as Siberian tigers, require even larger areas (two tigers require 10,360 km^2 or 4000 mi^2. Five hundred would need over 5 million square kilometers).

This system is quite a lot of work. But, the calculations can be simplified using three levels of tertiary predators across all identified ecosystems. For example, the US has 233 distinct ecosystems. Wilderness for the US, using three levels of tertiary predators for the 233 ecosystems, can be calculated in Table 4735-1.

Table 4735-1. Wilderness Area to Hold Top Predators

77 x 2000 =	154,000 km^2
78 x 5250 =	409,500 km^2
78 x 60,000 =	4,680,000 km^2
Total =	5,243,500 km^2

The total area of the US is 9,373,000 km^2. By this calculation 55.9 percent of the country should be set aside as wilderness. By extension, that percentage could be extrapolated to the rest of the area of the planet (.559 x land area plus a calculated sea area).

The current wilderness in the US, which is the result of conservation efforts, is inadequate. Again, including Alaska, wilderness in the US is only four percent (374,920 km^2). But an additional area, 40 million ha (400,000 km^2), of public lands could be designated wilderness in US. Eight times as much would have to be created or restored.

There is another way to calculate Minimum Viable Areas. That is to sum the requirements necessary for each species, since each species is genetically unique, not simply address the top predators. This is considerably more difficult, since we do not know how many species exist, where they are, or how much home range they need; nor do we always understand how the areas overlap. This calculation will have to wait on a complete inventory and monitoring program for the planet.

4.7.3.6. *The Mixed Method*

A mixed method might be more appropriate given the differentials in wilderness saved, unused but unprotected areas, and humanized landscapes. First, set aside those areas that are essentially wilderness already. Antarctica is especially important because we do not really know if it is possible to save only half of it, while drilling and utilizing the other half. Because it its influence on the water level of the rest of the planet, as well as political uniqueness as a research continent, it should be preserved intact. Other parts of the Arctic, Sahara desert, and Micronesia, should also be set aside, that is, be limited in terms of not increasing human impact.

Therefore, first we add: Antarctica (14,100,000 km^2); the Arctic parts of North America, Europe, and Asia (calculate); Amazonia, Central Africa, Asia; and Micronesia and Australia. Then we add hotspots of diversity: Madagascar; Klamath mountains, Ecuador, and others. Then we calculate areas of wilderness from the remaining areas, in terms of nations: United States, Russia, China, Europe, and others. Finally, we calculate the areas to be restored to minimum wilderness areas (in the categories, neopoetic and restoration, from the previous system): Europe, Asia, Africa, and others. This could be done in terms of ecoregions or ecosystems. As percentages, by Division, which allows finer distinctions, it results in 90,061,000 or 60.26 percent of the land area. See Table 4736-1 for a sample calculation of one ecodomain.

Table 4736-1. Wilderness Calculation by Sample Regions

System	**Size (km^2)**	**Planet %**	**Save %**	**Save size (km^2)**
400 Humid tropical ecodomain	38,973,000	26.64		10,382,434
410 Savanna division	20,641,000	14.11	35	7,224,000
M410 Savanna Mtns	4,488,000	3.07	75	3,366,000
420 Rainforest division	10,403,000	7.11	70	7,308,000
M420 Rainforest Mtns	3,440,000	2.35	75	2,580,000
…	—	—	—	—
Sum Domains				70,707,000
Sum Divisions				90,061,000

4.7.4. *After we decide on wilderness numbers, how do we set it aside and protect it? Does wilderness have to be separate from humans?*

There are species that cannot coexist with humans. There are habitats that are critical to the functioning of the planet. There are habitats too fragile to bear human interference. There are habitats that are of virtually no use to us. All of these could be set aside and monitored from satellite (even airplanes can have some impact on some systems).

The wilderness that could tolerate small incursions, such as scientific research, would probably tolerate some human presence. Those wilderness areas that have coevolved with human cultures could simply be controlled by limiting human presence to traditional cultures or to sophisticated ecological cultures. Not every person in every culture wants a car and television. The allure of simple traditional cultures is such that many people would like to go back to them and live that way.

Some wilderness areas could probably tolerate a higher impact from people. Traditionally, borders (between human and nonhuman habitation) have tolerated human impacts. Most borders are between cities and unused areas. These are permeable and undefended, except for the few reserves. The boundaries are fuzzy anyway, due to the ability of pollution and trash to reach any area.

Even the idea of wilderness has been turned inside out, from the nature outside to the nature preserved from us and our activities. Confucius declared that *fang-wai* (outside the square) was the edge of his interest; now that we understand the interconnections, we need to reverse that attitude as well.

The patterns we impose on all of nature now determine what species thrive and what do not, their numbers and ability to move and evolve. We tend to homogenize nature—homogenize is such an appropriate word—it means made the same, but also perhaps the process of sameness promoted by homo sapiens, the homogenizer.

The numbers look great, but how important is shape? These areas have to enclose a large percentage of interior space to protect interior species. The areas also have to be lined up with watershed and airshed patterns. The context landscape is also an important consideration. Historical developments, such as drought patterns, should be considered; for example, to accommodate anticipated changes from planetary heating, reserve designs could have longer north-south axes (for a longer discussion of shape, see the book *RDP: Regions*).

4.7.5. *Summary: Service & Wisdom*

Wilderness provides necessary ecosystem services to the planet and its inhabitants, including regulation of weather, developing and maintaining biodiversity, sequestering carbon, and maintaining watersheds. Wilderness is the source of evolutionary change. For humans, and possibly other beings, it has political and spiritual significance. Wilderness provides and maintains conditions conducive to human life, globally, regionally and locally. Maintaining wilderness areas permits continued global ecological sustainability. According to Reed Noss, "wilderness" protection and restoration must be the first major ecological conservation strategy.

Ecosystem conservation offers several advantages over a species-by-species approach for the protection of biodiversity. It directly addresses the primary cause of many species declines (habitat destruction), it offers a meaningful surrogate to surveying every species, and it provides a cost-effective means for simultaneous conservation and recovery of groups of species. The idea of representing examples of all ecosystems in protected areas extends back to the nineteenth century in Europe and in Australia and to the early twentieth century in North America. Ecosystem conservation does not remove the need to understand the autecology and the protection requirements of individual species. It is not a replacement for existing conservation measures such as the Endangered Species Act of 1973 in the United States. Not all species that have gone extinct in the United States since European settlement would have been saved by this kind of coarse filter, which does not protect all presently endangered species. We must save rare and endangered species along with this plan.

Conservation plans for all ecosystems should be developed, starting with those that are at greatest risk of degradation or conversion. Global conservation, in general, has to include key elements:

- Salvage the hotspots, including Madagascar, Hawaii, Klamath, and Ecuador
- Keep the five largest remaining frontier forests in tact: Amazon, Congo, New Guinea, Canada, and Russia
- Cease logging in all old-growth forests

- Save wetland systems, rivers, shores; save marine hotspots
- Restore some of the oldest landscapes, e.g., Mediterranean coasts, African wetlands, and Iraqi grasslands
- Restore areas that are overused or under-represented, such as grasslands and deserts.

Conservation plans have to include monitoring. This requires understanding the rates and locations of land-cover change, as the result of natural processes, natural disturbance and human interference, and understanding the processes associated with biological productivity. Both involve monitoring and assessment of landscapes that are changing rapidly due to extensive and intensified land use and natural disturbance regimes.

These plans must be kept in the context of human populations, cultures, and technologies. Human populations must be balanced with wilderness. If human populations cannot be reduced, then large areas of wilderness have to be restored.

Many wilderness areas and ecosystems are endangered, especially those that have a long history of human settlement, such as the eastern coast of North America, or those that hold desired resources, such as the beech forests at the tip of South America. Most ecosystems, much less ecoregions, have little or no legal protection. They have been ignored only because they are inhospitable or resource-poor. Plans to protect them have to have a strong legal component.

Wilderness is not something that can be preserved in one desired state; it is always changing. But, the processes that are continuously creating wilderness can be preserved by preserving the boundaries that limit wilderness from human landscapes. The wilderness cannot be managed; it is that which is not managed by definition. But, people, technologies and interactions can be managed.

Partly, things change, partly we reinvent things. Now we need to reinvent wilderness, cities, homes, and intercultural interactions. We need to keep everything in a complete context. That means political changes and population planning, as well as just designating and protecting wilderness. We need to act as if we were wise, according to Jonas Salk. Wisdom is a kind of action, based on theory, and with an understanding of ignorance.

Figure 4734-1. Alan Wittbecker surveying Altazor Forest, Idaho, 1993.

4.8. *Designing Planetary Patterns*

From looking at photos of the planet from orbit, from the moon or from intersystem and interstellar craft, we can see the large patterns of the continents, ocean and atmosphere, and sometimes human structures or influences. Many of the changes are visible, but the actual influences may not be visible. For instance, the Panama canal had a measurable effect on invasions of plants and animals. We have to be cautious about making canals between oceans.

Many kinds of pollution are visible. Pollution of air is a serious problem. Air moves rapidly around the planet, except for some stagnant areas. Pollution of water is a serious problem, also. Water dissolves many kinds of chemicals and minerals.

4.8.1. *Oceanic Patterns (Hydrospheric)*

Ocean covers almost three quarters of the planet, and we live on an ocean planet. Here on the water planet (Arthur Clarke suggested calling it Ocean), water is the dominant feature, especially seen from space. For over 4 billion years, water has ebbed and flowed over the planet. One hypothesis is that water derived from the interior of the planet, separating out as the continents started floating up. Another is that it preceded the continents. A third idea is that water arrived on planetoids that collided. In any case, as the continents have drifted around the globe for at least 3.5 billion years, the total volume of water has been relatively constant, although the ice caps have expanded and contracted, causing the sea level to rise or fall.

The oceans are part of the global energy "engine" driven by the sun. The oceans, along with the atmosphere, by its motion, distributes energy around the planet. Water is also a universal solvent, taking up minerals and gases on its travels. The oceans act as a reservoir of dissolved gases, which helps to regulate the composition of the atmosphere.

The action of water has shaped landforms, the shapes of embryos and the organs of plants (for a discussion on the power and spirituality of water, read *Sensitive Chaos*, by Theodor Schwenk). Water also cycles. It comes to the earth in rainfall and leaves through evaporation; it is thrown into the air by volcanic action; it flows into the ocean. By far the largest amount of water is contained in the lithosphere (roughly 20 times as much as in the oceans). The ocean, of course, has a lot of water. The smaller pools, in the atmosphere and circulating ground waters, are the most active and the most vulnerable to disruption and pollution. On the oceans, more water evaporates than returns as rainfall; just the opposite happens on land, causing a cycle of water flowing from land to sea, evaporating and falling back on the land. The ocean invaded land as interior parts of algae, plants and trees. Trees are standing water. Over three fourths of the active biomass on land is situated in trees.

Although we can affect ocean patterns slightly with physical structures, such as dikes or other barriers and channels, these have rarely been permanent. Damming rivers has had a more dramatic effect on the flat plains and the delta, which can disappear, affecting the river canyons below the shoreline. We do not know the long-terms effects, although we can observe the decline in fishing in those deltas and canyons.

Perhaps the best way to restore favorable patterns, instead of massive geoengineering projects, is to create natural engineering projects. Use proven alternative forms to generate energy, so dams can be deconstructed. Free-flowing rivers will allow valuable species, such as salmon, to return, and the rivers will transfer materials and nutrients to the ocean. Restoring fish and whale species to precatch numbers will restore the many iron, carbon and nutrient cycles in the ocean, which will affect other patterns.

4.8.2. *Atmospheric Patterns*

Many atmospheric patterns are tied to, or driven by, oceanic ones. The water cycle is a dramatic example. Vapor and materials taken up in the atmosphere from the ocean can cycle much faster, often reaching distant parts of the planet (usually separately in the northern and southern hemispheres) within days. Atmospheric deposits in the ocean can sink or be moved by currents, often taking months, decades or millennia before reentering the atmosphere.

Our greatest influence on the atmosphere seems to be from pollution, which not only affects air quality for breathing and seeing, but it affects birds, insects and other airborne plants and animals. Although it might be nice to control the jet stream and other air currents, so that they might be predictable and benign to our structures, crops and animals, we are unable to predict the consequences to those areas outside the control areas and may not even be able to physically alter them for control.

Geoengineering proposals have ben made to increase certain kinds of pollution to increase the reflectivity of the planet to reduce incoming solar energy. But, none seem to have been offered for controlling atmospheric patterns.

The increase in carbon and other greenhouse gases, including methane and water vapor, in the atmosphere is having a noticeable affect on wind patterns, however, resulting in floods and droughts in many areas. The solution to returning these patterns back to the 'normal' patterns seems to be in reducing pollution, which is easy to do, actually. All we have to do is cleanup our industrial processes, by creating an industrial ecology, and reduce our consumption in most areas. The most difficult consumption to reduce may be the use of fossil fuels for vehicles and for heating. There are alternatives; if we can change to them immediately, the last fossil fuels might be partially used for a transition and saved for a few critical uses, perhaps a much-reduced air travel.

4.8.3. *Land Area Patterns*

The total land area of the earth, excluding ice caps, is 128.8 million square kilometers (1.288×10^8) or 33.92 billion acres. The biosphere varies considerably in its density, from deserts and tropical seas to marshlands and tropical forests. The effect of a bombardment of energy from the sun on rock over time results in the weathering of rock. The disintegration of rock from physical and chemical processes produces a substrate for soil. The physical layering of erosion results in a profile. The procession of living beings, from algae and lichens to ferns and trees has resulted in considerable organic matter getting mixed in to rocky rubble, resulting in soil. The soil differs from the parent material in shape (morphology), composition, physical and chemical properties, and biological characteristics.

The underlying patterns of soil and rock, combined with the cycles of water and air, provide base conditions for ecosystems. Within those constraints the ecosystems develop and change over short and long periods, often being 'reset' by catastrophic changes from earthquakes or volcanic eruptions.

The largest patterns seem to develop from the combination of temperature and moisture. For instance, most productivity occurs on land area across the Equator; other productive zones grow poleward where water current and wind patterns bring extra moisture, e.g., Southeast Asia and eastern India. Due to the energetic levels, the biota builds up complex structures exemplified in tropical forests; these structures are stable as long as the energy continues. Little material is kept in soils. Poleward from the temperate zones, where there is water and light, but much less light energy, the ecosystems are productive and build large extents of forests; because there is much less decomposition, large amounts of biomass end up in the soil. Between these two extremes, ecosystems can replace one another, from forest to savanna or steppe, to grassland or desert, depending on shifts in the moisture-bearing winds, north or south. All of these systems are now being exploited by humanity, and this exploitation is resulting in shifts to more desert landscapes.

4.8.4. *Natural Patterns & Connections*

The amount of light hitting atmosphere in the short-term is 2 gram-calories per square centimeter per minute—this is the solar constant, which varies minutely. This radiation is reflected or attenuated as it hits the atmosphere—on a clear day at noon, perhaps two-thirds of it reaches the surface.

The ecosphere acts as one system in which energy from the sun is cycled. The functioning biomass is integrated by feedback responses to extract the maximum of energy and still maintain a balance. Most of the solar energy is used for maintenance by the biosphere, which is an indicator of the biosphere's high degree of ecological maturity. Chemical equilibrium is a global regulator. The steady effect of light, the availability of oxygen, the thickness of soil, and the area and depth of the oceans is almost a steady state, as is the mean temperature of the planet. The amount of material that has passed through living organisms since Cambrian times (roughly a billion years) is of the same order of magnitude as the earth's crust—2.4×10^{25} grams. Assuming 1×10^{16} grams of carbon are fixed each year by photosynthesis (average over billion years), the total mass recycled of carbon alone exceeds 10^{25} grams. Total coal and oil deposited in lithosphere are estimated at 10^{19} grams. Elements frequently associated with life—calcium, phosphorus, iron, sulfur—are preferentially concentrated and deposited by living organisms.

Some material cycles between other ecosystems or in larger patterns around the planet. Some of the cycles are daily; some are seasonal or annual; others are years or decades; a few, like the carbon cycle, are century or millennia long.

4.8.5. *Exploitative Patterns & Disconnections*

The original vegetation cover of the planet was extremely diverse. The potential natural productivity of wild vegetation is 120 billion tons of dry organic matter per year. But not all is available for human exploitation. The proportion of NPP above ground would only be 80 billion tons. These are all rough approximations. This is the theoretical amount that would be produced by wild vegetation with no major environmental changes.

Much of this is not usable by humans. For example, in the production of forests, 65% of above ground production is not used by most lumbering operations. Possibly, over all ecosystems, the representative average of unusable material is only 50%. Taking most of the material is not desirable anyway because mineral nutrients are locked up in plants. Complete extraction of plants would result in removal of one to two thirds of potassium in the whole ecosystem. Although there is plenty locked in rock particles, this is released very slowly.

But the land has been "improved" to pastures and crops. Some crop productivity, usually at experimental stations, is capable of producing high NPP, in total dry weights. The most productive of crops can approach the NPP of the original cover, but average crops produce less than half of the natural cover. The highest figure was achieved in Japan, where substantial dressings of fertilizer were applied. In countries where no fertilizer is applied, the annual productivity is unlikely to be more than one quarter of the native vegetation.

In tropical climates, the NPP does not appear to increase in proportion to increased sunlight. The tropical plant also uses up far more energy for its own metabolism. The hotter the environment the higher the metabolic rate; so temperate zones produce higher yields than tropical. Wood and water use are very high.

4.8.5. *Problems in Patterns*

Our level of exploitation is becoming tragic. The essence of tragedy, remember, is to continue behavior that may be appropriate in one context into a context where it is no longer appropriate. Cutting trees is a logical response to a need for wood; cutting forests and destroying ecosystems is a form of madness, driven by mania for machine efficiency and immediate economic return. Imagine killing maple trees for the sap, or blowing up the planet to get purer iron. The scale of logging has become too big; we are killing forests for the trees.

Erosion is an ecological catastrophe on a planetary scale, causing thousands of higher plant and animal species, and countless lower species to be lost forever. Vegetation holds soil in place, reduces wind speed at the soil surface, and improves water absorption and transport in the soil. Erosion destroys soil and makes it difficult for plants to be reestablished. Recovery, if it occurs, may take decades.

Samuel Eyre estimates that the total annual terrestrial NNP has been reduced by 38.5 billion tons since the advent of agriculture. The complete removal of all forests, converted to cultivation and pasture, would lower the NPP to 27.6 billion tons, assuming all savannas, prairies and scrublands remained unaltered.

Unfortunately, there is a trend to deforestation and degradation, with no idea of the rates. The mean annual production of wood may still exceed the annual consumption and destruction by humanity, but that is not likely. Present trends in forest destruction and expanding pastoralism run counter to any of rational ordering of terrestrial resources that is necessary to cope with population doubling.

There are profound changes of global warming and habitat destruction, extinctions, social decay, new diseases, or technology. These changes are modifying the planet; some of them result from our dysfunctional styles of living, which may destroy us as well as those things we require for adventure or comfort.

4.8.6. *Pattern Solutions*

Although tropical ecosystems offer less potential for high levels of secondary production, microorganisms (autotrophic and decomposing) and invertebrates could be potential converters to high quality animal food.

We are living together with everything on the planet in a functioning whole. Human life depends on a matrix of life. The matrix is historical. It has duration; it extends from the past into a future of lives. This gives the past and future rights; they are part of the continuity of relationships.

Possibly, the demands for many decades could be met by establishing industrial plantations on 1 or 2 percent of the planet surface, according to Jack Westoby. Over 50 percent of the planet was forested at one time—down to about 28 percent now. We could restore at least 20 percent in the next decade, leaving all old-growth untouched and 2 percent for plantations. On the other hand, how much forest cover do we need to keep the atmosphere functioning the way we like it? Carbon dioxide (CO_2) accumulates in the atmosphere at the rate of 4×10^6 tons annually. Deforestation possibly releases about 2×10^6 tons of carbon per year (only a third as much as from fossil fuel combustion). Reforestation could remove carbon from the atmosphere. We need about 7×10^6 square kilometers of new forest to store 4×10^6 tons of carbon annually (after George Woodwell's estimates). Estimates of the minimum forested area for the planet are more difficult to arrive at. Houghton et al. (1990) suggest that the minimum should be about what remained in 1990: about 5.3×10^9 hectares, or 40 percent of the land area, although the area remaining that year is not definitely known.

Wood is heavily used as a fuel for heat and cooking (half the consumption world-wide, and most of that now is from small and poorly formed trees). But, wood also is beautiful; it has character, warmth, vitality (life), vibrancy, resilience, renewability, often a personal history (I have four porches: One built from wood from our sawmill, one built from timbers from a 1922 grain elevator in Viola, one from timbers from the Potlatch sawmill from about 1910, then the largest mill in the world, and one from our neighbor's sawmill), and it is of service to the ecological web and its participants in ways that concrete, plastics, and metal are not. The aesthetics of wood is immediate and persevering—perhaps it may someday replace the machine aesthetic.

Global goals apply to the planet as a whole, for Gaia as a metaphor for the living planet. They are not simply the sum of local and regional goals.

- Reimplement international initiatives to slow deforestation—the UN notes that previous initiatives *accelerated* deforestation, as in Cameroon, where log production is to double in the forest, home to 50,000 Pygmies with a unique and valuable cosmology and life-style.
- Plant and maintain forests sufficient to guarantee indefinite support of known and unknown global biogeochemical cycles.
- Protect fragile ecosystems with global importance.
- Reduce threats to forests from acid rain and other nonpoint-source pollutions.
- Plant 9 million ha of trees each year to meet current demands; for soil and water conservation, plant another 6 million ha (at an estimated cost of $6 billion dollars); and plant 110 million ha just to catch up with cutting.
- For the planet, reforest 1.4 *billion* ha to restore the 30-40% forest cover removed in the past 3000 years.
- Monitor the planet.

Personal and social goals are equally important. It has been said that large changes only come about from many small ones. What you do may change regional or global patterns (if the movement is large enough). Therefore, you may also wish to consider your personal goals with the goals of designing the planet. Personal goals might include: Questioning traditional ways of working in natural or artificial areas, thinking ecologically, acting cautiously, finding personal security and personal fulfillment, or living well, that is frugally, on the wealth of the planet. As designers, we need to spark some changes. We need:

- To see with as large and as long a perspective as possible;
- To measure (implying relating and valuing) the wild system, its resources and our work, rather than just count everything (after Peter Drucker);
- To crawl and climb as well as walk and ride for better perspectives on forests (after Gary Snyder);
- To slow down, focusing on good work in ecological time rather than fast counting. Modern culture and economics are in such as rush to do things that the speed becomes more important than the purpose;
- To use everything as long as possible in as many incarnations as possible, e.g., the wood in a stereo cabinet becomes a bookcase or video cabinet, ultimately to be buried in the ground;
- To adapt our needs (forget the wants for a while) to the limits of regional resources, to be self-sufficient and self-reliant (in R.W. Emerson's words);
- To influence and change those technical, social or political behaviors that encourage or demand bad exploitation, e.g., waste, profiteering, or subsidies.

4.8.7. *Conclusion: Diversity & Redesign*

For the planet, wild ecosystems have been critical organs in the balance of carbon and water. Many scientists argue that forests are the lungs of the earth; others that shallow seas do more of the breathing. Both kinds of ecosystems are now under stress. Diversity is being lost. Diversity (is in biological diversity) means species richness, different age and size classes in a population, and genetic differences in a species, as well as kinds of habitats present in an ecosystem and the kinds of communities occupying the habitats; and the kinds of ecological processes that maintain habitats; and the variety and richness of the planet's genetic heritage.

We should restore typical ecosystems where we have found them, including perhaps deserts. Deserts may contribute to some kind of global balance. Rather than exemplify failed systems, deserts occur under certain conditions; furthermore, the dust and sand from deserts may be necessary for the flourishing of other systems, such as tropical forests and shallow sea communities. Where deserts have expanded after human civilizations, we should restore the grasslands and forests. We can design large planetary patterns for diversity by setting aside large areas with connecting corridors, and then refrain from exploiting those areas, much less interfering destructively with them. We need, therefore to redesign many human forms of imaging and managing, also. Redesigning the planet requires concentration and dedication. Working together, perhaps we can restore ecosystems and landscapes to their place in the body of the planet and in the heart of our lives.

4.9. *Designing a Cool Planet*

Since it's first molten state, the planet has developed during several stable states, including a hot phase with no ice cover at all and a cold phase with ice caps at both poles. Despite increased solar output and several orbital changes, the cold phase occurred relatively late in planetary history. Humanity as a species developed during the long 'summer' of an interglacial period. Many scientists have noted that anthropogenic changes to the carbon cycle are creating long-term changes to the climate, and that these changes, beyond extending the interglacial, could cause the cycle to skip a long ice age. Several people suggest that a warmer planet would benefit humanity, allowing more northern areas for crops and greater access to resources, especially hydrocarbons; other people fear that the next ice age would severely cripple civilization, destroying complexes of large cities and wiping out agricultural lands. Few people would design conditions that would allow an ice age.

But, which state would we prefer? Which state would be better for the planet? Of course, before now, we never worried that human actions could precipitate one or the other state. Some people argue that we should avoid an ice age because of the decrease in available northern land area. Certainly each state can be said to offer some advantages and disadvantages. A warmer planet is thought to have a larger surface area and be more productive, but it would surely have an increase in diseases of plants and animals. A warmer planet could have more droughts; vegetation would create more fibers and toxins; cold or sub-ice species would die out. Yet, a colder planet that tied up fresh water in ice would have possibly an equal area of land exposed around the equator and in the southern hemisphere. The diversity of habitats would increase. In the past, the challenge of cold has forced changes in some populations; human cultures created more sophisticated tools and clothing in response to cold conditions. Although the productivity of the oceans would likely increase, many life forms in the northern hemisphere would be driven extinct or forced south.

Change has happened, and will continue to happen, regardless of the extent of human impacts and contributions. And, it is unlikely that humanity will be able to exercise conscious control of specific conditions or over the process of change itself. In recent history, design has only had to cope with smaller scale temporary change, and not the extremes of a hothouse or ice age (although some archaic human groups did expand at the end of the last ice age). If the interglacial continues to warm, and the atmosphere becomes more chaotic, a global human civilization will have to alter its food-producing and distributing habits, with likely dramatic changes in energy use and resource use.

A nonlinear model of the planet has strong positive and negative feedbacks that link the biosphere to atmospheric composition. It is not an equilibrium model. Thus, even if no extra carbon dioxide were produced for years, the planet would stay in the hot state. James Lovelock says stabilization seems only possible at 5 degrees hotter or 7 degrees cooler than it was about 200 years ago. The transition from negative to positive feedback occurs at sensitive points, not just anywhere. The long-term climate history of the earth shows the existence of several stable (but quite different) states. Present day models do not predict their existence. Climate theory is based on atmospheric physics. Lovelock points out that to be complete it has to be based on geophysics, biophysics, and ecosystem science. The earth seems to have two stable states: greenhouse and icehouse, with metastable states between, like interglacial.

The best known hothouse was 55 million years ago, the Eocene, the dawn of mammals.

Later, Lovelock states that any catastrophe that causes the Gaian regulation system to fail could lead to a hot dead earth, and human actions could precipitate that. Heat-loving plants and bacteria may not have a critical mass of living things to regulate the environment. There is a critical mass of life implied, and that may be related to a critical area inhabited—Lovelock mentions 70-80 percent of the surface, which may not have been maintained during the last ice ages, although the low sea level tripled the area of some surfaces, such as Florida in the US. What would happen if carbon dioxide (CO_2) went over 1 percent as a result?

Whitfield and Lovelock also point out that self-regulating systems tend to overshoot a goal and stay on the opposite side of the forcing. If too much heat comes from the sun, the system regulates on the cold side of the optimum. In the past the planet developed this way through a complex web of feedback. For humans to keep the planet cooler, for our comfortable civilization, we will have to manipulate what we perceive as controls or triggers. We might enter another ice age, which might be healthier for the planet, but might be equally disruptive to civilization.

James Lovelock suggests that such a colder planet is healthier, more productive and more stable. Lovelock refers to the interglacial state as a fever (see Section 3.1). For life, a cooler earth may be a safer response to solar increase, but there is not a lot of evidence that it was more productive during ice ages, even having a greater land area with vegetation and fewer deserts (or rather a large area of ice instead). Lovelock argues that, because of solar increase, Gaia has greater control during glacial epochs, which has a lower CO_2 concentration in the atmosphere, which he interprets as indicating that the biosphere was healthier and more productive, because cold ocean water is more biologically productive. He states this without noting that the oceans are relatively biological deserts, and that life on land may be more critical for cycles. The argument needs to be filled out, since some data of the carbon composition in the deep ocean indicates that there was less organic carbon being fixed. Was the CO_2 too low for plant productivity, even with a larger land surface available near the equator? He notes that the rainforest is an adaptation to recycle water in a warmer environment. And, it is relatively fragile. And now it is important for carbon sequestration as well. The ocean deposition of CO_2 is important of course, as a physical process of the dissolution of silicate rocks, and as the biological flow towards a sink.

Think about the other consequences: Ice caps cool the atmosphere and lower the sea level. More land is exposed in the equatorial belt, which absorbs more heat. Do trees make the difference, creating more clouds? Are cool ocean currents less cool in glacial conditions? Do they bring up more sediments or less? Is there less sea life than before? Was CO_2 too low for more productivity.

Humanity could be triggering the equilibrium back to a hothouse state. The situation is a catastrophe and requires emergency actions. We need a coordinated massive program of changes.

If so, how can humanity avoid a hothouse state and also design and implement the conditions of a limited icehouse state? Reduce carbon dioxide in the atmosphere to be sure. Replant forests. Perhaps even use technology to institute positive feedback mechanisms that would lead to more ice and faster cooling. Then, global temperature homeostasis might come about through a negative feedback cycle of phytoplankton, which produces dimythylsulfide, which gives rise to cloud condensation nuclei, which aids cloud formation and thus diminishes incoming solar irradiance and global heating, with an adverse effect on phytoplankton activity. Thus the chain of influences comes full circle, with a net negative feedback effect. The best strategy has to be a combination of conservation, reduction, restoration, and a few appropriate high-technology changes. Smaller, more mobile and adaptive human populations, reflecting a reduced planetary population, would have advantages over large populations trapped in drought conditions or along current shorelines. Anticipating the losses of many cities and fields, populations could be inspired to create new ecological cities, complete with ecological farms and neological mixed ecosystems, in known stable, higher locations.

Figure 490-1. James Lovelock with statue of Gaia.

5.0. Facing Culture Through Design

Human beings are mammals who live in groups and are good at imitation. These talents have allowed humans to create cultures to adapt to stressful environments. Cultures became useful in many ways, from externalizing memory to training the young. Many adaptive patterns were developed over the past 12,000 years, from agriculture and cities to technology and industrialization. While these adaptive patterns allowed great and dramatic improvements, their application in every circumstance is resulting in tragedies. Perhaps one solution is a global culture or a conscious framework for traditional cultures, but this solution would depend on understanding cultures and human motives.

5.1. *What is Humanity? Is Humanity Global?*

Human Beings are mammals—omnivorous, social, bipedal, featherless, symbol and tool-using, game-playing, neotonous, bilateral-hemispheric, culture-making generalists—who, as George Woodwell (1976) put it, live as "one species in a biosphere whose essential qualities are determined by other species." Mammals are the best regulated of highly evolved species. Like other mammals, humans change their habitats to suit themselves. Humans have modified animal and plant associations in a different way, simplifying patterns of energy and chemical exchange, solidifying themselves at the end of many food chains as a dominant species. Unfortunately, they often dominate their habitats. A dominant is a species with greater influence than any other in its biotic community, changing the lives of other species and the character of the habitat. Humanity is a pandominant species. As such, humanity reclaims, overgrazes, clears, depletes, and wastes at a level that threatens the stability and existence of many systems. One of the ecological consequences of human activity is the degradation of wild habitats for human developments (food, housing, and recreation) and the introduction of novel elements into the biosphere—elements that have not been harmoniously worked in over time. The biomass, or demomass, of the human species probably far exceeds the biomass of any nondomestic species, and that biomass is supplemented by the tremendous biomass of domestic animals, which is four times greater than the human (Borgstrom, 1975). This biomass forms an equivalent population that consumes much of the same food, such as milk, fish, and grain. The domination of humanity is related to other characteristics as well, such as our large biomass (6×10^{14} Kcal), large annual increase (2 percent), high structural organization (information, matter), and our high energy use (globally, 13 times mammal equivalents).

This dominance has major effects on ecosystems: Transient perturbations in energy relations (from oil spills, burning); chronic changes/shifts of systems (from dams, irrigation, chemical wastes); species manipulation (from the import and export of exotics); and, interference competition with wild species, as opposed to exploitative competition, which can be stabilizing). None of these effects are exclusive to our species, but they are excessive, rapid, compounded, and large-scale.

Probably no consequence of human development has had a greater impact on the natural landscape and ecological processes than the production of food. Patterns of eating have influenced the constitution of species and the very contours of the earth. Throughout their history, humans have used animals and plants for food and clothing. Animals were followed, herded, corralled, tamed, and finally bred. Plants were domesticated later. As technologies developed, human relationships with animals and plants changed. Hunting, grazing, and agriculture provoked large ecological disturbances. Early domestic animals were revered, but nondomestic animals were considered competitors or nuisances. Now, animals are treated as commodities processed in factories and wildlife is regarded as useless. Hunting persists, but mainly as recreation. A few plants provide the bulk of human diet; the rest are considered ornamentals or weeds. Humans are omnivores, although they have been represented as carnivores, vegetarians, or fructivores by different factions. In view of our control over animal and plant populations, a reexamination of our eating habits, and our use of animals and plants, is critical. The functional biological requirements are rather minimal for humans, however, being only food, clothing, shelter, and reproduction. Other requirements, such as respect, comfort, and self-fulfillment, depend on cultural systems.

5.1.1. *Adaptive Patterns of Living*

While some species adapt to a niche, for a way of eating, others create niches. The individual is much more than a summation of all of its historical responses—it is intentional and flexible, sometimes stress seeking and maladaptive. This kind of behavior can result in new adaptive patterns.

Humans started out as scavengers then went on to become hunters and gatherers, foraging in a territory identified with a band or tribe. Through their senses and reason they acquired an empirical, holistic knowledge so well fitted to their environment that they could cope effectively with the wild systems in which they lived. The food habits of hunters were formed by location and at the densities of resources. Gathering seems to be more important in warm climates, and hunting in cold climates. Hunters tend to be nomadic. Mobility and food limits are incentives to remain in small groups, which tend to have low population. They tend to share resources equally, as a result of egalitarianism and reciprocity. They have "natural" leaders, who lead by the example of being a good hunter or a good shaman. Territory was shared with neighboring bands.

After the ice age, animals were captured and gradually domesticated. Domestication has been used to imply one simple process, but it is various grades of relationship in which humans have degrees of control over reproduction and composition of animal groups. Factors leading to increased domestication include food, ritual, play, and transportation. Perhaps young humans playing with wolf pups, drawn to easy food near kitchen middens, might have lead to some kind of adoption.

Different ranges of activities in hunting lead to herding. Random hunting and controlled predation, followed by attentive herd following, could lead to loose herding, and then eventually close herding. As hunters gradually encouraged some characteristics in wild animals, they would eventually have complete physical and genetic control. Change of climate and overkills of animals possibly contributed to the necessity of herding and farming.

As people started gathering wild plants, they may have settled in semi-permanent villages and have expanded their ways of eating and living. Herding domestic animals would have advantages, such as knowing how many animals were available for milk or meat. There were some disadvantages, such as an increase in the amount of work responsibility for forage over the entire year, which doubtless led to following, then circulating or directing the animals by season (transhumance).

Foragers understood the principles of gathering seeds and planting them. They knew when and where their favorite foods were. They engaged in broad-spectrum collecting. Many of the activities in the gathering of plants could lead to plant domestication and agriculture. Tending wild plants in burned or dry areas resulted in more knowledge. Throwing unused seeds into a kitchen midden might have resulted in some crops growing in richer soil. Selecting specific plants that required intervention might have made plants dependent on human collection and planting. Selecting for various features, such as closeness of seeds or gigantism might have led to selecting those plants only, or to monocropping. In its early stages, agriculture is constrained to early stages of succession—it uses nutrients and energy for rapid growth and reproduction, rather than invest in efficiency, durability or maturity.

As technologies developed, human relationships with animals and plants changed. Hunting, grazing, and agriculture provoked large ecological disturbances. Early domestic animals were revered, but nondomestic animals were considered competitors or nuisances. Animals are treated as commodities processed in factories and wildlife is regarded as pests. Pastoralists and farmers have had a profound influence on native vegetation.

5.1.2. *Attachment to Place*

Ecosystems are embedded in places. The making of places by human beings is an ordering of a distinct structure and center. The organization of perception, meaning, and thought is intimately related to specific places. Place is a focus of meaningful events and a platform for ordering a world. The individual image of a place is modified by memory, experience, emotion, imagination, and intention.

A place is a part of the environment claimed by feeling. Emotion binds together motion and perception. Emotion can transcend distance. Emotion creates an 'in-place'. A place must be found and made; it does not exist before a priori. Humans, like plants and animals, identify greatly with local environments. Maybe this is a function of the limbic system of the brain, a function we share with territorial mammals. Human emotion creates an 'in-place.'

Maturity is linked to the increase of identification with, and care for, others. Albert Schweitzer noticed the expanding circle of care from family to humanity to animals, although different cultures have different emphases. What makes home different from house? Participation in its making and commitment to its existence. People invest parts of themselves in a place, to make a home. Permanence is important element in idea of home. One ecological benefit of rootedness is that people will take care of a place if they realize they are going to be there for a thousand years. Having a place means that the inhabitant has stock in it and participates in its unfolding, through planting and protection. Detailed understanding of plants in a locale allow gathering of food and medicine. People cultivate a sense of place.

Humans learn to love place (topophilia), as well as life (biophilia) and home (ecophilia); perhaps this love is an instinct or a meme. Edward Wilson (1984) argues that the essence of humanity is inextricable tied to life on the planet. He claims that biophilia is the natural affinity for life, and central to the evolution of the human mind.

Adolf Portmann observed that insects and animals displayed a powerful attachment to places; that it was best understood as home. In the human dimension, it is love of home—

ecophilia (Wittbecker 1983). The building of a place to dwell on earth is hard earned; civilization is held together by practical and political activities. Building and planting, taking care of the self and others, are prosaic human activities. Love of home is a more poetic activity.

Paul Shepard (1967) suggests that for each individual the organization of thinking and meaning is intimately related to specific places. Every place has a unique identity, a persistent sameness as a result of combinations of factors. Topophilia, love of place, is the recognition that all human beings have affective ties with the material environment (the word was coined by Yi-Fu Tuan).

Home living is simultaneous on different levels; the importance may shift from city to nation, or nation to state, or house to bioregion, or state to habitat. Each level is a metaphor for the next. There are parallels between the planet and a house, as the basis for home. Solar space is like the landscaping; wilderness is the foundation; conservation areas form the shell and provide services; and each bioregion is a unique room. The analogy cannot be carried too far. But it shows that a house is not, as Le Corbusier said, “a machine to live in.” It is a matrix for home. Home is not just a house, either; it is a complex of significant events centered in place. It is the foundation of our individual identity on one level, and our role in the community, on another.

Several metaphors have been used to describe the human place on earth. The earth is a storehouse, property, or a spaceship. But the earth is not a spaceship or storehouse; it is home. Victor Ferkiss proclaimed that: “The world and humanity are one entity, one system in equilibrium. Earth is humanity’s only home; humanity is one people in relationship to the earth.” Gaston Bachelard (1969) has written much about the significance of home: “For our home is our corner of the world. As has often been said, it is our first universe.” The home is a springboard to understanding the planet and universe.

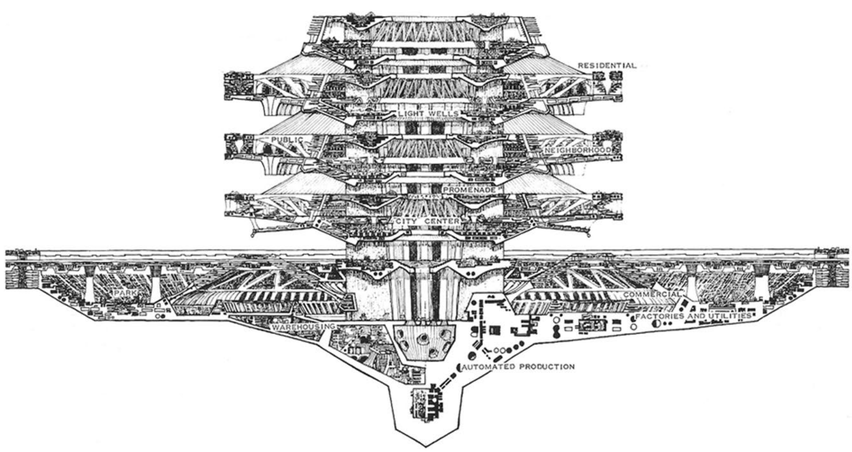

Figure 721-1. Paolo Soleri Babel Arcology

5.2. *Human Limits for Global Design*

Physical and ecological limits are important for design. Human psychological and cultural limits may be equally important, especially when we ignore them. Human beings have many kinds of limits, from obvious physical limits, such as height and bone shape, to psychological and emotional limits that keep people from listening to every single item of bad news. Some of these limits are relatively strict, while others are malleable. We are only finding these kinds of limits as we exceed them, or try to. However, when it comes to a global design or planning, we cannot afford to operate this way. We need to anticipate these limits and act accordingly.

5.2.1 *What are Human Genetic Limits?*

Our genetic make-up predisposes us to some things and pushes us in other directions. It does make limits on our plasticity. It could promote behaviors that damage the environment, and hence our long-term interests. If behavior is limited by "'tone-age' genes, then some pro-environmental behaviors may be ineffective, while others are effective. For example, we must have some contact with the natural environments where we evolved or suffer some psychological and physical harm; this is suggested by several hospital studies. In general, however, behavior is determined by immediate personal consequences, that is, short-term egoism, regardless of eventual consequences in modern world.

The limited genetic potential of a species limits success in general. Species limitation ensures the diversity and integrity of the whole. A species that was too successful, perhaps like humanity, might endanger the interactions of many other species.

As members of cultures and physical beings, humans have very real limits. Our physical limitations are well-known. We cannot run or jump as fast or far as we want, for instance. We cannot lift too great a weight. We seem to be allocated only a finite number of heartbeats, according to Isaac Asimov, in a single lifetime. Dysfunction, or feelings of fear, seem to be expressed often. There may be limits of crowding. Are there social limits, in terms of the number of people one can tolerate? We may have a requirements for personal space, home space, and wild space.

5.2.3. *What are Cultural Limits to Human Cosmologies?*

The very circumstance that makes each cosmology unique—being in a unique place—ensures that they have limits. The entire cosmology of a culture is concerned with some form of adaptation or modification. Particularly in agricultural societies, cosmologies are gauged closely to seasons. Cosmologies make the world manageable by limiting it. They can be tuned to the limits of the local ecology, within their knowledge of interactions. Some cultures ignore the long-range ecological consequences of drainage, irrigation or overexploitation, and these cultures may decline and die. But many archaic cosmologies are a form of fitness and limitation. Like the Tukano people, most try for adaptation before domination, according to G. Reichel-Dolmatoff. Many of their rituals limit the hunting of fish and game. The entire cosmology of a culture is concerned with some form of adaptation. Particularly in agricultural societies, cosmologies are gauged closely to seasons.

Furthermore, J. Rifkin states that cosmologies are a way of hiding the unimaginable:

Extensive voids, confusing gaps, or sheer size. A cosmology can relieve apprehension. They make the world manageable by limiting it. They make the world comfortable and small. Rifkin claims that humanity inflates its daily activity into its image of the universe. In some ways we do.

Yet, human cosmologies are limited and contradictory. All cosmologies cause destruction and waste; all produce the opposite (evil or enantiodromia) of the good intended. Archaic and modern, occidental and oriental world views are complementary but not complete. Often, a cosmology is accepted as unquestioningly as a language, technology or place. Cosmologies can influence a culture to accept or ignore limits.

The adaptiveness of religious belief is related indirectly to ecology. Religion is sometimes responsive to ecological and economic conditions, for instance, when the Catholic Pope decreed fish to be eaten on Friday to help fishermen. Many archaic religions are even more a form of fitness and limitation. The ritual cycle of the Tsembaga can be interpreted as a regulating mechanism to maintain limits on fighting and using resources, according to Roy Rappaport. Their rituals also facilitated trade and distributed local food surpluses.

Once powerful cosmological ideas are adopted, they can influence many cultures over centuries. The principle of plenitude, restated in Christian terms, says that an intelligible creator gave an earth of *unlimited* bounty to humanity for their use. This principle seemed to be confirmed in the Renaissance with the discovery of the richness of heaven, of microscopic life, and of unexplored continents. Many modern political ideologies and economics have been shaped by the principle of endless wealth. Adam Smith once calculated that the real price of anything was just the toil acquiring it. Inequality in a world of abundance could only exist through human suppression and exploitation of other humans. The invalidity of this principle came with the recognition of limits.

The frontier of myth no longer exists. And we cannot understand new frontiers until we are divested of the old one. One new myth has to be stronger, the myth of participating in organic beauty, where development, not growth, is without limit. Once doubt is sown—let another recession do that—then the cognitive dissonance from poverty proclaiming that it is wealth will transform the old myth. The universe is a frontier, the mind is a frontier, but they are based on a whole and healthy planet, a nature of which humanity is a special part among special parts.

Our cosmologies influence how we respect or exceed such carrying capacities. If for instance a global culture had a cosmological image of the earth as a desert planet, the carrying capacity for humans would probably be reduced to only 100 million people. If a global culture saw itself as completely technological, it would consider that technology could extend the capacity to 10 billion through conversion and substitution. Many modern cosmologies, modified by advances in technology, pretend that the limits can be exceeded. The cosmology of biotechnology is still economic in a primitive sense. Only the myths have changed to include greater manipulation. It is still concerned with utility, growth and efficiency, as short-term goals. The problem with efficiency is that it is defined within such narrow limits. True efficiency means continuity over long periods of time, as with natural processes. Long-term exchanges in nature are not efficient in the industrial sense. The large sense of economics is the measurement of nature.

5.2.3.1. *Are There Economic Limits?*

Economics is the formal study of how people use their surroundings (from the Greek words meaning "law of the house"—house is used as a metaphor for human society and nature). The word has come to mean the management of resources to supply human needs. It is basically concerned with sharing.

The acknowledged fundamental problem of economics is the contradiction between scarce resources and unlimited human wants. The kinds of resources and the possibilities of using them in production are considered in the scope of economics, as are flows and stocks in homes and businesses, the role of the government, business cycles, monetary details and policy, stabilization and growth, international trade, consumer behavior, production costs, pricing, and resource markets.

The focus of economics, however, is rather narrow, in that the concept of resources is very limited and the unlimited wants of human beings are not much discussed. There is no psychology or ethics; there is no ecology or aesthetics (thoughts about beauty). There is no concern with the triviality of the free choice of a worthless 'doodad.' There is no concern with the welfare of the other beings that share the ecological community. Economics has to attempt to understand and predict the behavior of complex, interconnected systems where individual behavior and flows of energy and material are important.

The earth is finite economically as well as physically. No matter how technologically expert humanity becomes, the multitudinous beings of the earth cannot be "produced" in the same manner as 3 billion years of evolution. Nor can we throw away the ambihuman dimension and ignore at that cost. There is no romance or honor in throwing away every life that we can.

There are two basic roads to wealth in a culture, according to traditional economics: (1) producing a bigger pie (supply) or (2) reducing each portion (demand). This assumes that wealth is defined as supply divided by demand.

Equation 2721-1. Supply ÷ Demand = Wealth

Demand, as Paul Ehrlich and others have pointed out is physically a result of the number of people and their expectations. If supply is limited, then wealth can still be increased other ways: (1) reduce the expectations of individuals, or (2) reduce the number of individuals.

Supply may be mostly material things (but not status, for instance); demand has the more psychological dimension. Therefore, because of demand, wealth will always have a psychological dimension. Gregory Bateson thought that economics may be founded on a fallacy because of that dimension.

Economic culture defines the means of production and livelihood, techniques of distribution, and values and norms underlying economic behavior (and this can be more closely related to kinship); Political culture holds the values, prejudices, inhibitions, and ideas that condition political behavior and determine nature of institutions and change.

5.2.3.2. *Are There Political Limits?*

Politics is the art and science of human government. The first goal of politics is to ensure the survival of the human community. Then it has to maintain the affairs of that community. Politics is the interactive means of providing the basic food and necessities of a community. As survival is survival in nature, politics rests on an ecological foundation. The organization of a community must be in accord with natural laws. Political participation depends on information, much of which can be provided by ecologists.

The politics of community is small-scale and local. Moral consensus is applied to daily operations. Robert Bellah and associates make three distinctions of politics, of which politics of the community is the first. That is followed by politics of interest, where different interests are pursued, according to agreed-upon neutral rules; conflict tends to overwhelm consensus. Finally, the politics of the nation addresses the "higher" affairs of the nation. It is more concerned with leadership than citizenship. Like the politics of interest, it accepts the status quo of relations of power or distribution of inequality. Symbolism becomes more important (perhaps because now the citizen diminishes in importance and the symbolism unites and includes them minimally).

Government has become subservient to economic actors, according to John B. Cobb. Partly because the ideology of economics is so positive. It proclaims that continued growth will solve most of the problems of modern civilization, from poverty to conflict, although the promise has not been fulfilled in the past 400 to 800 years. The problems have increased: Food shortages, housing shortages, energy shortages, unemployment, inequality of opportunity or goods, environmental deterioration, increase in weapons, and insecurity.

These problems continue due to the limits of politics. For example the size of society is a real limit; if there are too many people, within a limited territory or limited system, politics cannot provide them with an identity or control them. Size limits the distribution of things, food, housing, jobs and wealth, also. The time-frame of the political society is also a limit; the short-range visions of national interest are often inimical to the long-range ecological requirements of the support system.

The participation of the members of a society is also a political limit. Communities have always had face to face limits, in terms of numbers of face-to-face encounters. In terms of distance. Communities have always had face to face limits, in terms of numbers of face-to-face encounters. In terms of distance.

Leadership is another limit; the pool of applicants is usually relatively narrow. The use of power is a limit. How do we describe the will to power? This does not seem limited to the community, as does participation. The will to power can be observed in human communities for at least 13,000 years. It seems to have been extended from the simple domination of other community members to all of nature.

Security is a problem for local communities and national governments. It becomes more difficult to protect against most any kind of weapons. Perhaps the solution is a global one, with the coordinated change in national policies and worldwide distribution of excess wealth. Communities and nations would be more secure if they were self-sufficient.

Some facts result in motivation or fear, fear of the future in general, or the reactions of others, in general. Our response is a defensiveness in face of an unpredictable future. Thus, psychological limits intersect with political limits.

Policy is an intuitive value judging process. Planning has to acknowledge uncertainty. Policy cannot be based on one analytic method. Ozone loss will create patterns of good luck and bad luck, as will species losses and ocean rises. If we do not act responsibly, we are gambling that the cost is more than damaging the planet. If we act responsibly we are gambling also.

5.2.4. *How do we Deal with Limits? Can We Exceed Them?*

There are many ways to deal with limits. One obvious way is to ignore them. Ignoring limits usually results in cultural collapses, as happened to the Easter Islanders and others. Recognition of limits, however, does not mean that we are forced to live as bacteria. Limits allow a considerable amount of freedom within their numbers.

Another way to deal with limits is to try to expand them. Eric Jantsch states that limits to growth can be overcome by the evolution of dynamic structure; they appear as widened limits. Expansion has happened before as the result of ecological evolution. To some extent, technology can expand limits.

What are responses for anthropogenic forcings? Restore forests and grasslands; use alternative forms of energy. Should we try a high-tech solution? A massive program, like the atom bomb, only on alternative energy technologies, might work. Global climatic chaos could lead to reversal of ocean currents.

Or, we can respect limits and work within them. This is an ethical way. The systems and processes that we deal with are intergenerational. Economic rationality is even more limited. Future values are discounted at current rates. Planting a tree that takes 30-200 years to mature is calculated to be uneconomical (the giant sequoia takes almost 200 years to flower, for instance). Who benefits from it? If our ancestors had planted trees for our benefit, it would be easier to justify continuation. But identification through time is related to that with place, locational stability. People not living in place have no vested interests.

The land ethic Leopold described was a sense of ecological community between humanity and other species. When we see land as community to which we belong, we will use it with love and respect. Such an ethic would change the human role from master of earth to plain member of it. Predators are members of the community; no special interest has the right to exterminate them for the sake of benefit for itself. This attitude is important for habitat protection. Aldo Leopold describes the extension of ethics as "actually a process in ecological evolution. Its sequences may be described in ecological as well as in philosophical terms. An ethic, ecologically, is a limitation on freedom of action in the struggle for existence." An ethic, philosophically, is a differentiation of social from anti-social conduct. These are two different definitions of one thing. The thing has its origin in the tendency of interdependent individuals or groups to evolve modes of cooperation.

Is there a limit to human ethical feeling? How many individuals can a person care for? 100? 50,000? A billion? Or, how many animals or plants? How many living beings? Are these fair questions? Obviously, there is some kind of limit—otherwise, everything alive would be cared for and protected. People seem to be limited to their extended families and groups, as well as some kind of larger groups, a race or nation.

New ethical principles may develop out of the convergence between ecology and theology. The principle of reciprocity in ecology is that no entity can exist by and for itself; everything is connected to everything else. In religious terms, this is the golden rule (see Aldous Huxley's *Perennial Philosophy*). Reciprocity is the recognition of mutual obligation. All things are bound in bonds of mutual dependency.

We could respect limits by being wise. Jonas Salk defined wisdom as the art of disciplined use of imagination in respect to alternatives, exercised at the right time and in the right measure. Judgment is required as to what is right, and judgment may be an innate art.

It is a new kind of fitness, supplanting the biological kind of evolution. Humans have made radically different conditions that they must now accommodate. If the mind is exposed to economy of nature, as revealed through living systems, humans may recognize the necessity of balancing values. Total win-lose conflicts are unwise. Value systems concerned with dynamic equilibrium, aesthetics, complementarity, reciprocity, justice, interdependence, reconciliation, and intuition are the language that biology speaks.

Myths (with transformations) and metaphors (with structure of integrated differences) are modes for conveying ecological wisdom; they are less concerned with survival than the survival value of a good fit between dualisms of life. Equilibrium is needed between self-restraint and self-expression, between self-protection and self-restriction. Not self-expression or self-restraint, or exponential growth or plateau, but all in the finest fit. Fitness attunes us to limits. Wisdom cannot be dependent on perfect knowledge; it does not exist. Humans must act "as if" they were wise, circumspectly, with caution and respect.

5.2.5. *Why are Limits Important or Necessary?*

Limits to growth, even talk of limits, is regarded as a defeatism, as pessimistic, and a blow to human growth. Unseen limits have as real effects as seen limits. Denying limits does not make them go away. Furthermore, as William Catton has pointed out, there is a difference between raising the limits of carrying capacity and simply permitting greater overshoot of the limits, with the threat of a greater and more catastrophic collapse.

Limits define locality, local spaces, and local systems, from the global. Limits are not only important for life, but also are implicated in diversity and maturity. But, even these limits are based on the physical. Although physical and chemical limits are real limits, they are aggravated or increased by psychological limits, which are aggravated by sociocultural limits, which are further increased by political limits. Each "higher" more complex level makes other levels worse. The attempt to exceed limits becomes less efficient. One of the most important psychological limits is our ability to process data and to draw conclusions from it. We are so ignorant of the complexities of ecosystems that it is suicidal to pretend to "maximize" their use for resources. A free market civilization has to be limited by conservative calculations of ecological balance. It is almost impossible to estimate the economic value of this natural balance. The discussion of limits is expanded in the following chapters, especially when the concept is applied to wilderness or human populations.

5.3. *What is Culture? Is it a Global Design Factor?*

The word culture has been used to identify human groups, as well as describe their unique beliefs and artifacts. The word is also applied to the emergent properties of other living groups from wolves and termites to bacteria and fungi.

5.3.1. *Animate & Human Culture*

At first humans were considered special because of their divine spark. Then, they were special because they were disconnected from nature by culture, a magical reification of the opposite of nature, a social structure that we could produce at will to overcome the constraints of nature. It has been argued that culture let us push out of the constraints that limit other hominids, like chimps and apes. Culture was once considered an attribute exclusively in the human domain. Now, we admit its presence in some other species, but emphasize its complexity in human groups.

What is required for culture? Many theorists require the following things for a group to have a culture: Language (for communication); Dexterity for tool making and using; Brain power for artifact design and making; Social skills for home building; Governing or self regulation; and, External memory (in customs or things). It can be argued that none of these things is exclusively human, but only humans easily qualify for having all of them. For humans, culture is an extension system, but the extensions are more elaborate. A simple extension enhances the function of an organism, as knives are better than teeth for cutting. Extensions permit faster changes to answer challenges without waiting for the body to change. Edward Hall points out that externalization allows one to examine what was inside the head, to study it and change it as a thought experiment. Initially, extensions are low-context and this is what allows dramatic change. That means they are easy to learn and easy to change. Culture works as an adaptation to a changing environment; it allows us to respond to drought by moving or storing food.

Culture can acquire an identity and a history. It can also allow sharing, not just of tools like knives, but tools like cultures, radios, poetry, and plays. Because extensions change so fast, they can seem lifelike and more important than the biological and ecological environment. They can also destroy the environment. Extensions, once they are outside the body and mind, can lead to detachment. They allow dissociation. They allow changes in perception, so that others are less alive and can be killed without moral problems. Theoretical systems are treated as real, and everyday life problems are dismissed or undervalued. Cultures can be ranked by use of extensions into high-context or low-context, as extensions decrease context and allow things out of context. Low context cultures are better able to use extensions without screwing up the integrity of the culture.

Culture provides a filter between humans and environments. So, culture can serve as another evolutionary filter. It designates what we attend or ignore. It has to screen less valuable information (to avoid overload, even in archaic times). In a way, culture is like a trigger. It allows less information to activate the system. And this is the only way to increase information handling without making the system larger and more complex—of course, this is what stereotypes and metaphors do, also. Culture programs the individual or institution.

All cultures ask and answer these questions about how the world got the way it is and what is the role of humanity in it. Some of the questions cannot be answered from direct observation. And, many of the answers are not limited to observable events. Ideas concerning humanity and the nature of the universe tend to form a coherent system in which ideas are integrated or rejected over days or centuries. Culture includes all of the expectations, understandings, beliefs, and commitments that influence the behavior of human groups. Culture exists in minds, signs, and things, but most importantly in places. The word culture, from the Middle English, meant 'place tilled,' from the Latin word. For the Romans and English, to have a culture was to inhabit a place and cultivate it, and to be responsible for it. Later scientists have liberated it from place, defining culture as everything produced by human beings, from digging sticks to the idea of a world city.

The use of metaphors might contribute something to the understanding of culture. Culture is an 'organism' that grows and matures, that is, it is organic and whole, with a finite life span. It processes energy and matter to survive. But, it does not have a skin or genetic limits—nor does it have a genetic way of passing on its characteristics, although it has the memory of its members, and they can communicate. Perhaps, culture is an 'ecosystem' that is a self-maintaining, stable yet changing pattern. But, that neglects an ideational component, as did 'organism.' Like systems, cultures develop over time; they are capable of evolving. There are similarities in their evolution: Similar dynamics and machinery, and a direction towards complexification. Evolution, biological or cultural, depends on two things: The rate at which useful changes arise and the rate that they spread in the communities. But, this neglects internal states and forms of ideas.

Culture stretches vertically to include the physical, up to economic, political, religious, and artistic. It stretches horizontally to include society as a whole. In fact, culture is concerned with all things and beings. So everything in it is interrelated in some degree. Many relationships are encompassed by the holistic perspective of culture: The relation of people to themselves, to each other, to objects they create, and to their natural environment, and to their cultural environment. These bear on psychological well-being, social bonds, material legacy, and on the association with other forms of life.

These many definitions overlap and can be combined in to a synthetic definition, with common characteristics: 'Culture is a symbolic system of shared beliefs, values, customs, behaviors, and artifacts that emerges as a unique, coherent whole pattern that orders the experiences and meanings of its members and that members of society use to adapt to changing environments and to adjust to each other, and that is transmitted to succeeding generations through learning behavior and language, so that culture and the environment constrain and construct each other over time as a complex of ecological, social and historical processes.' This is used as a working definition to discuss a global culture.

5.3.3. *Properties of Culture*

Culture is imbibed through a process of social interaction. People acquire culture unconsciously through social interaction, as well as consciously, through apprenticeship or formal learning. The young, or new members of a culture, observe others and imitate that behavior. Cultural models are internalized by individuals, so that part of culture resides in a shared mental sphere. Beliefs and knowledge are not shared equally by all individuals, thus culture is shared differentially.

Human beings use conceptual devices, such as symbols, to communicate abstract ideas about nature or society to one another. Through our linguistic capacity, we can use symbols as meaningful representations of reality. Public shared meanings provide a set of designs that allow an educated individual to survive nature and society. The understanding and practice of culture is shared in a culture. A culture has properties that are related to ecosystems and places (Table 533-1).

Table 533-1. Contrasted Properties of Different Levels of Patterns

— **Nature** —		— **Culture** —		— **Design** —	
Field	*Ecosystems*	*Place*	*Culture*	*Good Places*	*Good Society*
Process	Course	Dynamicism	*Conduct*	Action	Method
Autopoesis	Self-making	Identity	*Wholeness*	Individuality	Extension
Differentiation	Diversity	Uniqueness	*Flexibility*	Richness	Variety
Integration	Construction	Investment	*Adaptation*	Conviviality	Cooperation
Constancy	Stability	Regularity	*Endurance*	Consistency	Loyalty
Development	Productivity	Renewal	*Vitality*	Health	Harmony

Conduct is the course of cultural behaviors through a behavioral landscape or field. New mathematical treatments of fields tend to be three-dimensional. Culture is concerned with all things and beings in a whole, from identity to all possible relationships. To paraphrase Arthur Koestler, culture is a holon, a stable subwhole in a hierarchy that displays structural gestalt constancy and rule-governed behavior. The rules lend order and stability to the whole, as well as flexibility. Flexibility means not being over connected, or not being too rigid or efficient. Than means that culture is able to slough off people or community structures and to incorporate new people and structures. Culture is able to keep some options and unused connections open. Culture is a loose-fitting patchwork of ideas, relationships and things. It is tolerant of discontinuities and contradictions, and this gives it flexibility. Humans can tolerate inconsistency and operate with contradictory beliefs, although if the contradictions become too maladaptive, however, then the culture can collapse.

The patchiness of culture is parallel to the co-constrained construction of a species and its environment. Culture has to balance between embracing change and resisting change. Many rituals of some cultures are concerned with ecological balance, though not necessarily self-consciously. Polyandry in Tibet, for instance, may be an adaptation to limited resources. The cultural system exhibits endurance; it is stable and persistent in time. It is a general property of some systems that acquired information is used to close the door to further inflow. A mature culture needs less information, since it works toward preservation, and closes itself off to information that does not fit the shape of the culture. To be constant and stable, a culture has to be vital; it has to be productive, to be able to convert energy and materials into foods and structures for survival. The culture has to have access to needed resources. The system is self-creating. It renews itself as its contents change, as disturbances change the parameters of the system.

5.3.4. *Functions of Culture*

Culture has to deal with the facts of life, from change to death, so that people can survive in their communities in their places. Freeman Dyson distinguishes three crucial biological inventions in the transition from unicelled organisms to multicelled: Death, which allowed differentiation of the future from the past; Sex, which enabled the characteristics to be shared and mixed; and Speciation, which increased diversity through separation and genetic barriers. Life can experiment with the diversity of forms and functions. Dyson notes that each biological invention has its analog as a cultural invention inhuman societies: For death, it is tragedy; the fact of death is made a theme in ritual and drama. Great cultures have distilled great works from the fact of death. For sex, it is romance, where sex is turned into a thing of mystery and beauty, in dance and poetry. Speciation has been transformed into cultures and languages at the human level. The flexibility of social institutions grew out of their differences and places.

A culture has 5 basic functions. A culture grounds people in their place. A culture selects what is important and presents it in myths and stories to be learned by people. People in a primary culture share a common image of their world—from the German word meaning 'man-image.' The image is a construct of human knowledge that reflects awareness of a local environment. The image is constructed metaphorically, but treated 'as if' it were true. The image guides their behavior.

A culture orders a whole cosmos (from the Greek word meaning 'to set in order'). A culture selects what is important from the undifferentiated phenomena of nature to make a whole. With order and integration come stability and security, without which no one can survive. Culture explains the universe and the behavior of its adherents. By explaining reality, culture binds the human and ambihuman, and the past and the present, into a meaningful whole. Culture explains why traditions are necessary, why things are as they are, and how they came to be that way. Culture provides a filter between humans and environments. Thus, culture can serve as another kind of evolutionary filter. It designates what we attend to or ignore. It was a way to screen less valuable information to avoid information overload, even in archaic times. In a way, culture is like a trigger. It allows less information to activate the system. And this is the only way to increase information handling, when the system is larger and more complex—of course, this is what stereotypes and metaphors do.

Another function of a culture is to justify human activities, in order to have those activities continue. Unless an activity satisfies a basic human need, it may not be repeated. The needs may be physical, psychological, or social, such as acquiring status. And, finally, another function is to control behavior. Some human behavior is regulated through the use of space. Culture controls many behaviors, from hunting and birthing to leadership and status. To succeed over time in a specific place, a culture has to control the behavior of its members so it fits with the characteristics of the local environment. Conserving the local environment is one requirement for survival.

5.3.5. *Effectiveness of Culture*

There are similarities of concepts between a culture and an ecosystem. Culture is a sloppy concept, like an ecosystem. Culture is also scalable, like an ecosystem, and can be nested. Properties of a culture resemble those of any system, such as an ecosystem. They include: Identity, openness, productivity, co-constrained construction, and vitality. Like an organism, a culture has to satisfy needs to continue. Like an organism in an environment, a culture engages in activities and interrelations, such as change and development. It can compete with or take-over other cultures. It can cooperate and trade. There will always be some clash or misunderstanding, from having different images and metaphors, limits and rules of behavior. The strengths of a culture may allow it to persist for a long time; its weaknesses, though, ensure that it will eventually fall apart.

The functional requirements of culture are rather minimal for humans, being only food, clothing, shelter, and reproduction. Throughout their history, humans have used animals and plants for food and clothing. They have been able to convert animal and vegetable resources into all their needs for food, shelter, and clothing. Other requirements, such as respect, comfort, and self-fulfillment, depend on cultural systems. But, the differences in local environments and cultures ensure a diversity of those things.

Many gross operations of a culture seem familiar and may be comforting in their familiarity. All cultures seem to have certain things in common. Of course, many of these are referred to as soft universals, since everyone needs food and shelter. Other differences may be the result of contacts between cultures, because cultures are mimetic, that is, they copy one another. This may be the secret behind agriculture, cities, and industrialization. Some of the over 65 recognized universals are: Age-grading, cooperative labor, dancing, education, ethics, games, gift-giving, marriage, medicine, status differentiation, taboos, tool-making, weather control, and war-rules.

Some scholars have argued that these universals could allow a global human culture. That may be true, although the relationship of a local culture to a global culture may be problematic.

5.3.6. *Summary: Dependence & Constraints*

Our minds are not only nature dependent, but culture dependent as well. The wind, trees, birds are sources of signals and symbols, and so are gestures and words. A community implies that the experiencers share ways of experiencing or the same experiences. This enables an individual to go beyond a finite view, to see the embedded culture as one of many ways of relating self to universe. Culture evolves from the interactions of humans with nature; both are in a constant state of flux. Cultures may be thought of as parallel to other species. The study of human adaptation to nature is cultural ecology.

Culture is a codification of reality, a symbolic system that transforms physical reality into experienced reality. Culture codifies reality through expressions, which can be preserved and transmitted through generations through language. Different languages program events differently, therefore no culture or belief system can be considered entirely apart from language, or language entirely apart from place.

Culture puts real constraints on our actions, as well as our imaginations. The structure of the earth also puts constraints. The structure of our bodies and minds adds more constraints. Culture may be referenced to the discrete events that brought it into being. But, the process is chaotic and arbitrary. We do not know all of the events or their progressive development. Even without a theoretical framework, the process of culture is abundantly inventive and beautiful.

5.4. *Is There a Global Culture? Is It a Global Design Factor?*

Human societies have tended to grow larger over time. With the change in scale of populations, other changes have occurred in the structure of settlements, fields, governments and religion. These changes may foreshadow some kind of global culture or government.

A healthy culture has many of the same properties as a healthy ecosystem. Unlike an ecosystem, however, cultures tend to grow beyond maturity to a point of collapse. At that point or sooner, another major difference manifests itself: Violence in the form of war. Big problems of human culture include: reproductive success, ecosystem conversion, then overshoot and stagnation, followed by stupidity and violence to try to rebalance the culture. Violence does sometimes work for a culture, usually by reducing the population and redistributing some of the wealth. In fact, every culture goes through a cycle that may have from two to six phases. For example, G. Modelski describes long-term cycles in cultures in terms (1) preference for order and (2) availability of order, each of which may be high or low.

Table 540-2. Modelski's Long Cycles in Politics

Cycle phase	Preference for order	Availability of order
1	High	Low
2	High	High
3	Low	High
4	Low	Low

The time structure of the operation of a complex system is a set of phases. Moving through a sequence of phases can create a whole cycle. Phase one could be global war; afterwards, phase two initiates a new world power; then, plenitude and security erode, and the system becomes delegitimized; finally, a low pressure for order and a preference for wealth, combined with low available order, deconcentrates the system. Modelski suggests that nation states are in the second part of the long cycle, a phase of decline. The model predicts increasing salience and rising nationalisms associated with increased conflicts. It could lead to a new global war.

In normal stochastic processes, from molecules to nations, things bunch together or move apart. We can identify cycles of this. For instance, great wars and dominant political powers can be also correlated to major innovations in discovery or technology. Cycles in politics are not just repetitions—they spiral outward, taking up the old ideas and processes—who says we do not learn unconsciously from history.

Based on this system, cultural historians William Strauss and Neil Howe suggest that modern history moves to the rhythm of life rather than just to institutional or economic cycles. They suggest an 80-year cycle, perhaps related to a human lifetime, composed of four phases: (1) The High, or first turning, is confident expansion as a new order replaces the old. Perhaps the most recent one began in 1945. (2) The Awakening is an inward turning away from the outer order, which is rebelled against. This phase may have started in 1964. (3) The Unraveling is characterized by waning public trust, fragmenting culture, changing values, and alienation. This phase may have started between 1983 and 2003. (4) The Crisis represents a major discontinuity, leading to a new order that replaces the old order. They suggest that this phase began around 2004 and might continue for twenty years.

Interestingly, C.S. Holling and his group used a more ecological approach to identify four phases of a cultural cycle. These phases are based on high or low values of capital and connection. Except for the last, high connection/discontinuity crisis, the phases are similar and provocative. Certainly long-range economic cycles seem to mirror some short-range ecological cycles.

Table 540-2. Two Models of Cultural Cycles

Cycle Phase	Model 1 (after C.S. Holling et al.)	Model 2 (after W. Strauss & N. Howe)
1	Low Capital	Expansion
2	High Capital	Inward turning
3	Low Connection	Unraveling
4	High Connection	Crisis of discontinuity

These kinds of cycles may explain many kinds of phenomena in cultures. Order is certainly a major factor in a culture, as are connections and capital, ecological or financial. One wonders if a cycle of the life of a culture or one cycle within its life, could be explained by combinations of population growth, security, stagnation, overshoot and environmental challenges, such as drought. Stability seems a characteristic of archaic cultures. We can even state it in Newtonian terms: A culture at rest tends to remain at rest. According to D.J. Harding (1960), when forced to act on changes, a culture will only accommodate those changes that preserve its fundamental character. Groups like the pygmies have specialized to fit the requirements of the environment, successfully. This makes it difficult for them to adopt other cultural arrangements, such as jet transport. Since cultures have been traditionally self-reliant, resistance to imbalance is a positive act. Resistance to change or other cultures, is an adaptive mechanism that may encourage isolation. Yet, isolation is what allows a culture to develop in a unique way. Yet, isolation may lead to stagnation.

5.4.1. *The Growth of Megacultures*

Some cultures grow, and in growing, decide that growth is a good thing to have without limits. Many lucky accidents, such as the rediscovery of the Americas, gave some cultures an impetus to keep growing. Other developments, such as science and industry, followed the conditions created by plagues and environmental restraints. The Spanish became a megaculture after benefiting from their exploration and exploitation of the Americas and western Pacific. The English became a megaculture after establishing an empire from North America and the Caribbean to Africa and Asia. North America became a megaculture in the Twentieth-Century. Each megaculture was able to dominate part of the planet with its influence and to see some of its products or rules become ubiquitous. By virtue of its demomass and political system, China is becoming a megaculture. Chinese products are dominating the economies of other nations.

Global capitalism undermined many traditional cultures by offering consumerism in the place of traditional cultural guides for behavior. Social roles seemed irrelevant by comparison, if the good life could be bought without effort. Yet, it did not seem to work in Europe and the U.S. Instead of being free from economic want to develop their potential as creative human beings, people became trapped in a consumer cycle. Self-actualization was postponed for self-gratification. Democracy seemed to be good for balancing a middle class in some cultures, but it ignored other cultures and economies.

5.4.2. *Emergence of a Simple Global Culture*

Trade and exchanges by various cultures extend to distant lands. Over time, a global system starts to develop, with newer connections and technologies, which draw the cultures and civilizations, of all ages, into a tighter pattern. Global technology draws the cultures and civilizations, of all ages, into a tighter pattern. Some global civilization may result, but what effect will it have on the earlier patterns? So much is lost, of ways of being and acting in a more natural less technological environment. The world has acquired a global economic structure.

A global political system is emerging, as there is increased vertical differentiation, evolving from nations and regions, that leads to differentiation into political groups and economic interests. The world does not function well politically at a global level. It could be made better. It functions in the absence of a common culture or language. There is no world law, but there is a set of rules regulating international behavior; these are generally observed and understood. There is a small homogenous subculture, which belongs to the rich elites of every nation. This serves to integrate to some extent.

The modern world has become a very interactive system, especially with computer and communication technologies, which can lead to totally integrated mass communication and the extreme compression space and acceleration of time. It is said that the global system has no center. That is a good thing. But, it is expanding without limits and that is a bad thing. It could cause the disintegration of natural systems that are interlinked with our economic exploitation.

Perhaps this emergence can be linked with a major cultural revolution, as identified by W.I. Thompson, Planetization, as there is absorption of a new consciousness surrounding the old. Other earlier revolutions resulted had a similar attendant process of miniaturization. The forest was miniaturized in clumps of trees; animals were miniaturized in artistic image; time on a lunar tally stick; plants in a garden; women in a household; and, nature by culture in 1800, under the glass roof of the Crystal Palace. The question is whether consciousness can create a global culture.

5.4.3. *Is Real Global Culture Possible?*

Both China and then Spain flirted with the possibility of becoming a global culture by exploring and using trade materials from both hemispheres in the 1400s. But, they pulled back for different reasons. Britain tried to establish a colonial global culture in the 1800s, but were surprised by a nascent nationalism in the colonies.

Is there such a thing as a global culture? In his *Notes Towards a Definition of Culture*, published in 1948, T. S. Eliot suggested that a "world culture which was simply a uniform culture would be no culture at all" and that humanity would be de-humanized in a miserable nightmare. But, since we could not give up the idea of a world culture, knowing that we could not imagine it, and conceiving it only as a logic logical term of relations between cultures, Eliot concluded: "We must aspire to a common world culture, which will yet not diminish the particularity of the constituent parts."

The local and the particular are required parts of culture, so global culture has a contradiction. Eliot noted that difficulty in a national culture of Britain: "We have not given enough attention to the ecology of cultures. It is probable, I think, that complete uniformity of culture throughout these islands would bring about a lower degree of culture altogether." He concluded that a national culture should be a constellation of cultures that have to benefit each other and the whole to flourish.

The disappearance of peripheral cultures, in Britain and elsewhere, might be a calamity, but modernity in the predominant versions of liberalism and Marxism, sees the goal of history in a universal world culture. Alas, one wonders if a global culture would be worse than the national cultures that are so irreverent with their peripheral cultures. In destroying world peripheral cultures, there might not be any culture left to be global.

The homogenization of the world is a result of economic dominance, with its trade networks, consumer rituals and ruthless advertising. This may undermine the identity of other cultures, but does not make a global culture, the idea of which has become a consumer object as much as burgers, fries and coke. Other local phenomena, such a Hollywood movies or Chinese slippers, that extend around the planet are local things that have been globalized. Cosmopolitan travel has the same flavor. Some cultures have more power because of these competitive advantages.

Although modern communications technology could work the same, it also may allow cultural differences and complexity to remain. The center seems to yield to the periphery, as other cultures all have hotel rooms, burgers, slippers and things. People can react by emphasizing the uniqueness of their ethnicity. No real globalism can exist until cultures and nations create a framework for the use of and protection of the capital of the planet, and until cultures enter into dialogues about a global culture.

5.4.3.1. Upside of Global Culture

A global culture, that could emerge from the interactions of local cultures, would allow for more rapid exchange of ideas and things between individual cultures. It would provide the opportunity for trade in special goods, that have the potential to benefit every culture. It would provide paths for communication that might stimulate cultures. Cultures could learn from one another. A global culture could present a global morality, built on universal human tendencies, that would not be prescriptive of our private and public behaviors, but it would be proscriptive of damaging behaviors from murder to obsessive greed. Global functions and problems, such a atmospheric warming, would be easier to address. New global economic or political structures would also be easier to address, as would global problems, such as the overconnection of markets.

5.4.3.2. Downside of Global Culture

According to most theories of cultural adaptation (or integration or evolution), resistance to change is normal as a cultural process. Groups like the pygmies have specialized to fit the requirements of their environment, successfully. This makes it difficult for them to adopt other cultural arrangements.

Nature makes divisions and diversity. We need no more a unity of all people any more than of all wolves or fleas. Is it wise to have a single world? A single market in a single culture with a single control? It might create a suite of problems (see Table 5432-1).

Hyperadaptivity is a serious condition that allows humans to adapt to poverty, bad diets, crowding, stress, suffering and immense natural loss. Of course, we are unconscious of many of these problems. Capitalism does not seem to be adequate as the only global economic strategy. It breaks down useful limits and boundaries. The homogeneity of forms promoted by a global communications and advertising campaigns leads to loss of diversity. A severely limited number of ways leads to a lack of flexibility (stagnation). Then, we have the hyperpersistence of error, in the forms of stupidity and violence, which forms a positive feedback loop. At the same time, interactions are accelerating.

Table 5432-1. Global Cultural Problems

Hyperadaptivity (Success and overshoot). Humans can adapt to poverty, bad diets, crowding, stress, pollution, and other unhealthy environments.
Homogeneity of forms (loss of diversity)
Lack of flexibility in the system (stagnation)
Hyperpersistence of error (stupidity and violence)
Lack of conscious planning (ecosystem destruction)
Limits of capitalism as a global strategy
Acceleration of interactions
Breakdown of boundaries and limits

5.4.4. *Creating a Global Frame for Small & Large Cultures*

The desire to refine the focus has allowed the frame of reference to be neglected. An adaptive holoculture could place the human values of all cultures in a global framework. A new world order is a cultural problem more than an ecological or economic one. A global culture could incorporate the positive features of traditional civilizations:

- Personal security
- Respect for the individual;
- Responsibility for actions (self-discipline);
- Social integration;
- Concern for others;
- Reverence for nature.

Such a global framework for culture would also consider important principles drawn from ecology. The proper attitude of an ecological global culture would be care (in Heidegger's word), a positive spontaneity, but also a "letting be," a reverence toward the wild alienness of nature, a willingness to comply with the limitations of natural systems, and a willingness to reduce the dominance of natural systems and to set aside wild areas. In addition, a global perspective might define:

- An authentic concept of humanity;
- Rational economic development, with respect to health;
- A holistic education beyond that of a native culture;
- The responsibilities of societies to themselves, others, and the earth;
- Respect for all cultures.

The truth of human cultures and wild ecosystems is apprehended through myth. Cultures, through myth, need to fit our growing knowledge of the geology and biology of the earth into our hearts. Mythology is constructed as a poetic system. Campbell states that "Mythology—and therefore civilization—is a poetic, supernormal image." Mythologies and religions are great poems. When recognized as such, they point through things and events to the ubiquity of a presence that is whole in each.

5.5. *Global Problems: Ecosystem & Cultural Collapse*

Ecosystems and cultures share many properties, perhaps since cultures emerged from being in place in ecosystems or perhaps because they are both complex systems. They also share stages of development, which always end in collapse.

5.5.1. *Collapse*

Collapse is the rapid, significant loss of an established level of complexity after some catastrophic event. By this definition, ecosystems can collapse during climate changes, and cultures can collapse after social or environmental changes. For an ecosystem, collapse can mean less complex food webs, fewer species and decreased diversity. Ecosystem collapse is a regular process, often precipitated by environmental change. For a culture, collapse can entail the loss of centralized control and regulation by elites, decreased flow of information between center and periphery, less trading and redistribution of resources, losses of complexity in organization and stratification, drops in economic specialization, and reduced investment in the complex physical structures. Many cultures have collapsed and disappeared, often without being remembered or documented. The known collapses range from the Old Kingdom of Egypt (2181 BCE) and the Harappan in the Indus Valley (1750 BCE) to Rome (476 CE) and the Khmer in Cambodia (1431 CE). Recent collapses include the Kachin of Burma (1950 CE) and the Ik in Uganda (1970 CE).

5.5.2. *Kinds of Ecosystem Collapse*

An ecosystem can mature through a series of stages, described as succession, to old age and dissolution. Pierre Dansereau delineated four general stages of succession (modified here): pioneer, consolidation, mature (Dansereau's subclimax), and closed (Dansereau's climax). A fifth unmentioned stage is collapse, where the system reacts to a disturbance by dropping to an earlier stage or by completely collapsing. Eugene Odum characterized the pioneer stage as having a linear food chain. A typical pioneer stage might have lichens, mosses, and annuals. The consolidation phase may have perennial forbs, grasses, mixed herbaceous plants, shrubs, and a few shade-intolerant trees. The mature stage might have shade-tolerant trees. The closed stage would have emergent trees and a mixture of plants and animals that resist exotic species, in effect closing the system to further colonization or invasion. In the mature and closed stages, complex food webs are dominated by decomposers. For animals, body sizes increase and life-cycles and strategies become more complex. At this stage, the system has learned the cycles of the environment. Throughout this process of maturity, according to R. Margalef, there are changes in productivity, efficiency and nutrient cycles. Diversity increases and trophic structure becomes more complex, with added numbers of consumers and decomposers, and more specialized niches. During a collapse the networks and webs fall apart, the system can drop to any earlier stage, and individuals and species disappear or disperse to another system.

Catastrophes (used in the mathematical sense meaning a down-turning), such as storms, fires, glaciers, and clearcuts, can set back stages of succession or change its direction. Stages do not necessarily begin in order or progress uniformly; they can begin anywhere and overlap. Nor are they exclusive, as life forms in one can occur in another, for instance, when lichens appear in all stages in a coniferous forest.

A mature ecosystem can collapse when internal overconnections between species make it fragile or incapable of being flexible enough to respond to environmental change, either large changes or new patterns. Climate change, especially drought, long or short-term, has caused the collapse of many natural ecosystems. For instance, the change in temperatures and moisture patterns at the end of the last ice age replaced many forests with grasslands, and many species could not adjust to the change and were extinguished.

5.5.2.1. Local Ecosystem Collapse: Mt. St. Helens

During the eruption of Mt. St. Helens in Western Washington State in May 1980, thousands of animals (at least 5000 deer and 1500 elk) and millions of fish (probably 12 million Chinook and Coho salmon) were killed; over a hundred square kilometers of forests were destroyed by a super-heated wall of gas and ash. In the direct blast zone, everything was obliterated. In an intermediate zone the blast was channeled by the hills, and trees were flattened. In the outer zone, the trees were seared and killed, but left standing. Mudslides flowed down creeks and rivers. The landscape was described as 'scorched and lifeless.' Although natural disturbances, such as fire and drought, drive the direction of many forest ecosystems, this large-scale disturbance destroyed many systems, sterilizing a plain north of the crater and leaving a 'forest' of dead snags to the east.

Ecosystem recovery started within months after the eruption, in different stages at different rates. Communities of plants and animals under the remaining snowpack were little affected. Many burrowing animals and insects survived in the intermediate and outer zones, as did numbers of ground dwelling insects and spiders. The rate of recovery depended on proximity to remaining original forest, that is, the biological legacy. Areas close to surviving forests experienced faster recovery. In the blast zone pumice plain, as seeds blew in, willow and alder shrubs have rooted and other tree species are evident. Along the blast zone, seeds have created an alder forest with some conifers. Birds and mammals have returned to many areas, followed by their predators, although the species mixes are unusual. Along some streams, coniferous forests have been replaced by a deciduous woodland, with alder, cottonwood, and willows, inhabited by neotropical migrant bird species. Other coniferous ecosystems are reestablishing themselves. Salvage crews took out over a billion board feet of downed trees and planted stands of Douglas-fir, which should also be subject to succession.

5.5.2.2. Regional Ecosystem Collapse: Mesopotamia

By the end of the last ice age, the storm tracks had shifted north from Africa to Mesopotamia, and brought moist air masses. The ecosystems switched from being boreal to being temperate. Grasslands and deciduous woodlands expanded.

Around 8200 BP, there was a sudden cooling that may have been caused by the collapse of Lake Agassiz, which had formed over 4000 years of melting, after the ice wall collapsed and the lake suddenly discharged through Hudson's Bay or the St. Lawrence Seaway (and may have changed the salinity of the north Atlantic and caused the thermohaline circulation to alter or shut down). Temperatures and snow accumulation dropped dramatically. It affected North America, Greenland, and Europe, as well as western Asia. The regional climate adjusted, and things became colder, drier, and windier. Lakes in Africa dried up, including a large one in the Sahara, which never reformed. In western Asia and Mesopotamia, ecosystems dried up and were replaced by desert ecosystems on desert soils. Some systems in Turkey and the Zagros mountains survived.

There were subsequent coolings in 5200 BP and 4200 BP. The first event caused a drought that coincided with cultural collapses in southern Mesopotamia along the Euphrates and Tigris rivers. Although irrigation canals brought water to fields, a weakened river flow would have reduced irrigation and yields, so people may have had to switch to drier crops or abandon the effort entirely. Settlements in the interior of Arabia were abandoned around this time. In the second event, the westerly winds bringing moisture to the Mediterranean and Mesopotamia failed. Precipitation fell 30 percent. Hot winds contributed to drought. Some of the cities, such as Tell Leilan, were deserted; many villages were abandoned. Between 4200 and 4100 BP, Mohenjo-Daro and Harappa, around the Indus River, declined suddenly.

5.5.2.3. Global Ecological Collapse: Chicxulub Asteroid Strike

Dust, asteroids and comets are part of the environment of the planet. Although collisions have become more rare as the system ages, there have been large strikes that have pushed life in new directions. Notable strikes occurred at these junctions and seemed to have precipitated large extinction events: Precambrian-Cambrian (570 million YBP), Ordovician-Silurian (438 MYBP), Devonian-Carboniferous (360 MYBP), Permian-Triassic (245 MYBP), and Cretaceous-Tertiary (65 MYBP). This last event allowed mammals to claim dominance over reptiles in the hundreds of thousands of years that followed the event.

Very large-scale disturbances, such as volcanic eruptions or asteroid impacts, can destroy entire ecosystems or disrupt global biogeochemical cycles. However, such very large-scale disturbances are rare, and the ecosystems often have thousands or millions of years to become reestablished, although changed. Disturbances that are not part of the history of an ecosystem may cause irreversible changes to the system, because the system has not evolved a defense or response mechanism to such a rogue disturbance. An asteroid strike would be such a disturbance, especially if the landform was altered by a crater. The Chicxulub asteroid strike 65 million years ago destroyed a large area, broiled the surface and ignited global firestorms, created a series of massive tsunami perhaps 300 meters high, and created thick dust and particles that blocked sunlight and covered the surface of the planet for 2-10 years. Species that depended on sunlight for photosynthesis declined or became extinct. Plant-based food chains collapsed. Organisms that fed on dead matter, omnivores and insectivores, survived. The climate cooled and was affected for thousands of years. Species that depended on a stable climate declined. Acid rain fell. Volcanic activity, for instance the Deccan Traps, may have increased and further destroyed ecosystems, changed sea levels and altered climate.

The Chicxulub crater is the largest impact structure still existing on the planet. Nonavian dinosaurs are found only below the K-T boundary. This event caused global extinction patterns and shifts in biomes. There was a global disruption of plant communities. Fungi, however, which live on organic matter, proliferated for a while. In general, aquatic and semi-aquatic species survived better than terrestrial species—perhaps due to available organic debris for food and the ability to swim or burrow. Species that had been stressed before the event may have been pushed to extinction by the effects of the impact. The biodiversity of the planet required a long time to recover.

5.5.2.4. Discussion of Ecosystem Collapse

If a catastrophic event is total but localized, plants and animals can recolonize the ecosystem. If it is total and regional, ecosystems may disappear. If it is partial and regional, many ecosystems can recover over ecological time. Certainly the subtropical ecosystems on the northern Yucatan peninsula disappeared immediately at impact, which not only changed the rock substrate, but also dramatically altered the soils and topography.

5.5.3. *Kinds of Cultural Collapse*

Cultures seem to mirror human growth, development and aging. A fragile or old culture may collapse at the end of its cycle. The stages of a culture could be described as: Origin or Renewal, growth, maturity, collapse, and dispersal; this might be a rough parallel to the stages of an ecosystem: pioneer, consolidation, maturity, closure, and collapse. After closure, the ecosystem either collapses or is bumped to a lower stage by some disturbance or interference. Lance Gunderson and C.S. Holling, in their book *Panarchy* (2002) present a stylized representation of ecosystem functions—exploitation, conservation, release, and reorganization—that they use also as a four-phase heuristic model of institutional dynamics and other applications. This representation will be related in a different section.

Joseph Tainter uses several models to describe cultures: In the Runaway train model, a culture is impelled on a certain path without the ability to change directions; although it is dynamic, its course is fixed, as when the Aztec continued to ensure the rising of the sun with sacrificial blood. The House-of-cards model stresses that a culture is inherently fragile, with little ability to respond to stress; perhaps the dramatic decline of Rapa Nui is an example. The Dinosaur model suggests that a culture is a lumbering colossus with a big investment in one environment, but too static and maladaptive to adapt to any change. Other models still might account for collapse. The Fungus model presents culture as an adaptive, problem-solving, intensive social structure that, although it can respond to many environmental challenges, can still fall apart with scale or be overwhelmed by large events.

Cultural collapse can entail any set of many factors. The rapid loss of an established level of sociocultural complexity may be first expressed as a breakdown of central authority. Provincial provinces or villages may break away. Revenues to government may decline. There may be foreign challenges over territory or resources. The upper hierarchy may start to claim resources for themselves. Ordinary people may become disaffected. The military may be ineffective. Continued central direction may not possible. The center may lose power. Distribution of goods may suffer. Trade may decline. The city center may be ransacked and abandoned. Small states may start to emerge in the same territory. People may lose the protection of the law. Public art and monument construction may cease. Literacy may be lost. The small remaining urban populations may reuse the architecture and subdivide rooms. Palaces, government buildings, churches, and storage facilities may be abandoned. Technology may revert to simpler forms. There may be a great reduction in population size and density. Peripheral ecosystems and animals may recover, although not always.

Generally four concepts leading to collapse can be identified (J. Tainter 1989 and J. Diamond 2003): Cultural systems need energy to be maintained; increased social complexity results in increased costs per person; the investment in complexity reaches a point of diminishing returns; and, the cultural system fails to react to very large, slow or invisible catastrophes. Of course the culture could respond to those challenges. At some point, all energy income is used for maintenance and none is left for other problems, such as starvation of classes of people. Cultures often know how to deal with resource uncertainties, but do not know how to reduce populations to reduce pressures on scarce resources (although they allow disease and war to lower populations for a time). Cultures also seem to know how to deal with regular catastrophes, but do not seem to know how to minimize them or avoid them; catastrophic fires or floods could be minimized by relocating buildings or replanting native trees—perhaps the people grew tired of the increased costs. Cultures also seem to know how to provide and control labor, but they cannot reduce management levels (and this applies to royal classes as well).

Collapse can occur as a result of other reasons or combinations of circumstances, from invasion to social dysfunction. Such reasons include: Resource depletion, establishing new resources, catastrophe, insufficient response to environment or change, intruders, conflict mismanagement by class, social dysfunction, religious or mystical factors, chance series of events, and economic failure. An example of social dysfunction is class conflict. In the Mayan lowlands, class conflict was complicated by militarism, overtaxation, and land degradation. These contributing factors may have been solved, except that three long droughts weakened the Mayan cities further until they collapsed. Group conflict, isolation, deforestation, and population increase contributed to the collapse of Rapa Nui.

Economic inefficiency was a contributing factor to the collapse of the Ottoman Empire, which had to support an expanding population and an expanding government and military. Their agrarian system was unproductive, the influx of Spanish gold hurt the economy, and the economy was also by-passed by new oceanic trade routes.

Bad luck was a critical factor in the fall of Rome. Weak emperors and their mismanagement of the Huns and Visigoths contributed. Other, mystical factors may have been important; perhaps the final challenge was a loss of virtue or a spiritual or physical exhaustion. Other cultures also have been ruined by bad luck or chance events. Byzantium was unsuccessful in its competition with Venice for sea-lanes and trading, and they also suffered the loss of many agricultural lands. More recently, the Ik people of Africa lost their territory after European conquest and had to switch to farming, which they did not like.

Political dysfunction was a major factor in the collapse of Babylon; the loss of provinces and high taxation made things worse. Political dysfunction was also contributing factor to the collapse the Inca and the Aztecs, who also had a very maladaptive cosmology (the constant thirst of the sun for blood). Invasion was also a key factor, but other South American empires had collapsed long before the Spanish invasions. Invasion can be a sufficient cause by itself (Table 533-2).

5.5.3.1. Local: City Taxes and Collapse in Mesopotamia

City-states on the Tigris and Euphrates flourished around 2800 BCE. Irrigation systems and arts developed. The Akkadian empire formed. Two hundred years later, the city-states rebelled and became independent again. Shortly afterwards, the Third Dynasty of Ur set up a larger bureaucracy to collect taxes and tribute. They rapidly expanded the irrigation system, settlements and the population. This led to a more rapid and more complete collapse. In the following hundreds of years there was a 40 percent reduction in settlements and a 77 percent reduction in area.

Table 533-2. Internal Kinds of Cultural Collapse

Reason	*Main factor*	*Related factors*	*Examples*
Invasion	Invading Aryans	Effete society	Harappan, Indus
	Invading Sea People		Hittites, 1200 BC
	Invading Mycenaeans	Thera eruption, earthquakes	Minoan Crete
	Invading Dorian Greeks	Climate change, drought	Mycenaean
Social dysfunction	Class conflict	Militarism, over-taxation, degradation	Mayan lowland
	Peasant revolt		Huari, Peru
	Group Conflict	Agricultural collapse deforestation	Rapa Nui
Economic inefficiency	By-passed by trade routes. Agrarian system unproductive	Spanish gold ruined economy. Expansion of government/ army	Ottoman 1500s
	Increase scale for control	No support for surplus population Contrast with rulers	Chinese dynasties
Political dysfunction	Loss of provinces	Increased taxation	Babylon
	Roman Withdrawal	Regional tribalism	England 411
	Maladaptive ideology		Aztecs Rapa Nui
	No inheritance from old rulers	Continued conquest to enrich new ruler	Inca
	Bad management	Lack of economic development	Spain 1700s
	High taxation		Netherlands 1700s
Bad luck, chance events	Weak Emperors	Mismanagement of Huns and Visigoths	Rome
	Loss of agricultural land	Unsuccessful competition with Venice	Byzantium Rapa Nui
	Loss of territory	Switch to farming	Ik
Other factors	Mystical	Loss of virtue, exhaustion of energy	Rome?
	Spiritual exhaustion	Small population	Rome?

Political power shifted north to Babylon and Hammurabi. That empire only lasted 80 years to the death of Samsuiluna in 1712 BCE. Succeeding kings ruled smaller realms. The last resurgence of Babylon was ended by Cyrus the Great. Mesopotamia was incorporated into successive empires, under which agriculture and city building was expanded. Then after the 7th century CE the river systems changed courses and alluvial deposits. By 1100 CE the total area was only 6 percent of what it was 500 years earlier. Population was at its lowest point. Tax revenue was down 90 percent. People rebelled. The only remaining irrigation weirs were in the vicinity of Baghdad. The region was claimed by nomads for a long time after that.

5.5.3.2. Regional: Diseases in North & South America

When European people started to explore and colonize North and South America, they came in contact with large native populations, many of which welcomed and helped them. Almost immediately, native people started dying. Entire villages and tribes were wiped out. Survivors often moved in with neighboring tribes, mixing belongings and cultures. Epidemics spread from tribe to tribe, often well in advance of the Europeans themselves. European explorers commented on how empty the land was. Some disease-devastated or abandoned villages were overgrown by vegetation; a few were noticed by the explorers. The pre-Columbian native populations were reduced to 5-10 percent of their original levels by the epidemics. In North America the original population may have been 10 million; in Central America, over 17 million; and, in South America 25 million—these estimates are being revised, now.

Insects, diseases, and animals, more than being simply agents of mortality, are native components of complex food webs in ecosystems, and they contribute to the selection of species. The domestication of animals from Mesopotamia to Asia and Europe exposed people to animal diseases, which transferred to the human populations. Epidemic diseases originated in domesticated animals. Measles, smallpox and tuberculosis came to humans from cattle, flu came from pigs and ducks, and whooping cough came from pigs and dogs.

In North and South America, only the dog and lama were domesticated, with less disease transfer. American peoples did not have epidemic diseases or immunities because they did not have the domesticated animals that gave rise to the diseases. Europeans, however, were exposed to syphilis for the first time.

Disease was even more important than horses or guns in the European subjugation of the Americas, according to Jared Diamond. Disease not only reduced the numbers of native peoples, but it wrecked havoc on their cultures, so that the enormous competitive advantages enjoyed by societies with horses and guns were more effective when they were used. Diamond recounts how Spanish conquistador Francisco Pizarro used 62 horsemen and 106 foot soldiers to destroy thousands of Inca soldiers on one day, November 16th, in 1532. In hours, Pizarro's small band captured the Inca emperor Atahualpa, leader of South America's largest and most advanced state, by panicking the emperor's 80,000 guards.

5.5.3.3. Global Cultural Collapse

Although many local cultures and various regions, from the Mediterranean to the Indus River or Eastern Asia, have collapsed, there has not been an event that caused every culture on the planet to collapse within a short time.

5.5.3.4. Discussion of Cultural Collapse

In the Sahel and Mesopotamia, the argument was that overgrazing and human population caused the droughts. Exposed soil contributed to a changed albedo and hot air, which did not permit rain-forming clouds. Recent research indicates that, for the Sahel, a single variable made most of the difference—rising sea surface temperatures of the Indian Ocean, from greenhouse gases, was responsible for most rainfall decline. Despite the fact that we often focus on political and behavior causes, environmental changes or catastrophes are critical factors.

5.5.4. *Conterminal Ecosystem & Culture Collapse*
Cultures and ecosystems produce co-effects on each other. In some areas, such as Mesopotamia and Central America, the synchronization of plants used for crops can increase conflicts over food. The simplification of complex ecosystems for agriculture usually causes the collapse of the native system. Overuse of a wild ecosystem can cause it to collapse. Even targeted removal of keystone species can cause the system to collapse into a simpler system. English forests, for instance, changed after large predators, such as wolves and lions, were eliminated; deer and goats reduced the germination of trees, so grass or scrub lands expanded.

Table 554-1. Kinds of Environment-driven Collapse

Reason	*Main factor*	*Related factors*	*Examples*
Catastrophe	Maize mosaic virus	Overpopulation Droughts, lack of flexibility	Maya lowlands
	Earthquakes, plagues		Teotihuacan
	Eruption of Thera	Competition with Mycenaea	Minoan Crete
	Malaria	Lead poisoning, exhaustion, political corruption	Roman state
	Climate change, drought	Salinization	Hohokam
	Climate change	Agriculture-base	Hopewell
	Nile flood failure	Destruction, elite rule, over-taxation, parasites	Egypt
	Flooding	Collapse of trade	Harappan, Indus
	Climate, drought	Famine, migration	Mycenaean
	Climate change	Agricultural collapse, erosion, Deforestation, invasion	Roman

5.5.4.1. Local: Maya
The Lowland Maya formed around 1100 BCE. By 200 BCE, massive public architecture was rising. Temples and palaces were built. Vast public works, such as aqueducts, were undertaken. The arts flourished. The entire landscape was modified for planting. The zenith of organization and population occurred between 700 and 900 AD. Perhaps 75 percent of the region had been cleared for agriculture at that time. The Maya had a high density, stressed population, with intensive agriculture, complex hydraulic systems, in large centers, with an elite class, calendars and rituals. Population growth triggered competition and conflict, which lead to positive feedback that caused more stress on populations, which led to disease and stress on the surrounding ecosystems.

Drought was a major consideration for the Mayans, who had built so far from water. Maybe the southern centers were sited for water. Much of the culture was devoted to collecting and distributing water. The water lily had iconographic significance because it was indicated good water quality. Between 810 and 910, Mayans had three droughts of three, six, and nine years, in 810, 860, and 910. They entered the drought with a maximum population and limited flexibility.

People suffered from the stress. Analysis of skeletons shows that in the Late Classic they became more fragile. Although people became 7 centimeters taller by the Early Classic, by the Late Classic the stature of men had declined markedly; they also exhibited degenerative bone conditions, bad teeth, scurvy and other pathologies. There was a collapse and depopulation, from 3,000,000 to 450,000, which never completely recovered. The current population is 1,250,000.

Collapse probably improved things for the Mayan peasants by removing the burden of rulers, elite, priests, and artists. In the long run, however, even the peasants were decimated, perhaps due to environmental deterioration, stress, and infighting. By the time of the Spanish, the area seemed to be unbroken forest. The Spanish introduced malaria and hookworm, which made the forest worse to live in. Environmental degradation did play a role in collapse of the civilization, either as a contributing cause or effect. Complex societies put harsher demands on local environments when political regimes set production demands too high.

5.5.4.2. Regional: Mediterranean & Mesopotamia

As the ice age was ending, stands of grasses grew in the Zagros Mountains, and people started living in permanent settlements nearby. Goats, sheep, pigs, deer, and wild asses inhabited the area; in addition to the wheat, barley and oats, there were oak, maple, hawthorn, pistachio, and apple trees. Plant collecting was vital, although hunting and gathering were important. People started planting grasses closer to their settlements and trading surplus grains to those on the steppe-lands south and the Tigris-Euphrates alluvial plain. Then, the Younger Dryas event, between 12800 and 11600 YBP, brought a long, 1200-year drought and people went back to hunting and gathering. With later warming, people went back to collecting grasses and living in permanent settlements. By 8400 BCE there was another shift in the northern hydrological cycle, likely from the collapse of the ice wall containing Lake Agassiz in North America. This brought another cycle of droughts to Mesopotamia. In the alluvial plain, people brought the rich grasses from the north and planted them around permanent settlements near the rivers, which were used to flood canals through the fields.

Some settlements became cities, such as Uruk, which began building monumental buildings, including grain storage buildings. City society developed stratified classes, with religious leaders, military, administrators, craftsmen, farmers, and slaves. Some of the cities grew to 10,000, perhaps as many as 50,000 people, and created an intricate network of irrigation canals. Crops increased with sunny weather and plentiful water. However, evaporation from the sun increased the salinization of the soils and crops were shifted towards barley, which could tolerate higher levels of salt. Eventually, there was too much salt, and no crops could be grown. People in the cities had to rely on stored grain, trade for more, or attack other cities. Many cities were abandoned and people returned to nomadism, or more rarely, to hunting and gathering. Abandonment of the fields, however, allowed the soils to recover as the rains and rivers washed out the salt. As people returned after generations, they rebuilt the cities and canals and were able to depend again on agriculture.

This cycle was repeated several times. With each collapse of a city, the residents dispersed to other cities or returned to herding animals; the soils were renewed in the absence of stress. Sargon conquered many cities and established the Akkadian Empire in

2370 BCE. When that collapsed, power moved north to Babylon by 1800 BCE. By 1300 BCE, the cities were weakened and collapsed again. Even with drought, the land renewed itself. The Achaemenid Empire (600 BCE-650 CE) renewed cities with public works and roads, but the cycle turned again and people dispersed. By 700 CE, new canals were dug and Arabian Baghdad flourished. But, salinization increased, and cities weakened. By the 1200s CE, the area was conquered by Mongols. Then, there was a massive collapse and the population dropped from 1.5 million to 150,000 by 1500 CE. People returned to nomadic lifestyles. Cities were reinhabited again and the population grew, especially with trade. Currently, 200 million people are supported on 10 percent of the land by intensive agriculture and intensive imports from trading oil.

Each collapse allowed the native ecosystems to recover and renew the soil. Each renewal allowed people to return and reestablish an irrigated agriculture.

In the Minoan civilization of Crete, the earliest palaces were built after 2000 BCE. Although they were regularly ruined or destroyed by earthquakes, each was rebuilt more splendidly, with a sophisticated knowledge of architecture, engineering, hydraulics, and drainage. The Palace of Knossos was more luxurious than any in Egypt, especially with flushing latrines.

The palaces were administrative and trade centers, but also warehouses. Knossos had the capacity to hold 240,000 gallons of olive oil. There were craft production rooms for potters, weavers, and metal workers. Written records show how goods were directed to the palaces and then redistributed. Scenes on widespread frescoes on the walls were generally peaceful. The palaces were not fortified.

In 1500 BCE, a powerful earthquake precipitated major destruction and widespread changes. Knossos started to dominate the other palaces. The Mycenaean Greeks competed with Crete for sea trade. They introduced new kinds of warfare, with new weapons and horses. About 1380 BCE the palaces were all destroyed, and the civilization collapsed. Parts of Knossos were rebuilt and a reduced administration carried on for a while but even that ended by 1200 BCE. The early script Linear A was replaced with Linear B, which was Greek.

The Mycenaean Greeks themselves inhabited a hilly topography with good forests, rugged semi-arid regions with small alluvial valleys. Villages dependent on domesticated plants and animals appeared about 6000 BCE. The core of Greek subsistence was small scale farming. Agrarian success led to increased soil erosion. This civilization began to develop around 1650 BC. It reached its height about 1400, around the Minoan collapse. Central and southern Greece was divided into independent city-states. Mycenae seemed to be the most powerful. It had 16 administrative districts, each controlled by a governor. Each was an economic center for distributing goods and foods. Aqueducts were built to carry water and roads to carry people and goods. The cities had massive walls with major structures. Palaces had frescoes and bathrooms. Under supervision of palace authorities artisans cut gems, worked metals, and threw pots.

After 1200 BCE, palace after palace was destroyed. The artisans seem to have vanished. Writing disappeared, and art became much simpler. Cities became more fortified and dug into their rock bases for water. The number of settlements dropped from 320 to 40. Athens survived but suffered a political collapse. Overall population declined from 75-90 percent. Some people migrated to the southwest Peloponnese. Around the same time, after 1200 BCE, the Hittites in Anatolia, and the Vera basin people in the southeast

Iberian peninsula collapsed—deforestation of uplands, and a shift to barley monocropping, were made worse by the desiccation and many Vera basin villages were abandoned. Egypt experienced troubles. There were also local collapses in the western Pacific, for instance Kangaroo island off Australia.

A shift in westerly winds brought long droughts to the entire eastern Mediterranean. Some hypothesize that this abrupt climate change may be related to a supernova, bolide activity, comet or asteroid impact, volcanic activity, El Nino event, or earthquakes. Cities were not able to survive on reduced crops. Populations dropped; people returned to herding or foraging when possible.

5.5.4.3. Global Collapse

No combination of ecological catastrophes and cultural disintegrations has resulted in a global collapse of linked cultures and ecosystems around the planet.

5.5.5. *Discussion of Collapse*

Combined cultural-ecological collapses are probably the most common kind of collapse. That is, every cultural collapse seems to have an ecological component, and every recent ecological collapse seems to have a cultural component. This should not be surprising, as people are embedded in ecosystems and tend to use them and transform them. Combined with the human propensity to multiply to fill in every niche, the sum of human activities puts strong pressures on ecosystems.

There seem to be two basic problems with living in ecosystems: Perceptual and managerial. Often, we do not perceive the system in its complexity. We depend on initial observations and ignore a wealth of details. We tend to make general responses to complex, detailed challenges. We make general models of the environment for thinking about it. We also tend to transfer generalities from one ecosystem to another, without being attentive to critical differences. Assumptions by immigrants entering new ecological zones shape their perception. The earliest aborigines must have thought herds of diprotodons stretched forever. The first Americans may have thought mammoths were numberless. The Maori may have thought the moa were limitless. Hunting would have been easy and successful. Deception is also a problem. Europeans thought that America and Australia were *terra nullus*, empty lands, or under-utilized ones. Deception can turn to disillusion as resources disappear.

Managerial problems can arise from difficulties with communications and assignment for responsibilities. With more than one level of management, the response to a challenge might be delayed or entirely inappropriate. Furthermore, with each level of management, there is a degree of detachment from the participant. These problems can lead to poor recognition and to poor, untimely responses.

Of course, our perception of challenges is improving with advancing science and increased communications. Climate change is only one of the challenges to ecosystem or cultural health. Other threats can be summarized briefly as global or local problems. The local problems include such things as the removal of key elements, species, resources, and productivity; the disruption of natural cycles; the introduction of novel elements (as the result of inappropriate technologies); the human take-over of habitats for human purposes, often the result of simple population pressures, but also of greed and sloppiness; and, the extinction spasms in general, but specifically, for example, the decline of amphibians worldwide, due to habitat loss, pollution, and fungal infections. The global problems include such global things as global climatic chaos; ozone depletion (chemical caused); disruption of global cycles; and, contaminations (nitrates, mercury). The words 'global climatic chaos' are used instead of atmospheric heating to indicate that the heat content of the planet is also a factor in climate change.

Any combination of these threats can cause ecosystem collapse. Ecosystem breakdown happens as a result of stresses, singly or grouped, that relate to interference patterns in the system, most of which are caused by the human species now, although the potential for asteroids, volcanic eruptions or long droughts remains.

Collapse is often part of physical, biological and cultural cycles. Collapse can happen when a culture is too static in a changing environment. It can happen a culture selects growth to try to overcome certain environmental obstacles. Sometimes the collapse is thought to be the result of internal moral or technological failings, as well as conquest or some other external influence. Cultures are adaptive systems that have to integrate a number of challenges, opportunities and pressures, from drought to invasion, and then reconcile them to changing economic and political situations. Collapse can happen by bad luck, chance that is, or just a coincidence of bad leadership, bad images, cultural problems, external social pressures, and environmental degradation.

5.5.6. *Patterns of Collapse: Recovery and Renewal*

There are many ranges of collapse. In some cases, the population collapses, but there is not much loss of cultural complexity. Ireland, for instance, lost half of its population, during and after the potato famine, because of its reliance on that one crop; due to English rule, the government continued. The population stabilized at a new lower level, under 3 million. After 1960, with the development of industry and then membership in the European Union, the population has been increasing to 6 million (still less than the 8 million in the 1800s).

In other cases, there has been a tremendous population loss, along with a political crash and complete loss of organization. The Maya collapse eventually led to the complete abandonment of the cities and the urban way of life. The population dropped dramatically. Some parts of a culture may collapse, such as the Southern lowland Maya, while the Northern upland culture continued to survive for several generations before collapsing. As part of a cycle, after people disperse to return to older styles of living, the local ecosystems can regenerate, without the pressure of use or overuse, and recover.

In still other cases, local city states may collapse for a generation or two, and then be rebuilt in place, as the local ecosystems have experienced some level of renewal, perhaps at a lower level of complexity themselves, where the forests and woodlands may be gone, but the grasslands have recovered. Mesopotamia civilizations recovered numerous times, as new states were able to benefit from the natural process of desalinization of soils after the hundred years of rest for the soils.

Of course, some of culture may survive and be used by new or other cultures. The ideas produced by a culture may spread and reproduce. The culture of ideas continues through people leaping to other places. Lower levels may survive with many of the ideas of the larger complex. So, the Roman Empire collapsed but not parts of Italy or France. The Germans were able to return to chiefdoms.

5.5.7. *Future Collapse*

Elman Service uses a biological analogy, where social organizations are modeled as plant or animal species that are initially successful because they are adapted to niche, but later become overadapted and less flexible. In this model collapse is part of an unalterable natural cycle. Adaptation denotes a systemic homeorhesis in which a range of variability is activated in response to various environmental and social perturbations. Service believed that complex systems were profoundly maladaptive since their responses to stress became less flexible.

This argument does not consider weed species or the maturity of the system. In a systems model, collapse is part of stochastic process, which implies that civilizations will die, but not necessarily within a definite time frame or for specific reasons, such as overconnection. Perhaps one reason for cultural collapse is due to overconnections, between trading groups and social classes. This could be a problem with modern globalization, in the 1990s, as well as with simpler regional connections, such as in the 1300s in Asia and Europe. In the general system model, complex systems are hierarchically composed of many stable lower and intermediate orders, strongly connected horizontally, but less so vertically. The problem may be more one of scale than complexity.

Human cultures tend to fill all available space, carrying capacity space, even though some of the spaces are occupied by other species or other cultures. This makes them prone to crash after sudden changes. They have adapted to marginal environments with behavior and technology, such as that for water storage and grain storage, to buffer themselves against the known changes of the environment, but when an unknown change happens, such as a nine-year drought, they fall apart. Few people have the luxury of moving to an open area.

Global climate change has been established by many scientists as a real threat to the public health and safety of cultures. Examination of Paleolithic records establishes that climate, far from being benign and uneventful, has been dramatically unstable for local or regional patterns. Droughts can start abruptly and continue for tens or hundreds of years, far beyond the ability of the adaptations, such as urban living, to cope; agriculture is disrupted and the technological innovations, such as grain storage buildings, cannot continue for the duration or amplitude of change.

Increased planetary heating is related to human activities. Human contributions of carbon dioxide, methane, and water vapor contribute to a much faster temperature rise. If the trend continues, global atmospheric temperature increase could develop deserts where croplands exist, dramatic sea-level changes would flood low-lying areas, and shifting rainfall patterns would affect crops and fisheries. Global climatic chaos could lead to reversal of ocean currents, unpredictable redistribution of rainfall, and other unpleasant, deadly effects.

Because people live in groups having unique cultures, they react differentially to diseases and stresses, even war. In crisis, people tend to pull back to smaller groups. Smaller populations can adapt faster to smaller resources. This was appropriate as a response to local catastrophes, but it may not be the best way to deal with global ecological threats or conterminal collapses. Dispersal to other healthier ecosystems is no longer an option for most cultures. The problem is scale and it has to be addressed on a larger scale.

Scientific models can provide the information to design strategies to give cultures more flexibility in responding to change and challenges. With international cooperation, the risks can be shared and vulnerable cultures can be helped with minimal disruptions.

5.6. *Global Problems: Culture & Bad Images*

No culture has developed a perfect balance of human and situational needs. Some do better than others, but all cultures change and age. As a culture ages, it may become abstract, indifferent, self-centered, and forgetful, suffering rigid rituals and cultural amnesia. If the contradictions become too great and maladaptive, however, then the culture dies.

5.6.1. *Changes & Cultural Transformations*

Cultures emerge from groups of human beings living in places. The variables of the environment influence cultures in a number of ways. For instance, a high Net Community Productivity (NCP) can allow larger annual crops, or, a low number of sunny days can contribute to psychological depression. Cultures have been unique programs, using local materials and ingenuity, for satisfying basic human material and spiritual needs.

Cultures develop over time as the groups change and always seem to grow larger. Cultures are influenced by climate, resources, and of course by human ideas about their places and themselves.

There may also be larger patterns of human culture. For instance, reproductive success and overshoot of resources may always occur in the development of a culture. The asymmetry of sex and violence, ecosystem conversion, and limited time horizons are also things that seem to alter with human development.

How does this happen? Culture does not fit together into a perfectly integrated whole. A culture is a loose-fitting patchwork of ideas, relationships and things. In that sense, it is parallel to species adaptation to an environment. There are discontinuities and contradictions. The mode of operation of nature consists of a rhythm of dissolution and reformation. Often the elements of a culture will simply be rearranged by a succeeding culture.

According to most theories of cultural adaptation (or integration or evolution), resistance to change is normal as a cultural process. Groups like the pygmies have specialized to fit the requirements of the environment, successfully. This makes it difficult to adopt other cultural arrangements. On the other hand, resistance to change itself is an adaptive mechanism. According to Betty Meggers, it works as a successful "cultural isolating mechanism." Isolation is what allows a culture to develop in the first place. But, then does it force a culture to become stagnant?

Stability is a characteristic of cultures. We can even state it in Newtonian terms: A culture at rest tends to remain at rest. According to Harding (1960), when forced to act on changes, a culture will only accommodate those changes that preserve its fundamental character. Since cultures have been traditionally self-reliant, resistance is a positive act.

Thought experiment. If we found a way to live in the forest, using solar power and eating only farmed algae in small arcologies, would the pygmies adjust to that?

William Thompson identifies six major shifts in the transformation of human cultures. The first he calls the feminization of primates; females abandoned estrus and became open sexually (200,000 YBP). In observing synchronicity between bodies and nature, women established system of symbols and notation (art 50,000 YBP). Then women discovered that they could collect enough cereals in three weeks to last the entire year, more than a hunter could kill; but it required storage. Agriculture gave a surplus; that and crop failure and excess property lead to excitement of war (Agriculture 9000 YBP). Civilization became the domestication of women, according to Thompson. This emphasized a patriarchal structure (Civilization 5500 YBP).

Industrialization (200 YBP) is an intensification of civilization. In each case of cultural absorption, there was an attendant process of miniaturization. The forest was miniaturized in clumps of trees; animals were miniaturized in artistic image; time on a lunar tally stick; plants in a garden; women in a household; nature by culture in 1800 (206 YBP) under the glass roof of the Crystal Palace; and now by the new consciousness surrounding the old. Ratio becomes logos. Measuring becomes pulling in, and perhaps shaping (*morphos*). Planetization, along with miniaturization (48 YBP), contributed to the idea that the planet was an organism, that it could maintain itself in the environment of the solar system, and that it could balance its atmosphere with living communities. The photograph, from the Moon, of the earth in space, became the symbol of the change.

5.6.2. *Patterns & Renewal*

Nature consists of moving patterns whose movement is essential to their being. As a rope makes the knot visible, so the body is a pattern made visible. The body is a movement that maintains a topologically stable pattern; it is a vortex but not the water. The thing, the pattern, is a cross section cut through the movement. The mind is an invisible knot that is capable of recognizing both visible and invisible patterns, that is to say, a rope is not always necessary for the demonstration of a knot. Culture is also this kind of pattern. Culture can be analyzed into smaller blocks; the pattern of the whole organization is reflected at every division in differences of organization on either side of boundary. The wholeness of the character of a culture is reflected at every level. Patterning relates symbolic meanings in the context of a cultural system as a whole. The patterns form another level of meaning that has to be addressed in understanding a culture.

There are patterns of interactions of cultures, which arise out of several possibilities: Indifference, trade, competition, cooperation, conquest, or respect. Some archaic cultures seemed to be limited to indifference, that is, they ignored one another, and to trade. Competition and conquest may have accelerated with the acquisition of territory for agriculture. Cooperation and respect seem to have occurred under some circumstances of trade or unification.

The mode of operation of nature consists of a rhythm of dissolution and reformation. Perhaps this process applies to cultures. Often the elements of a culture will simply be rearranged by a succeeding culture. A new culture can only be made from the heritage of the old. The International Workers of the World urged its members to make the new world in shell of old one (in a way similar to genetic recombination perhaps). Our survival depends on the capacity to remake the image of the world from within, phoenix-like.

5.6.3. *Weaknesses of Culture*

No culture has developed a perfect balance of human and situational needs. Some do better than others. But all cultures change and age. As a culture ages, it may become abstract, indifferent, self-centered, and forgetful, suffering rigid rituals and cultural amnesia. Even a culture that fits its adherents and place changes and may become unfit even as the adherents and place also change. Cultures seem to have no limitations of size or kind, although declining mental health may be indicative of some limit exceeded in industrial culture; a culture can grow beyond ecological limits.

5.6.3.1. Holding Arbitrary ideas

People sometimes construct their worlds from preconceived notions. Success in one area may become associated with a chance happening, an event that is repeated to continue the success. In this way a maladaptive image of nature can be built. Some primary traditions may work against the conservation of a place; for instance, the Algonquian notion that game animals spontaneously regenerate after death means that there is no reason not to overhunt. A powerful arbitrary idea, such as the Christian principle of plenitude, can influence many cultures over centuries. The principle states that an intelligent creator gave an earth of unlimited bounty to humanity for their use; this seemed to be confirmed in the Renaissance with the discovery of the richness of stars, microscopic life, and unexplored continents. Modern ideologies have even been shaped by the principle of endless wealth; the economist Adam Smith believed that the real price of anything was just the toil spent acquiring it. Many European cultures would have vanished if they had not been able to leave their exhausted fields for new lands.

5.6.3.2. Remaining Indifferent

Industrial cultures desacralize nature. Since the advent of the machine image, the concept of the sacred has been reversed. In the primary view, the familiar was sacred. When modern cultures made the familiar trivial, it became profane. The quality of sacredness was bestowed on the unknown, wilderness, or children. Modern cultures show reverence toward that which cannot be dominated. So, reverence for nature diminishes as control escalates. In industrial culture, all aspects of life become interchangeable artificial units, including soil, water, and land. This view impoverishes humans by claiming all consciousness for humanity. It claims that nature offers no joy, love, peace, or certitude. Emphasis on the emptiness of nature creates a gap between humans and their environment; there is no room for the intrinsic worth of nature. By granting human sovereignty over the entire earth, industrial culture justifies usurping the habitats of plants and animals for coffee plantations and recreational boating. Cultures may also be indifferent to long-term catastrophes, such as species extinctions, or to short-term hazards, such as volcanic eruptions or flooding; people always resettle floodplains and volcanic lowlands. Some cultures suffer from a collective amnesia regarding what life was like in earlier times; much of the richness of life is simply not known by later generations.

5.6.3.3. Overexploiting Nature

All peoples want some power over the natural order. Primary peoples rely on ritual acts instead of machinery. As technology supplies power to primary peoples, rituals decline. Power increases exploitation and interference. Exploitation can become pathological, when it interferes with the natural processes that maintain an ecosystem. The intrinsic worth of beings can become supplanted by monetary value. For example, some North American Indians were seduced into the fur trade by the lure of manufactured materials. The spread of power has two other effects. The natural order becomes simplified, the human world becomes increasingly complex—and both orders become unstable. Human society acts from ignorance of the bonds of living and nonliving beings. Applying culture beyond a small scale gives rise to behaviors that are nonecological and unsustainable.

5.6.3.4. Being Incomplete

The very circumstance that makes each culture unique—being in a unique place—ensures that each culture is limited. All cultures produce destruction and waste; all of them produce at least some of the opposite of the good intended. A culture rarely meshes perfectly with the natural order or even its own social order. That a culture includes so many patterns and dimensions makes its fitness less. To the degree that it is effective, any ideology can fit the order of nature. But the total mix of ideologies makes the overall fit very sloppy. As long as nature can be dominated, without catastrophe, the importance of the fit is not critical. But we do not know enough of nature to know when catastrophes occur, nor how to avoid them or minimize them. Nature is unpredictable. Cultures rarely have long-range plans; they do not concern themselves with global problems. They rarely consider any cultures other than their immediate neighbors; they do not have policies to help them. They are rarely conscious of their activities. Many cultures have little interest in gaining new knowledge on how to exploit their areas more effectively and efficiently. Many cultures have no way to cope with their own expansion or contraction.

5.6.3.5. Staying Inflexible

It was thought that cultures could vary infinitely and change rapidly. This is an exaggeration. Change is not always easy or adaptive. The inertia of cultural practices makes change painful. People may become fixed in permanent roles and personalities. Even if cultural attitudes are appropriate, they can trap a people if there are no longer functional reasons for the practices. Cultures can determine inappropriate attitudes towards nature. The Ik had a string of misfortunes after their hunting ground was turned into a national park. The difficulty of farming and adverse social conditions made their situation worse. The Ik acquired an attitude as victims, characterized by a cluster of new beliefs, including: Nature as alien, unjust, violent, or vengeful; things being better in the past; humans beings are out of place. By contrast, the English treated tropical lands as enemies to be defeated, then enslaved them in plantations. Their cultural attitude as conqueror of nature led them to treat biogeochemical cycles and soil requirements as temporary obstacles in a world where everything had its price.

5.6.3.6. Keeping Exclusive

When the largest social unit was the tribe or nation, it was possible for the local mythology to represent other people outside its bounds as inferior, and the local inflection of human mythology as the one true mythology. The young were trained to respond positively to tribal members, to love their home, and to project hatred outward. But, there is no outward.

5.6.3.7. Being Aggressive

Are humans innately aggressive, or does the nature of the culture of civilizations promote aggression? Cultures allow more aggression against people outside the home culture. The size of a local population increased the likelihood of its success. For cultures, size was important.

More important cultures were larger and more aggressive. Aggression may be encourage to protect a culture trapped in low food outputs or scarce resources. Aggression would be important to protect a culture, but it can become a prime way of relating to other cultures, especially very different culture, or neighboring cultures that may hinder the expansion of the home culture. Cultures need not be limited to aggression. They can also divert aggression from violence and war into propaganda and art.

5.6.3.8. Ignoring Limits of Culture

A culture will often develop without concern for limits of complexity or scale. How large or small can a culture be? How simple or complex? There are human cultural limits in numbers. For instance, a minima might be genetic, at only 2000 people; but for ideomass, the minimum might be one million. A maximum, based on wilderness, might be ten million, or there might be a social maximum of forty million. Each limit must be worked out, depending on place and the structure of the culture, but they should not be ignored.

5.6.4. *Challenges & Traps (Stress & Insanity)*

Sometimes, rearrangement leads to a position of not being able to rearrange further. In many cases it is hard to tell if the destructive use of land preceded ecological problems or followed from efforts to maintain production after an ecological challenge. Cause and effect are hard to separate. The same environment that challenges a culture with change also offers opportunities. New resources can stimulate economic activity and increase the level of living.

Cycles that do not operate with the right kind of feedback function as traps. Thus, on an elemental level, phosphorus becomes trapped in an ocean sink, and can only be recycled by long geological processes or by specific harvests through human activity.

Karl Marx contended that humans live in cages, partly natural and partly of their own making. However, human actions can modify the situation. The word cage is a metaphor; it implies being trapped. It is however, a metaphor that can be expanded with a description of space as a four-dimensional box. Perhaps the trap is a better metaphor, since we depend on nature and society as a foundation for life.

Traps function in different ways. The use of resources by a people, where the replenishment rate is constant and the rate of use exceeds it, is a serial trap. This trap results in ecosystem degradation that is less reversible. The industrial age mistakes the rate of discovery for the rate of recovery.

Agriculture is an energy trap, because it allows a higher concentration of energy, that is, higher yields, but then it requires more energy be put into the system to maintain it. The system has to produce more energy than it uses to be sustainable, with a surplus for trade.

Sedentism is a trap. As the population of sedentary communities increased, the wildlife numbers decreased. The productivity and narrowness of food increased. Thus, there was less possibility of returning to the foraging lifestyle. People became committed to the new lifestyle. Intensity was no longer an option either; it had to be pursued. Habits were set. One problem of sedentism is that the individual cannot simply move away to avoid conflict. People are tied to a particular place and have to communicate to adjust to sharing places.

The city is a different kind of trap, that offers intensity and opportunity, but requires massive imports of supplies to survive. The size and scale of cities create the dual centers of attraction and despair.

The cultural trap is that: One cannot transcend culture unless one knows the hidden structure, axioms and unstated assumptions about how life is lived, viewed, analyzed or changed. Cultures are systematic wholes composed of dynamic interrelated wholes. They are more easily described from outside with comparison to another culture, although transmitting culture to youth and watching the culture collapse expose hidden structures.

Language and art are also traps. Language because one is limited by words. Art because one is limited by styles or demand. Even if cultural attitudes are appropriate, they can trap a people if there are no longer functional reasons for the practices. The Nembi of Papua New Guinea may be trapped in their system, making stone axes with difficulty when thousands of steel ones are available.

Global capitalism can lead to a consumption trap. Capitalism claims to serve the wants of the people, but it spends half its income creating more wants in people. Not many of those wants are real, or as real as cereal and roofs. Few of the soft services satisfy real psychological needs. Markets advance individual desires and not social goals, by offering running shoes, not inner city restoration. Instead of being free from economic want to develop their potential as creative human beings, people are trapped in a consumer cycle. Self-actualization is postponed for self-gratification. Furthermore, capitalism can undermine traditional cultures by offering consumerism in the place of guides for behavior. Social roles seem irrelevant by comparison, if the good life can be bought without effort.

Being in a trap means much-reduced flexibility and fewer choices. Climate can drown whatever is in the trap. That is, being in a trap makes one vulnerable to many other changes that could be avoided if you were not in a trap. When the weather got colder, then hunters and gatherers could move south. Cities could not. Civilizations are more fragile and more vulnerable to smaller climactic changes.

Addictions, such as those to foods or oil or money, make it difficult to escape from a trap, a trap being a kind of energy well or gravity well. Addictions can amplify some emotions, such as fear or hate, especially as they relate to the possible end of the addiction or the threat of that end. Addictions can justify illegal behavior, especially those that seem necessary to continue the addiction. Of course, many cultures are addicted to the illusion of control and power. The U.S. is trapped in the belief that only it, among nations, can bring prosperity and peace to other nations, with trade or violence. Eventually the trap is escaped, or more likely destroyed or collapses with its victims.

Paul Shepard suggests that the entire Neolithic revolution has trapped us in behaviors that only end in madness. The feedback is inevitable.

Table 564-1. Agriculture and Population Feedback Sequences

Direction	*of*	*Progress*	——>	——>	|
Concentration	Intensification	Disease	Stress	Decline	Madness
Simplification	Instability	Famine	Drawdown	Destruction	Madness
Territory	Defense	Male dominance	Military	Take-over	Madness
Surplus	Specialization	Technology/Art	Novelty	Stress	Madness
Distribution	Taxation	Inequality	Insecurity	Slavery	Madness
Human order	Abstraction	Isolation	Stress	Drift	Madness
Knowledge	Habit/tradition	Manipulation	Control	Laziness	Madness

Now we have to ask, what happens after madness? Do we die? Do we change and get better? Do we stay the same and destroy everything. How would we act if we were mad? Better than consumers? Can we analyze our way out?

A final cultural trap is: One cannot transcend culture unless one knows the hidden structure, axioms and unstated assumptions about how life is lived, viewed analyzed or changed. Cultures are systematic wholes composed of dynamic interrelated parts or wholes. They are more easily described from outside with comparison to another, although transmitting culture to the young or watching it collapse also exposes hidden structures.

5.6.5. *Problems of Individual Cultures*

Problems of individual cultures include: Lack of Resources; environmental change; conflict and violent relations; environmental degradation; species habitat diversity loss; introduction of exotics species and artificial elements; cultural exhaustion; human limits; and, human inequity. Many of these problems arise from other activities, such as: Competition; take-over; cooperation; trade; exchange; clash of images and metaphors; differing ethos or ethics; reactions to trends or gigatrends; and, random changes or changes in luck. And these activities and reactions can result in the problems of overshoot, reproductive success, ecosystem conversion, stupidity, violence, or stagnation.

A new threat to small cultures is an emerging, incomplete global culture. To increase our economic wealth, we have created a 'global marketplace' in a 'global village.' We have tied together people with millions of televisions, hundreds of millions of telephones and billions of radios. More and more people eat the same foods, wear the same style clothing, and read, watch, and listen to the same entertainment. People are pressured to give up their ethnic identity and kinship for the 'global unity' of humanity. This global culture suffocates local cultures; unique dialects and ways of life are diminished.

Progress is erasing archaic cultures. There have been great cultural transformations over the past 20 thousand years. Primary cultures, previously called 'primitive,' regard the relationship of human beings to nature as one of kinship; all neighboring beings fall within moral consideration. These cultures observe the synchronicity between their bodies and nature and understand their culture through mythical explanations. They employ hunting, gathering, and shifting agriculture.

Secondary cultures analyze and deduce the operations of nature; rituals become more stylized. Cultural innovations permit larger human populations; ecological limits are raised by agriculture, although they are not eliminated. Moral consideration is reserved for human beings and sometimes other conscious beings.

Tertiary cultures (in fact, the real meaning of a third world: twice removed from nature), are based on mechanical images that objectify nature. Drastic changes in the production of goods forces other psychological and social changes; human relationships are based on economic allegiances instead of kinship and exist in societies instead of communities. Money becomes a symbolic representation for the value of labor and land, which are considered mere commodities. Social stratification and the specialization of labor become fundamental characteristics. Social and economic orders are rearranged during the process of urbanization. Moral order, for example, becomes subordinate to technical order.

Population pressures, resource shortages, and manufacturing "side-effects" cause instability in many societies; militarism, intolerance, crimes, and health problems are symptoms of that instability. Confusion and misinformation contribute further to the destruction of cultures. The instability of cultures, as well as stress, insecurity, and insufficient diets, results in psychological problems for people. Individual powerlessness and disillusion provokes the further disintegration of cultures.

Cultures can fail for many physical reasons. Early cultures had little understanding of their impact on ecosystems. Mesopotamians silted their water supplies and salted their soils; the Greeks overcut and overgrazed the Mediterranean hills. The Mayan culture probably became too large to grow and distribute food, and too rigid to respond to drought and crop diseases. The Marajo Island culture probably collapsed due to population pressure. For a society than needs surpluses to continue, with growing dependents and growing numbers of people, there is little flexibility to change. Some cultures, stagnant or senile like Rome, only avoided failure by expansion into new areas—for instance, Europeans expanded into Africa and America. Often the elements of a culture will simply be rearranged by a succeeding culture into a new pattern.

The images and diseases of secondary and tertiary cultures had immense repercussions on primary cultures. American cultures had no resistance to diseases bred in European farms and cooked in cities. Many cultures could not compete with more aggressive groups. Many primary cultures have lost 60 to 99 percent of their populations. The Tasmanians, for instance, lost over 98 percent of their population; that much stress on a culture usually results in extinction, as happened to the Ona and Yahgan in Tierra del Fuego. About one third of the known groups in Brazil were gone by 1957.

Some cultures are simply wiped out. The Herero people in southwest Africa were exterminated as a culture by German forces. The Yanomami and others in Brazil are facing threats from prospectors and ranchers, now. Other cultures subside or intermarry out of existence. The Birale people in southwest Ethiopia have only 89 remaining members—and only 19 of them speak the tribal language, Ongota.

Industrial culture is wrongly considered to be the evolutionary successor to primary cultures and is displacing them rapidly. Scholars once plotted an evolutionary trend of cultural types, from primitive through historic, modernizing, and modern; they speculated that later developments were more adaptive than earlier ones and should replace them. It was assumed that the modern view culminated from earlier ages; thus, the 'superior' modern cultures were justified in exploiting or removing 'primitive' cultures.

There is no evolutionary trend of cultural types from the primitive to modern. Later developments have not proven to be more adaptive than earlier ones; nor do they necessarily replace them. Ethnic groups are not anachronistic stages that point to Switzerland or Japan; they are equally valid ways of living. Any culture is only one of many possibilities, one way of living in a unique place—there is no single correct way. Industrial culture, depending on its expanding market system, is becoming unstable—worse, it is attempting to become a global system at the same time. We know that cultures can destroy their ecological basis, but we do not know how to extend their existence or expand one to a global scale.

5.6.6. *Problems Facing a Global Culture*

Our cultural images, our worlds, do not have a close match to the organization and complexity of nature. Our image of the world has failed; our myths, from progress to science, are no longer effective in dealing with global or local changes. There is no formal global culture. No global image has been formed.

A global culture would have emergent problems far more complex than any one individual culture. It could be crippled by hyperadaptivity (success and overshoot), since humans can adapt to poverty, bad diets, crowding, stress, and other unhealthy practices. There might be homogeneity of forms, from a loss of diversity, which could make the global culture more fragile. The global culture might exhibit a lack of flexibility, which could lead to stagnation and collapse. Other possible problems of a global culture include: Hyperpersistence of error (stupidity, violence); lack of consciousness and planning (ecosystem destruction); the limits of capitalism, or any single system, as a global economic strategy; the acceleration of interactions beyond the human social or political ability to keep up with them; and, a breakdown of boundaries and limits, especially ones that control productivity.

One big problem is whether a global culture can fit nature, whether it has the constraints of a local culture, whether it can keep within global limits, or whether it will just keep growing until it collapses, dragging every other system with it.

No culture has developed a perfect balance of human and environmental needs. Some do better than others. But all cultures change and age. As a culture ages, it may become abstract, indifferent, self-centered, and forgetful, suffering rigid rituals and cultural amnesia. Even a culture that fits its adherents and place changes and may become unfit even as the adherents and place also change. Cultures seem to have no limitations of size or kind, although declining mental health may be indicative of some limit exceeded in industrial culture. A culture can grow beyond ecological limits.

Cultures have weaknesses. They hold arbitrary ideas, such as the Algonquian idea of the spontaneous generation of animals, which led to overhunting. They sometimes remain indifferent, as the industrial image of the interchangeable artificial units allows no special value for things and no reason to preserve them. Cultures overexploit their environment. They are also inflexible and can become trapped in inappropriate practices.

The growth of a culture can lead into traps. Agriculture is an energy trap, because it allows a higher concentration of energy, that is, higher yields, but then it requires more energy be put into the system to maintain it. Sedentism is a trap. As the population of sedentary communities increased, the wildlife numbers decreased. The productivity and narrowness of food increased. Thus, there was less possibility of returning to the foraging. People became committed to the new agricultural and urban lifestyle. Globalism might be susceptible to an energy trap, as it keeps increasing energy use, going beyond the limits of alernative possibilities and focusing on nuclear fission and fusion.

Addictions, such as those to foods or oil or money, make it difficult to escape from a trap. Addictions can amplify some emotions, such as fear or hate, especially as they relate to the possible end of the addiction or the threat of that end. Addictions can justify illegal behavior, especially those that seem necessary to continue the addiction. Many cultures are addicted to the illusion of control and power. The US is trapped in the belief that only it, among nations, can bring prosperity and peace to other nations, with trade or violence.

Our survival, at the global level, depends on the capacity to remake the image of the world from within. The planet is wild beyond our imagining, and we need a wild image, a global image that can capture that wildness. Maybe then, we can formulate a global frame for all cultures that would unite them politically, but keep them local and healthy.

5.7. *Designing a Global Cultural Frame Based on Primary Cultures*

Our dream of civilization, in modern industrial culture, is the dream of order and beauty. But, as Aldous Huxley notes, the dream of order begets growth and tyranny, the dream of beauty ends in monsters and violence. Striving for the good life for many has left us with crowded roads and regimented jobs; trying to build beautiful cities has given us gigantic boxes and neighborhood violence. Trying to fulfill our dreams of comfort and security has provoked global threats and local nightmares.

There is a way to dream consciously so that the nightmares are diminished. The solution is to permit a political anarchy, based on traditional cultures, and coordinated by a global 'regulating' body, based on the United Nations. There are 500 million indigenous peoples in 15 thousand distinct groups, such as the Uighur in China or the Kuna in Panama; and, there are over 2 billion people in hidden nations within massive political structures, such as the Azerbaijanis in the Soviet Union or the Tibetans in China. Furthermore, there are regions in some countries, such as the Pacific Northwest United States or Wales in Britain, that may prefer independence to forced membership in a confederation. Any indigenous people with a traditional culture could become an independent nation without fear of conquest or compromise by existing political states. The benefits would outnumber those of a global monoculture and the negative aspects would be more manageable.

5.7.1. *A Frame for Cultures*

There is no outward or practical elsewhere anymore. Cultures have, or can have, contact with virtually every other culture on the planet. Our long-term economic, social, environmental, and political problems result in misalignments of rich and poor, east and west, north and south, energy and costs, communication and dominance, and in ideologies of all kinds. The expansion of any group often comes at the expense of another human or ultrahuman group.

Primary peoples are usually physically isolated and have a low population density; that makes them politically weak in international competition. Primary cultures are vulnerable to the industrial culture because of their size and locality and because of the perception of the inevitability of global culture. The impetus for a single world order represents a misunderstanding of a workable order. No one ideology can contain the truth. Cultural knowledge over the entire earth is complementary. Each culture usually knows its place the best. The content of all cultures is the collective memory of humanity.

Where human understanding of ecosystems and human cultural systems is still undeveloped, we cannot afford to suppress the diversity of thought necessary to adapt to a diversity of wild and domestic environments or to eliminate ecological habitats or the societies adapted to them. Instead, we need to create a conceptual and political framework that protects local cultures, that is fit around them, not as a replacement, but as a means of coordination and preservation, not so much to save any one culture, but to ensure the process of adapting to a place. This framework would also coordinate global communications among them. Cultural cooperation only happens if the integrity of each culture is maintained by strong myths, images, and rituals.

Our new mythology has grown to include the whole planet. A global mythology, however, cannot afford to teach singularity. It must teach a multiplicity of cultures. The centers of the world are everywhere, in every community, and not just Rome or Timbuktu or Beijing or Lisbon. The human desire to refine the focus has neglected the frame of reference. We must adopt a frame that considers all cultures, short-term and long-term reforms, and local and planetary adjustments.

An adaptive holocultural framework can place human values within a global framework, attaining a balance of human and ultrahuman nature. A holocultural framework can preserve a diversity of cultures adapted to a diversity of environments. But, like individual cultures, a frame could have weaknesses and strengths that need to be addressed if the frame is to work successfully.

5.7.1.1. The Strengths of the Frame

A holocultural framework can identify and attempt to solve global problems, such as the greenhouse effect or acid rain, which cannot be solved at the level of a culture. It can address the working of opposites in human affairs, where the solution to one global problem may cause another.

Social boundaries may be better aligned to ecological realities; the boundaries of a watershed or ecotone would be more appropriate than geometric lines. A natural region supports a great deal of life without human intervention; it produces enough life to support a reasonable number of humans. We need to know natural associations and limitations because these determine the harmony of development.

By being a global framework, it can adjust international economics. Local communities are based on traditional cultures, which have long-term lasting power. Traditional cultures often have wealth-leveling properties, absolute property ceilings, fixed wants, and production coupled with need—all of which results in a stable economy. Efficiency and productivity are less important than use and appropriateness. The framework can promote limited and rational economic development and coordinate international economic exchanges, protecting those cultures that choose to remain outside networks. It can put restraints on the current international community, from large corporations to large federations.

The framework can provide a holistic education of all cultures, besides that of the local culture. It can archive knowledge of other cultures. The experiences of many lives are encoded in myths, along with natural phenomena, supernatural beliefs, moral values, and features of the culture. All interpretation and recounting of the past is mythmaking. Mythic symbols store information concisely, which makes it possible for a person to assimilate the collective experiences of a culture. That is why myths reflect the detail of a culture.

A framework can justify a wide diversity in nature and accommodation to natural laws. It can recognize the value of the total biosphere and respect all forms of life, past, present, and future. It can do so, because, unlike traditional or industrial cultures, it is conscious of itself and its purpose.

5.7.1.1.1. Being Conscious. Creating a holocultural image requires changing the gestalt of images of self, nature, and society. That effort is revitalization. Unlike classic cultural change, revitalization requires the explicit intent of the members of society; it depends on restructuring elements already in use (or known). Where the culture remains responsible for the performance of ritual or the preservation of doctrine, the images preserved. When the images are anticipatory, they lead to development and social change. Attractiveness reinforces the movement towards them. We are dependent now on our consciousness of the entire system of nature and humanity. Undertaking a conscious orderly change in our living habits, before it is forced on us by an unbalanced environment, gives us more options.

5.7.1.1.2. Recognizing Context. A global framework for culture depends on important principles drawn from ecology. One role of ecology could be to urge the toleration of fluctuation, irregularity, uncertainty, and diversity. As adaptive systems, cultures change as ecosystems change. And sometimes ecosystem change is a result of cultural change. They are linked together. If humans adapted more closely to the complexities of natural ecosystems, then human cultures would be more diverse and stable. If humans adapted to the complexities of natural ecosystems, then human societies would be more complex. The proper attitude of an ecological framework is care, a positive spontaneity, but also a "letting be," a reverence toward the wild alienness of nature, a willingness to comply with the limitations of natural systems, and a willingness to reduce the dominance of natural systems.

The frame would recommend wilderness areas sufficient for a culture, although the shape and expression of these areas would depend on the kind of culture. Cultures can determine the minimum, or optimum, wilderness areas to support local ecosystems; for instance, very large areas are required in tropical ecosystems or deserts, relatively little ones in grasslands and temperate forests. They can determine the natural productivity and the percentage to be used by humans, as well as artificial productivity and costs. Cultures can key their population to natural productivity for long-term sustainable existence. And, they can multiply any increase by trade-offs, such as a reduced standard of living or exchanges with another group.

5.7.1.1.3. Being Comprehensive. A holocultural frame includes all human cultures without judgment. The framework provides a higher resolution image of the whole, since it incorporates all human cultures. It includes all its members, recognizing that each says something worthwhile. It is not details or knowledge of the operation that is critical, but an understanding of the wholeness of order.

The framework can interact with nature much like the mythic, but understand the rational and mechanical sides of thought. It would not be a conglomerate of sciences; it would not be limited by the facts of any science, even ecology. The insights of people of every culture must be considered. Each person tells of a way the world is; together, these ways make a holistic framework. The framework includes ultrahuman cultures in its consideration. The framework can attempt to combine the best single elements of industrial culture with the superior components of primary cultures, in parallel with Gordon Taylor's paraprimitive solution. High technology can offer immense benefits, with restraint and appropriate limits. Primary cultures can satisfy the human needs for belonging and status.

5.7.1.1.4. Making Authentic Images. The holocultural framework offers a holistic value of human worth, outside of any one local perspective. It promotes and protects universally accepted values: reciprocity—the repayment of obligations; territorial integrity for cultures; legitimacy—the value of children born in wedlock; and the working of opposites—life and death, sacred and profane. It can promote basic rights human rights: The right to land, food, shelter; to equal opportunity to develop, regardless of race or sex; to participate in global affairs as desired; and to live without excessive discrimination or conflict.

5.7.1.1.5. Protecting the Diversity of Cultures. Industrial culture condemns to backwardness any culture that is not part of its global electronic neural system. This definition of backwardness means only a lack of fast things or professional enslavement. Primary cultures do not lack art or play, or food, tradition, freedom, or happiness. It might be good for cultures to be uncoupled economically; it might be a sound option for traditional societies unwilling to make the same mistakes as industrial ones. The frame would keep cultures separate and coordinate any exchanges between them. It would resolve disputes that arise from territorial expansion, the past movements of people and borders, or the unequal expansion of cultures in the same territory, such as the Sinhalese and Tamil in Sri Lanka.

5.7.1.2. The Weaknesses of the Frame

History does not show a progressive unfolding of human betterment; loss and defeat are much of the texture of daily life. A frame will not be able to solve all problems, especially ubiquitous ones like hunger. No human construct is perfect and completely comprehensive. No human framework can expect to solve every problem to everyone's satisfaction. The framework can be expected to exhibit a number of weaknesses.

5.7.1.2.1. Abstract. A holocultural framework is a general human construct, which may not be implemented. There is no working model of global unity. Our experience with international cooperation on an immense scale is minimal. Our ability to plan our cultures and foresee our impacts is minimal. Other abstract ideals, including democracy and communism, have been disappointing and severely modified in practice. Kinship is more rigidly localized than other dimensions of culture, which can be more rapidly disseminated and assimilated. The transition from kinship to a simultaneous abstract global citizenship may slow. Kinship loyalty sometimes clashes with global perspectives. A framework trying to lessen the conflict and resolve contradictions may be faced with more conflict.

5.7.1.2.2. Uncritical. Such a framework, by definition, accepts any human culture, even bad ones. It cannot make judgments about use. In avoiding ethnocentrism, it must accept failure. It may not be able to deal fairly with cultures that are dying out, because they are unfit or because they are victims of a large coercive culture. Yet, it cannot artificially support bad images. It must preserve the process of making and sustaining a way of living, not every individual culture. This framework does not reject or judge cultures, but incorporates all the practicality and paradox. It makes no distinctions between right and wrong or good and bad; these polarities are more like positive stimuli useful to development. Hence, there is no evil, as considered in many cultures, only suffering that results from lack of wisdom. Many customs, like sacred cows in India, at first glance, seem to be dysfunctional. But, even sacred cows provide dung for cooking fires.

5.7.1.2.3. Contradictory. It used to be, as Karl Marx said, that village life enslaved the human mind with traditional rules and subjugated it. No more—too much communication is a greater threat. Our excess communication tends to wear out our ability to feel empathy and react to suffering. Some cultures may overcommunicate and others may undercommunicate. Undercommunication may result in ignorance and suffering; overcommunication may result in passiveness and insignificance. The framework will have to abide the contradiction.

5.7.1.2.4. Weak. The framework may not have the power or authority to make agreeable boundaries. It may be unable to set aside large enough areas for natural processes. It may not be able to dictate population restrictions for some cultures without seeming to be genocidal or prejudiced. It may not be able to achieve an agreeable redistribution of some kinds of wealth. Any action may result in some dislocation and suffering. It may be impossible to limit the interdependence of nations. The framework may not be able to deal with incompatible cultures or the divisive forces of large industrial cultures. Some cultures may refuse to participate. It may not be able to handle large differences or to limit the influence of powerful corporations, which have no local accountability. Some traditional cultures may have trouble incorporating new ideas, such as the equality of women.

5.7.1.2.5. Fallible. A holocultural frame may address global problems that may be insoluble within its range. Some of its actions may have negative consequences for some cultures. For instance, in mediating boundaries that have changed over centuries, it may be difficult to rectify imbalance, theft, or suppression. Cultures have dominated, displaced, merged, or destroyed other cultures for millennia. No one knows how far back to trace a wrong. The dividing line might always seem arbitrary. It may be appropriate to return lands to the Pawnee, but not to the people that the Pawnee displaced.

5.7.2. *Summary: Nightmares & Wisdom*

Our dreams have become nightmares, which are symptoms of rotten images and unbalanced ways of living. Our ecological, social, and political problems do not have simple technological solutions; a single industrial culture cannot solve all problems in every place. The problems are cultural and polycentric.

Industrial cultures have two great myths, progress and nationalism, originally successful, that are reducing our fitness to the environment. Progress has been described by Aldous Huxley as the theory that one can get something for nothing, that the gain in one field is not even paid for in another. Progress assumes that all consequences could be foreseen and that ideal ends justify any means. Primary groups, it was thought, only obstructed the march toward paradise and could be murdered or assimilated if necessary. Nationalism is the theory that one state is the only true god; all other states are considered false. Conflicts over prestige or power, as crusades for the true state, still lead to human and environmental destruction. The cure for progress lies in the responsibility of small nations for their own environments; the cure for nationalism is a holocultural framework of small nations.

Nations have embraced a dominant industrial culture for the benefits they perceive that it gives them. But this monoculture tends to displace local cultures, such that the local knowledge and traditions—the ways of living in unique places—are lost. Nations have tried to assimilate their indigenous cultures, but many of the cultures consider themselves to be independent. Indeed, there are over 100 separatist movements in half that many nations, from Lithuania to Slovenia, fighting for their independence, for the right to speak their own languages and teach their own traditions to their children.

The right to self-determination is listed in covenants of the United Nations, but the right has been limited to states and not primary nations. The UN, by promoting a holocultural framework, could produce a dialogue of cultures to avoid the crippling extremes of uniform homogeneity or tribal insularity. Corporations, nations, and trusts have legal rights, but cultures, and ecosystems, have been denied rights so far. The UN can rectify this dangerous oversight.

There are signs that some nations may be recognizing their indigenous populations. Peru recognizes two indigenous languages, Aymara and Quechua. Nicaragua has a regional autonomy plan for 100 thousand Miskitos, Rama, and Sumus. Some groups, like the Shuar of Ecuador, have formed legal federations to acquire title to their lands. Australian Aborigines are asserting their traditional culture and independence in the Outstation Movement, with decentralized communities.

The framework for cultures should have few adverse effects on traditional cultures. Sometimes the widening of a culture results in a creative, explosive radiation, as when medieval Christian culture made contact with the ideas of Greece and Rome and with the achievements of China and India. Then people have more opportunities. The ideal images intensify human experience and widen its potential. We need to consciously direct our creative explosion without consuming the creativity of every other species. A framework for cultures can help initiate a true global culture.

A culture is a process of continuously self-creating, but the process now needs to be consciously guided to avoid disaster. Let us restore the political power of cultures, which are bounded by their nature and limited in their activities. These small cultures can practice restraint in terms of production and resource use. They are authentic and timed by natural rhythms.

Continued healthy cultural existence depends on the existence of good equilibrium between elements of change (youth) and elements of conservation (age). Rapid development may rupture tradition. Neither the young or old know how much traditional knowledge is necessary for healthy cultural life, so the future holds some experimentation no matter which direction we take.

Cultural traditions, however, describe what we may be and helps us become what we are. The world tends to become how we imagine it, as a spaceship or garden, as a global monolithic state or a loose confederation of cultures. So we must create the images carefully. Kenneth Boulding offered the perfect machine metaphor for the operation of the earth—as a spaceship. As a metaphor, the spaceship suggests the limits of the earth and the value of a limited life-support system; unfortunately, it implies that the earth is a human creation that can be controlled and fixed by a conscious captain and crew. The use of the word 'ecology' by Ernst Haeckel implied that the natural world was a house, a place to live, rather than a machine. This image is more compatible with all cultures, from hunters to industrial corporations.

Equilibrium is needed between self-restraint and self-expression, between exponential growth and precipitous decline. The myths and metaphors of a culture are modes for conveying ecological wisdom; they are less concerned with bare survival than the survival value of a good fit to a place. Wisdom is the new kind of fitness; it is guidance by a knowledge of the whole interactive system, which if disturbed can change catastrophically.

Wisdom cannot be dependent on perfect knowledge; that does not exist. Humans must act "as if" they were wise, according to Hans Vaihinger, as if this earth were the ultimate reality and as if our human time were unlimited; we must act with caution and respect. Wisdom, as defined by Jonas Salk, is the art of disciplined use of the imagination in respect to alternatives, exercised at the right time and in the right measure. The time is now and the measure is primary cultures.

5.8. *Avoiding Cultural Adaptations & Traps*

Human groups have adapted to their environments, have changed them and have been changed by them. Some human groups were trapped by their environments and could not change. Sometimes the adaptations themselves can act as traps that limit human behavior. Perhaps education can be designed to afford understanding of adaptations and traps.

5.8.1. *Adaptation & Drift*

Rene Dubos suggested that humans can adapt to anything. Humans adapt rather than plan. Are we genetically hard-coded to do that? Overpopulation is adaptation to an uncertain environment (or is it an expression of expansion of all life?). Agriculture is adaptation to diminishing game and slow overpopulation; it is stable source of lower quality, lower diversity food. Irrigation is an adaptation to growing exotic crops under low moisture conditions. Permanent settlement is an adaptation to more abundant local food supplies. Large buildings and cities are an adaptation to permanence, slow overpopulation and uncertain environmental conditions, such as droughts. Coal is an adaptation to overuse of wood, oil to overuse of coal. Forest over cutting is an adaptation to environment and increased demands for houses and glass, but it changed the environment and made it more variable. Ecoforestry and conservation biology are adaptations to the overuse of ecosystems.

Our genetic make-up predisposes us to some things and pushes us in some directions. It makes limits on our plasticity. It could promote behaviors that damage the environment, and hence our long-term interests. If limited by stone-age genes, then some pro-gene behaviors may be ineffective, others effective. For example: We must have contact with natural environments where we evolved or suffer psychological and physical harm. Behavior is determined by immediate personal consequences (short-term egoism), regardless of its consequences in modern world.

Adaptation is a response to changes in the environment and the evolution of organisms. There seems to be no direction in evolution other than to live with a changing environment; genes become plans on how to live from experience; drift is selected to fit an environment that is evolving. Nature, that is the planet as a whole inclusive of many subsystems, regulates the stability of the climate and environment. Plant diseases, plagues, floods, volcanoes cannot occur too often, or nature could not purify air and water or reseed devastated areas.

Change is inevitable and we have to adapt to it, but we must make sure that we do not adapt to a low-level style of living, to drifting lower standards and performance, as Donella Meadows warns. We must not try to adapt, for instance, to an impoverished world without wilderness that we could preserve or keep separate. Some human systems get worse, that is, they drift to low performance. Rivers get dirtier, hospital service gets worse. Rather than adapt to these conditions, humans need to create goals and plans to avoid the drift to low performance. Similarly, our many individual enhancements to the human body, especially mechanical replacements of organs, without consideration of changed interactions or consequences may result in what William Thackera calls 'Borg drift' (from the word cyborg). Drift is a systems trap.

Evolution is an integrated process, partly open-ended, involving choices, and the selection of whole individuals in whole environments. The cost of evolution by selection is so heavy that most of the time most populations are not perfectly adapted to changing environment. For the evolutionary process, Varela suggests the metaphor of "bricolage," which is the putting together of parts in complicated arrays because they are possible (rather than part of an ideal design). He calls his alternative view evolution by natural drift.

5.8.2. *Drifts & Traps*

Donella Meadows calls the systems structures that produce common patterns of problematic behavior 'archetypes.' These archetypes are traps. A trap is a device for catching or holding animals (from the old English word 'to step'); it can also mean a stratagem for catching people. Many things can act as traps; many situations can act as traps. Other systems traps include: Addiction, policy resistance, arms races, and the tragedy of commons.

There are energy traps for instance. Agriculture traps energy for people, but it also an energy trap of people, because it allows a concentration of energy, that is, higher yields, but then it requires more energy be put into the system to maintain it. The system has to produce more energy than it uses to be sustainable, with a surplus for trade. The use of energy in general creates an entropy trap, since most of the energy (84%) is wasted, and it creates disorder in the surrounding system, making it harder to get more energy.

Agriculture could be considered a population trap, also. Not being limited by having to move or carry children, also, being sedentary, farmers had more kids. More kids required more food, which could be provided by agriculture. But, because of the surplus, farmers could out-compete foragers on a smaller territory, so if agriculture collapsed they could not go back to foraging. Perhaps the trap was also a material trap. Things required storage or transportation. Storage was cheaper and easier.

There are serial traps, also. An example of a serial trap is the use of resources by a people, where the replenishment rate is constant, and the rate of use exceeds it. This trap results in ecosystem degradation that may be irreversible. Industrial strategies sometimes mistake the rate of discovery for the rate of recovery. The two are different.

The rate of population growth can act as a trap, and the shape of population pyramids can act so, since it can change the reproduction rate dramatically. There is nothing to constrain humans in their growth. We could even adapt to too many humans and too much suffering, perhaps through abstraction and art. But, art could also be survival technique to being to adaptive. That is, it undermines the paradigm by showing the invisible effects of adaptation.

Culture can be a tool, an external set of memories and guides, but it can also function as a trap. The human culture that allowed humans to survive rapidly changing environments seems to create crises during more benign climates. In small scales, culture can be very flexible. But, with changes in scale, culture can be very inflexible and wrongheaded. Although culture is loose enough to incorporate medium-sized changes, such as automobiles, it may still be rigid enough to act as a self-perpetuating, inflexible monster when dealing with large challenges. Traditions, especially those reinforcing identity, can force people to keep to old ways that are inappropriate in new situations. For instance, the Vikings in Greenland tried to maintain a style that involved raising grasses for cows in a cooling climate, with disastrous results; they refused to learn from the Inuit style that was effective under those conditions. Culture can be a mental trap that limits choices and actions.

People may become fixed in permanent roles and personalities. Even if cultural attitudes are appropriate, they can trap a people if there are no longer functional reasons for the practices. The Nembi of Papua New Guinea may be trapped in their system; making stone axes is difficult, when thousands of steel ones are available. There are other cultural traps, such as slavery and brewing.

Humans developed as generalists, using creativity and flexibility to cope with unstable conditions following the glacial climate of the last ice age. If the future returns to the climatic variability of earlier interglacial times, this variability would impose difficult conditions on agriculture and cities, which developed in the relatively mild past 5,000 years. The most recent trends to interdependence, just-in-time supplies, and globalization are not adaptive to instability.

Global capitalism undermines traditional cultures by offering consumerism in the place of guides for behavior. Social roles seem irrelevant by comparison, if the good life can be bought without effort. Yet, it does not seem to be working in Europe and the US. Instead of being free from economic want to develop their potential as creative human beings, people are trapped in a consumer cycle. Self-actualization is postponed for self-gratification.

Capitalism is as massively adaptable as other human behaviors. Instead of being chastised for its weaknesses, it has incorporated the criticism into its advertising program. Protesters are shown drinking Pepsi. Aborigines are shown drinking Coca Cola. The computer revolution, to be the backbone of creative anarchy, is absorbed into corporate service. People become addicted to new commodities.

Addiction is a trap, since it requires higher rates to appease the need. Addiction can appear in human social systems as well, such as dependence on government subsidies or reliance on chemical fertilizers to improve crop yields. Cheating is a trap, that is avoiding the rules for personal or social gain. We are changing conditions so fast that new adaptation is necessary to fit into conditions we cause through growth and adaptability. What is the solution? Plan or adapt?

Violence might work. War has been a way to get out of traps. War can also destroy filters. But, there are other ways to change filters—by perception or thought. War can destroy cultures and ecosystems, so it may be too destructive to work as a solution.

Growth is a way to get out of some traps, but sometimes it leads to a larger trap. Meadows notes that because of the reinforcing positive feedback loop in the market, or ‘success’ to the successful, for example, US automakers were reduced to third place. This is a trap also, It can be broken, in species as well as corporations, by diversifying—and how does one diversify? Find the differences in the environment through education, specifically through ecolacy. Another way is to legally level the playing field with antitrust laws. One solution to growth is mature development within limits of age and size.

Traps can be escaped by reformulating goals, or by weakening or straightening feedback loops, by adding new feedback loops, or by recognizing them or altering the structures. The way out of the trap of escalation is to avoid getting in it, refuse to compete, negotiate, or interrupt. This is where education can offer alternatives, through the filters of numeracy and literacy. The solution to cheating is to redesign rules in a direction to achieve the original purpose of the rules. In fact, design and redesign are ways to remove traps.

5.9. *Global Design Factors: Cultural Solutions*

Intelligence, for Edward Hall, is paying attention to the right things at the right time. Western culture uses a highly specific classification system to deal with specifics and details to the exclusion of whole patterns. Other cultures depend on myths to comprehend wholes, but they have less success with the details of invention. Can cultures learn from each other?

What can modern cultures learn from traditional ones? First, they can learn or relearn how to have children based on limits, not on some abstract right to reproduce. Next, they can learn the art of sustainable living in fragile ecosystems. They can learn how to share and distribute the goods of a society equitably, And they can learn how to resolve conflict by resolution, or at least, how to fight personally.

Traditional cultures can learn some things from modern cultures, also. For instance, larger networks of trade—archaic cultures have always know how to be specialists and how to trade. They can learn the use of appropriate technology. They can learn some forms of larger communication. And, they can accept common rights and standards of universal human behavior.

Table 590-1. Exchanges between Cultures

What can modern cultures learn from traditional ones?
How to have children based on limits, not some abstract right to reproduce
Sustainable living in fragile ecosystems
How to share and distribute
How to fight personally
What can traditional cultures learn from modern?
Trade
Use of appropriate technology
Communication
Common rights, universal human behavior

This is not a complete list. Both traditional and modern cultures will have to learn new things. Some cultures do better at the prospect of greater challenges, in part due to their history, but in part due to their ability to change.

5.9.1. *The Health of Cultures*

All cultures need to have certain conditions to keep being healthy; if one or more of these conditions fails then the culture may fail (see Table 591-1).

Cultures have a lot in common with ecosystems. Both are open, productive systems. Both have an identity that is bounded by limits and is adaptive to place. And, both can achieve flexibility and stability by maturing in place.

The properties of an ecosystem include: (1) Identity and its factors, boundedness, limits, size, definition and shape, and wholeness; (2) Openness, related to energy and efficiency, structure, and connections; (3) Productivity, the self-generation and maintenance of systems; (4) Adaptation to place; (5) Vitality; (6) Stability, with its subcategories, Persistence, Accommodation, Resistance, and Resilience; and (7) Flexibility. By comparison, the properties of a culture are very similar, in terms of how they describe the system.

Table 591-1. Conditions for a Healthy Culture

Condition	*Meaning*
Source of energy / material	External, internal
Groundedness (boundedness)	Locality, isolation, security
Identity	Unique patterns, stability, resistance
Vigor	Productivity, health
Participation	Relation to other cultures, systems
Adventitiousness (continuity)	Ability to adapt / absorb
Sophistication	Self-maintaining, developing, aging
Complexity	Development of diversity
Heterogeneity	Toleration of diversity
Comprehensiveness	Acceptance of everything
Flexibility	Looseness, capacity to change
Renewability	Self-creating, self-renewing
Balance	Harmony of limits / extents

Human needs, according to Abraham Maslow, range from the physical, food, shelter, and clothing, to safety, which involves law, order, and security, then the psychological, about belongingness and love, then esteem, with its reliance on strength, self-sufficiency, competence, freedom, attention, and prestige, and finally, self-actualization, which is expressed through health, achievement and creativity. The needs of a culture, although they seem to include the physical resources and security, are much more formal and include emergent needs: To have a dynamic order, for human health; to be complex and sophisticated, with checks and balances; and, to be comprehensive, to allow change and diversity. The needs have similar things. Both patterns need physical resources and emergent properties that let them find, benefit and enjoy using resources to make better individual or group lives. Of course, this is logical, since human beings make culture.

Cultures can relate to each other in a variety of ways, beginning with the strict avoidance of others and competition with others, including violence and war. But, cultures can cooperate with others on several levels, including partnership and symbiosis. A responsible culture has to fit with the environment and display ethical treatment of all others as insiders or outsiders. Cultures may preserve themselves and possibly miniaturize their image or those of other cultures. Each of these possible relations has certain benefits or costs to a culture. Over time, it seems that cultures are becoming more cooperative and more ethical. Overall, there may be a decline in violence, and that may be related to education and travel. The interrelations with other cultures can range from indifference to war. One perspective that has allowed that has been the concept of the outsider, which is often part of a culture.

Cultures have always had responsibilities to their members. Many of these have to do with identity, continuity and protection. Cultures have several Responsibilities, that may be assumed or voiced formally: To have consistent rules; to keep ecosystems healthy; to be economically healthy; to keep their people healthy; and, to keep the culture itself healthy. Health figures significantly as a responsibility of culture. Not only do the people have to be healthy, but the economy and ecosystems have to be maintained in a state of health. One important aspect of health is the size of the culture relative to its place.

To be truly healthy, a culture (or a global cultural institution) has to address the issues of growth, development and maturity, related to size and scale. We know that life is geared for overproduction and that cells and bodies of organisms have corrective actions, such as signals to trigger cell death. We know that growth is the first phase to maturity, and when maturity is achieved, growth stops, although the organism can continue to develop. Where the signal to stop growing is absent or lost through interference, growth can continue until death from collapse or cancer.

Ecosystems can act in similar ways, where growth can stimulate overproduction, which can establish an environment for new, less pioneering species. The new species corrects the growth of the old by making conditions adverse. Maturity is a correction in general as a mature system closes itself to invasion by other invasive pioneering organisms.

Cultures grow also and received signals from environment. Archaic cultures may have slowly overgrown their environments and spread out and taken over other niches. Usually, the environmental signal slowed growth. After the application of agriculture, however, with all of its technological advances and social changes, such as permanent dwellings, signals were either ignored or overcome by technological or social changes. The human population has been free to grow tremendously, although large-scale disturbances, such as earthquakes or long droughts, have acted as signals and caused many cultures to collapse.

Cultures now, and especially any pancultural global institutions, have to address the situation of exponential human growth and its effects on institutions and ecosystems. They have to find a way to signal human populations to stop growing beyond the ability of institutions to manage them or ecosystems to support them. They have to stop growing relentlessly and start to develop and mature. Cultures can do this by modifying how they imagine places, in terms of their images of the planet or cosmologies. Cultures can apply their understanding of ecosystems and the cultures to use ecological designs and political processes to fit their health and prosperity within the health and vitality of ecosystems.

5.9.2. *Imagining Place: Human Cosmologies*

The present crisis is a consequence of the modern world view, which is too rational and mechanical, as a result of its machine image. Problems are more than matters of policy or management; war, injustice and environmental destruction spring from a common sickness. Unfortunately, the language from a mechanical world view dominates even ecologists and politicians. This world view impoverishes humans by claiming all consciousness for them. It claims that nature offers no joy, or love, or peace, or certitude. Emphasis on the evil of nature creates a gap between humans and the universe. There is no room for the intrinsic worth of nature. The problem is cosmological.

Cosmology is basically the complete set of ideas about the nature and composition of the universe used by a cultural system. This idea of the universe provides people with an orientation in their cosmos. A cosmology is a collective image. Ezra Pound stated that the image is an emotional and intellectual complex in an instant of time. He used the figure of a Chinese ideogram as an expression of a complex image created by throwing groups of elements together without predication, which is a characteristic of assertion of the universe. The set of ideas is common to a culture; some ideas may be shared among other cultures. Most cosmologies have to be understood in a cultural context, which means that they are not intelligible without reference to the culture they are particular to. A cosmology can only be understood within that culture, that exists in that location, with that unique history.

A cosmology rarely meshes perfectly with the natural order or the social order. The ambihuman order of nature could exist without humanity. In a sense it is indifferent. Cosmology arises out of the needs of humans. That cosmology includes so much—science, mythology, theology—makes its fitness less. To the degree that it is effective, any of the ideologies mentioned will fit the order of nature; science may manipulate invisible particles; technology may mold metals; beliefs in theology may save human or ambihuman lives. But the total mix of ideologies makes the overall fit very sloppy. As long as nature can be dominated, without catastrophe, the importance of the fit is not critical. But we do not know enough of nature to know when catastrophes occur, nor how to avoid them.

All peoples want some power over the natural order. Archaic peoples rely on ritual acts instead of machinery. But as technology supplies power to archaic peoples, rituals decline. The spread of power has two other effects. The natural order becomes simplified; the human order becomes increasingly complex. And, both orders become unstable.

We need to create a new holocosmology that can be a framework for traditional cosmologies. We need to appreciate the wisdom of those cultures. These cosmologies are being rediscovered; their tools are dance, song and history; they are open to nonvisual communication. Everything is vital. The consequences of these cosmologies would alter the character of modern life, making it closer to human and ecological reality, counteracting the tragic consequences of war against us and nature. We do not need to inflate a traditional cosmology to use for global design. Brian Morris suggests that the worlds of St. Francis, Buddha or Black Elk, have been destroyed by Newtonian science. He recommends an ecological viewpoint and understanding. But, no world has ever been destroyed by science. Science cannot even discourage astrology or bad eating habits. Technology has ruined many habitats and aggressive cultures have smothered many smaller cultures, but that is not an indictment of the cosmologies.

We need a new holocosmology that will incorporate an ecological perspective to address the emergent features of a global effort for design. The issue is not conservation against exploitation, but an experience of the natural world distinct from these two alternatives. A sense participatory rather than manipulative, a sense of the world as presence rather than object; a universe moving in vast cycles and rhythmic harmony instead of serial stages of beginning, progression, decay, and end.

A world view is more than skeleton of theory, it is a view of relation of human mind-heart-will to global factors. Ultimately, a model of the world—world-view or ideology—is what implicitly or explicitly guides the processes of social change and global ecological design. The basis of an ecological cosmology can be found in history, in the experiences of diverse cultures, and created intentionally be defining new values.

5.9.3. *Imagination & Metabolism*

As the adequacy of a habitual view of the earth is questioned, imagination offers alternative ways of seeing. Yet human imagination is limited, as is human knowledge. An aesthetic object should not offer a reassuring vision, which interprets or identifies nature, but a naive vision, which surprises, shocks, fascinates or seduces the senses, which awakens desire and stirs the imagination, and which furnishes a feeling of the invisible. Play is imaginative experience, natural learning entered into freely; education should be more like play than work. Vico pronounces that imagination is a turning out of one's self. An imaginative metaphysics shows how a human can become all things by not understanding them. The creativity of the imagination diffuses the world from the center of its being, creating a plenitude. Metaphor enlarges the imagination. Perception and expression are embodied in the flesh, but imagination is what makes the flesh visible; it is what allows inquiring beings to see into Being.

We must find a way to affirm the metabolism of nature as our own. Each individual is part of a world that extends around the self. There are different, partial worlds. We may see trees on a house site as encroaching, where a Dakota person may see them as standing peoples, with equal rights to the land. The self is related to each world in different ways. We may see plowing fields for seeds as an act of mastery and exploitation, where another may see it as act of tender involvement, bringing forth potential. The study of these worlds is a holocosmology.

The concept of nature and ecology require new conceptual definitions. They are major philosophical problems. As philosophy attempts to describe the world and discover the order of nature, it must go into mathematics, astronomy, physics, chemistry and biology. The scientific method fragments the world. The mystic feels the world as described by scientists and it is whole again. Most modern cosmologies are based on physical science. Older cosmologies were based on feeling. The new biological paradigm, combined with process philosophy and phenomenology, supports a new cosmology of feeling.

5.9.4. *Framing Imagination in a Holocosmological Framework*

Since the origins of the environmental crises are in human traditions, it should be possible to select—and create a new cosmology—from what is valuable in those traditions. If the world becomes as humans imagine it, then a larger frame will make a larger world.

When cosmologies, when human societies, were small, the amount of control and security was small. Although societies have grown, security has not. It should be easy to give up control that we never had; giving up trying to control may be more difficult. We need to fashion our behavior to the cosmos, not reversed. Since complete security is impossible, since complete power is impossible, why try? We are already participating in the cosmos; our images need to reflect that. We are already in relationships; those are what we need to learn.

We create the organization of a cosmology, then see nature work that way. But, we create nature by seeing what the brain filters. The world is too complex for our minds, thought G. P. Marsh and many later thinkers. So, our minds have to filter out what is less important. We filter data, arguments, emotions, and information. The filter allows a total picture of the whole with relatively little information. Of course that picture might be wrong. But, it is clear, as a result of filtering and thinking. Other human things act as filters, also, especially culture.

Walter Ong thinks that our hypervisualism may be outmoded; it may hinder understanding of the world as it is organizing itself. It would be productive to cultivate more aurally-based concepts, such as harmony, melody or cacophony, on which to analyze a world view. And to move from concept of world sense to that of world-as-presence, in the sense of presence between two persons.

Cosmologies adapted humans to limited places, but cosmologies clash and contradict one another. A global holocosmology is necessary for framework of local world-views on earth. Most cosmologies are circumscribed; a small section of the hologram is inflated into the whole. A holocosmological framework would not have that problem, since it incorporates all human images.

A new holocosmology could justify the wide diversity in nature and accommodation to natural laws. It could even allow a deeper understanding of the utilitarian. For example, what is the use—or the beauty—of a burned forest, as related to the function of lightening or the planetary carbon cycle? The whole idea of irreversible history sanctifies behavior, making it moral. If a life or species cannot be repeated, then it is special.

A holocosmology could show our relationships and our debts to other species. By considering only humans, and inflating them out of proportion, we diminish other species, and ultimately ourselves. Responsibility considers the interests of ambihuman nature. The interests of other beings is the same as human interests: To live and experience, then to reproduce that their heirs may, as Whitehead said, "to live, to live well, and to live better."

The human desire to refine the focus has neglected the frame of reference. An adaptive holocosmology would place human values within a global framework, attaining a balance of human and ambihuman nature. The sciences, humanities and other ideologies could be balanced in a holocosmology. Perhaps human behavior could be put in tune with nature through a popular literature or poetry. Humanity is not aware of limits, of its inability to fully comprehend the universe. We have never made earth completely home; until we do, no place will ever be home.

Such a global framework for cultures would also consider important principles drawn from ecology. A holocosmology cannot be limited by the scientific facts of any science, even ecology. The insights of mystics and the wise should be included. Individual world views penetrate each other in a transepistemological process. Each mystic or scientist tells of a way the world is; together, these ways make a holocosmology. It is a framework for all truths.

The proper attitude of an ecological global culture would be care, a positive spontaneity, but also a 'letting be,' a reverence toward the wild alienness of nature, a willingness to comply with the limitations of natural systems, and a willingness to reduce the dominance of natural systems and to set aside wild areas. In addition, a global perspective might define: An authentic concept of humanity, rational economic development, with respect to health, a holistic education beyond that of a native culture, a description of the responsibilities of societies to themselves, others, and the earth, and a respect for all cultures.

5.9.5. *Fitting in Place—Image & Place*

People not only fit physically into a place, by adjusting their eating habits and by making or shedding clothes and houses, but they also change their images of themselves and the place so that the two things fit together. A culture is a loose-fit with its environment. In that sense it is parallel to species adaptation to an environment. The fitness is never perfect, but that is what allows movement and change.

The individual feeds back into the cosmology in altered form what was received. It is almost like a closed loop between cosmology, culture and the individual. Archaic peoples translate the natural world into the language of myth. Being a narrative, a myth is aesthetic as well as intellectual. Myths develop in terms of their own internal logic, drawing together observations of the world. C. Levi-Strauss described the process as bricolage, fitting the bits together, identifying impressions of life as sets and forming them into mythical systems; the world picture is a metaphorical puzzle. Bricolage is the mentality of synthesis, a technique for learning, creating, and expressing understanding, using whatever is available from the past and in the present to achieve an integrating form. This is what mythological thinking does, and what scientific thought might do.

5.9.6. *Rebuilding Damaged or Extinct Cultures*

Cultures could be rebuilt or restored, much like ecosystems, by applying general knowledge of their operation and components, especially those that are redundant and replaceable. Special attention would be given to the health or harmony of a culture. One approach would be to use properties, principles, standards, and practices to describe how.

Cultures have properties very similar to communities and ecosystems. One unavoidable property is participation in habitats and cycles. Another property is effects on or manipulation of natural systems. Every culture uses an economic filter to screen the environment for resources. Every culture addresses the equity of its members. And, every culture has to deal with interior or exterior threats of conflict and violence.

Cultures are based on principles that are derived from the interactions in a specific environment, although the principles may be more comprehensive than a single environment. The first principle may be stated as 'self-preservation;' every culture strives to survive the challenges of existence, and often prescribes behaviors in the self-interest of the culture itself, before the self-interest of one individual. This leads to another principle, that the culture should strive to be healthy, that is, to maintain optimum levels of vitality and interest. Each member has to contribute to the health of the community and to the health of surrounding natural communities. Members have to respect the principle of ethical behavior (this is the domain of Deep Ecology or Ecological Ethics). As another principle, members have to recognize the intrinsic value of beings, as well as their connections and patterns. Members have to work to increase the self-realization of others through identification with them, the idea of the 'larger self' as part of that principle. Finally, at least for this rough list of principles, members have to act responsibly as part of the community.

Cultures, unconsciously or intentionally, create standards to maintain themselves in a balance with their surroundings. One standard is to present healthy, inclusive, positive images of the planet and universe. Another standard is to address basic human equality, especially of opportunity or value. There is a similar standard for granting opportunities for other living beings; other animals and plants should not suffer, be interfered with, or be pushed to extinction as a result of untenable human desires or ignorance. Another standard is the adjustment of population or consumption impacts below the limits of the ecosystem. Many animals, such as wolves, keep their populations at about 30% of the maximum possible number. Although wolf populations are related to the availability of territory, human populations due not seem to have any psychological or social limits. The limits have to be made culturally explicit, and this is what can be made through standards.

One set of practices is related to cosmologies and metaphors; a culture has to provide and use appropriate images, as well as examine interpretations of them. The cosmology, the world-image of a culture, may need to be restated regularly, at least every generation, to reflect changing challenge and increasing knowledge. Another set of practices has to do with economic and social justice; a culture has to have ways to share wealth, to set limits on demands and needs, and to be perceived as acting fairly.

The language of a culture is usually dynamic, adding and dropping words and concepts with each generation. Where the language has withered totally, as with Cornish, or just been abandoned informally, as with Gaelic, it may need to be relearned and used regularly until the habit of the language is recovered. Behaviors also may need to be sorted out in terms of effectiveness, or at least in terms of harm. Many traditional behaviors can be maintained or adjusted, giving the culture important continuity. Rules and taboos can be observed or introduced.

A culture needs to be flexible. It needs a space and time to adjust to changing conditions, without undue interference or influence from other cultures. Cultures have survived when they have been in tune with their environments. Some have survived because they are strong or loved by their members. Others have survived because they had luck with isolation or resource distributions. Most cultures have adjusted by adapting ecologically to their surroundings. Those that modified their surroundings did so within the limits of the health of the environment. Cultures have unique and useful knowledge of their places. This is necessary knowledge, often in advance of formal scientific knowledge, and is needed to keep the human element in balance with everything else.

Understanding the fit of a culture to a place, and the human need to fit within a culture, some cultures, or the global framework, might be able to help a disintegrating culture or reinvent an extinct one, if there are enough memories and clues, dictionaries and grammars, artifacts and foundations, to assemble into a whole. It might not work, but it would be worth the effort.

6.0. Designing Domiture

The early discoveries of science seemed to confirm that there was a real dualism between humanity and nature. New scientific research in quantum physics, psychology and ecology, focusing on anthropogenic effects on nature, suggest that the perceived dualism is erroneous. Nature is no longer a separate realm that we can look at from outside. Although the old dualism is a common misconception, human actions are embedded within human-dominated matrices, which are embedded with biogeochemical cycles and wild matrices.

Our level of interactions in many places suggests that human processes are significant drivers that affect the function, organization, and composition of many ecosystems (Turner et al. 1990). As the degree of our influence on the entire biosphere increases, especially interference with global cycles, we need to work to fit our actions into the limits of those cycles and systems, or risk having them collapse and require human restoration and control.

6.0.1. Nature Itself

G. Spencer Brown understands a much wider concept of the self. In describing the conception of form, Brown notes that the self constructed boundaries in order "to see itself.' But, in order to do so, it must divide into one state that sees and another that is seen—it must become distinct from itself. In this sense, the world has divided and subdivided itself. Whenever another division is made, a self—Brown says a "universe"—comes into being. The skin of an organism only cuts off an inside from an outside. But, the skin is permeable.

The earth has innumerable modes of being that are not human modes. Our direct intuitions of nature tell us that the earth is infinitely strange; it is alien, even when gentle and beautiful. It seems often mysteriously impersonal, unconscious, immoral, hostile, and awesome. J.B.S. Haldane recognized the strangeness of nature. "I have no doubt that in reality the future will be vastly more surprising than anything I can imagine. Now my own suspicion is that the universe is not only queerer than we suppose, but queerer than we can suppose." Perhaps the queerness results from sheer complexity. George Perkins Marsh believed that the equation of animal and vegetable life was "too complicated a problem for human intelligence to solve, and we can never know how wide a circle of disturbance we produce in the harmonies of nature ..." Barry Commoner echoes them both: "not only is nature more complex than we think, but perhaps more complex than we can ever think." In its immense complexity, nature seems wholly other, nonhuman, or ultrahuman. Nature consists of moving patterns whose movement is essential to their being. The holomovement enfolds and unfolds in a multidimensional order that is undefinable. Nature seems distant and unknowable, so it is feared as unfathomable and uncontrollable. Nature seems contradictory and sinister, shaped by death, which we fear. We fear to understand, to be compassionate. So, we try to dominate and control nature, to overwhelm it before it can overwhelm us.

6.0.2. Culture Itself

Culture as a filter to keep the details of nature from overwhelming us. Culture feeds back into what nature is, as ecosystems and species. As people learn a language, and as they learn from the collective store of memories and experiences, they contribute to their own change and the historical change of a culture. People, like termites, beavers and birds, modify the environment to improve their chances of survival. The modifications and changes become cumulative, so that houses change, ways of generating energy change, without having to be reinvented. Our general cultural ability, rather than specific biological improvements or specific adaptations, give us a greater survival potential. The accumulated cultural knowledge and their meanings as they are transmitted, is a semantic environment. The limits of this environment limits how we can design future environments. This environment needs to be redesigned before the overall environment can be redesigned. When experience is distilled in norms or laws, these secretions, as Anatol Rapoport calls them, change the semantic environment, in a way parallel to toxins or nutrients in the biological environment, encouraging or inhibiting actions.

Most cultures are multiracial and multilingual. Nations are even more diverse in peoples, customs and life styles. Culture forms an integrated design. Elements are fit into the design and related. A traditional culture integrates these relationships in a coherent whole, according to cultural values. By virtue of its integrative potential, culture provides an ideal framework for public and private decision-making. Order is a cultural problem. Order provides stability and security. Cultural order is necessary to deal with the redistribution of wealth and power. Furthermore, justice, ethics, freedom, and truth are based in culture. The study of cultural ecology—human adaptation to nature—has been neglected. The dilemma of the planet reveals the extent of this neglect.

Our minds are not only nature dependent, but culture dependent as well. As the wind, trees, and birds are sources of signals and symbols, so are gestures and words. A community is a place where a group of experiencers share ways of experiencing or the same experiences. This enables an individual to go beyond a finite view, to see the embedded culture as one of many ways of relating the self to the universe. Culture evolves from the interactions of humans with nature; both are in a constant state of flux. The development of cultures may be thought of as parallel to the development of species, where memes or ideas in a culture have the similar function of genes in a body.

Nature needs a place to play, without being controlled or converted. Culture needs a place to play, without being forced by nature. Nature is an extension of field, Culture is an extension of nature through human existence.

6.0.3. Domiture: The Coevolution of Nature & Culture

Domiture is the entire field of extensions as a unit of study, rather than the reification of something new, perhaps divided among the studies of natural history, ecology, human ecology, and cultural ecology. Domiture, a neologism made from the Greek word fragments for 'home' and 'again,' could do that. The system of culture is embedded in nature; domiture is a larger term to enclose the previous nature/culture dualism. It has to include human reason and human emotion, rather than simply putting them on opposite columns, as with order and chaos, higher and lower, linear and cyclic, as well as agriculture and wilderness. Nature and culture need places to play. Domiture envelops both concepts, giving them room to play.

Nature and Culture are systems. Domiture is the combination of those two systems. Culture was once called a "Second Nature," but human culture has expanded so dramatically that the two systems are better identified as one hybrid wild/developed system, now. The fitness of human systems is intimately related to the fitness of species and natural ecosystems. The human attachment to place is critical to understanding why people live where they do.

Domiture is the system of culture embedded in nature; it has to be a larger term to enclose the previous nature-culture dualism. It has to include human reason and human emotion, rather than simply putting them on opposite columns, as with order and chaos, higher and lower, linear and cyclic, as well as agriculture and wilderness.

Table 603-1. Changes between Culture and Nature over Time

Humans as part of environment	*Second nature is equal to environment*	*Second nature exceeds natural environment*
Wild ecosystems	Agroecosystems	Urban ecosystems
Natural environments	Cultural landscapes	Built environment
Dependency on natural environment	Modification of the environment	Major impact and control of environment

Even where the culture may be good, the scale of the culture results in conversion of wild ecosystems into limited human ecosystems. This is part of a large-scale problem of interference, not just in artificial systems, but also in wild ones. Landscape change is about intertwining ecological and cultural processes. Because we are humans and have cultural ideas and images, and because we have impacted ecological systems for ten thousand years, culture is part of any restoration. Environment is the natural; the landscape is cultural. But, it's the same thing. It is not environment or landscape—It is domiture, which includes all agriculture, cities, geospheres, and wilderness.

Stewart Brand thinks that the levels of a healthy society move at different rates. Each operates at its own pace, with the lowest and slowest sustaining the others. Culture moves at the pace of the "long now" according to Brand, at the pace of language and religion. Nature moves slower than culture

6.0.4. Pan Ecology

Design has to consider the rates of change of culture and nature, as well as those of emotion and technology. Nature evokes feelings of beauty and terror, joy and sadness—we can observe the wild or feel rewarded by the experience of nature. Nature is fun. It invites play. Ecology can be fun. It invites play. No matter how tiresome or frustrating ecology as a science can become, there is always the potential to enjoy it. Who cares if nature is not natural anymore? These are only human words and ideas. Nature is healthy, and that is what makes us healthy. Who cares if culture is claims dominance? Hurricanes and tsunamis are agents of cultural humility.

Nature becomes more complex through filtering, combining, dividing, and mixing. B. Mandelbrot suggests that nature is not made of three simple dimensions. Things can have 1.63 or 2.17 dimensions. Regular simple dimensions are imposed on nature by culture, which has its own odd dimensions of complexity. Euclidian nature is a fantasy. But, nature has gotten more playful with fractals. But, fractals too are necessary fictions. Thus, everything becomes a human fiction. Still, that fiction is based on the 'wisdom' of the wild planet, and we are compelled to ask questions: Does nature exist? What is the role of humanity in the destiny of the planet? Who knows? Let's play. Let's start with the adaptive patterns that have benefited our species and civilizations.

6.1. *Global Design Factors: Adaptive Patterns—Agriculture*

Agriculture is a system of plant use that human groups developed towards the end of the last ice age, when the climate and other conditions became much more variable. It is possible to look at agriculture as an adaptation to those conditions, which included drought, habitat exploitation, species shifts, and extinctions. A shift to growing plants allowed people to survive longer droughts and the disappearance of large game animals. Of course, it is also possible that after 40,000 years of gradual but constant population growth, people had filled all the available open niches for hunting. In that case agriculture was a response to the shrinking availability of territory for hunting and gathering.

6.1.1. *Advantages of Agriculture*

Agriculture offered many advantages. The source of food was more stable and more reliable. The plants could be isolated in fields or behind walls. Travel was reduced, since the plants would be brought to people, instead of people traveling to select plants when they were ripe. The selected plants would have increased food value and decreased toxicity. There could be a surplus that would allow people to live in one place, where more people could be supported on a smaller area of land. The surplus would also allow intoxication to be domesticated and expanded. Humans learned to cultivate soil, plant seeds and basically intensify use of the land. A hunter needed 10 km^2 per person for nourishment; intensive agriculture lowered this to 1 hectare (1/100 km^2). Agriculture could be 1000 times as efficient in terms of area. The extra people supported were needed to work in the fields or as specialists, praying for sufficient rain, creating standard containers, building tools, erecting houses or granaries, or coordinating everyones' efforts.

6.1.2. *Ecological Changes from Agriculture*

Agriculture started as an integral part of the environment in which it was practiced. Agricultural systems are distinctive types of human-modified ecosystems. An agroecosystem is a natural ecosystem that has been modified, or arrested at an early stage of succession, and then kept in an immature stage through continuous disturbance. In an ecosystem, humans are just one more group exploiting the system. But, in agroecosystems, humans are manipulating the entire system, that is, they are modifying the system and isolating it from neighboring systems. They do this in many ways, by: Simplifying the system by removals; managing the system with domestics; and harvesting the bulk of productivity. Each of these has effects on the system. Simplifying the system, or lowering diversity, allows fewer species. Not just the crop species, but also pest or system-building species. Crops are analogous to early colonizing plants, that is weeds, which exploit ephemeral resources following disturbance and maximize their seed output. Plowing favors crops that grow rapidly.

The diversity of use narrows with agriculture. There are roughly 250,000 described higher plants. Perhaps 30,000 are known to be edible. Of those, about 7000 have been used as food by foragers and horticulturists, and only 150 have been used as important crops—but only 15 are used as crops to supply over 90 percent of agricultural foods. Three cereal crops—wheat, rice and corn—provide over 50 percent of protein. The early agroecosystems were more diverse. In 1949, Chinese farmers had 10,000 varieties of wheat. In 2002, 300 were used. In Java, tropical gardens had between 100 and 350 species per hectare. Tree densities in Javanese gardens may be 2000 stems per hectare, with a biomass of over 120 tons per hectare. The Javanese used interspecific and intraspecific polyculture, that is, not only different species, but different cultivars of the same species, such as corn. Game theory shows that this strategy increases the chances of a good harvest. Diversity is low because people try to plant monocrops. But, uniformity is also a problem. All individuals are the same kind, size, age, and use the same resources at the same time. It is a perfectly uniform predictable food source for insects and pathogens. So, there is no protection from diversity in genetics, age, and size. The selection of the cultivars for what we want to harvest has eliminated some defensive traits in wild plants. From a weed's perspective, it is a boringly predictable competitor for light and water. Weeds can compete because of the bare ground disturbance.

Disturbance can be created by ground disturbance, such as plowing. Energy is used to maintain the early stage. Soil carbon is also oxidized and lost with plowing, as are phosphorus and potassium, also. Plowing eliminates members of the soil community such as earthworms. Plowing also breaks down the soil types, so that erosion increases as the surface is exposed. Carbon, nitrogen, and phosphorus decrease from the upper horizons. Disruption inhibits mutualistic links such as fungi. With disturbance, energy and material subsidies are needed to be productive. This limits efficient nutrient cycling, diversity, and resistance to disease. It ensures that the system will have low amounts of organic matter, small organisms with short life cycles and broad niches, open mineral cycles, undeveloped detritus communities and linear food webs. Nutrient flows are simple, one-way flows, from the industrial source of chemical fertilizers to outputs in harvested materials or mostly water runoff. Nitrogen for example, is applied in pulses and ends up being leached out. Applied fertilizer, usually anhydrous ammonia, which is oxidized to nitrates, can acidify the soil. Synthetic fertilizers inhibit the action of nitrogen-fixing organisms and detritivores, which work best when soil nitrogen is low. Erosion of the soil itself is a problem. Techniques expose the soil to wind and water at critical times.

From an ecological perspective, there are regional consequences of monoculture specialization. Most large-scale agricultural systems exhibit a poorly structured assemblage of farm components, with almost no linkages or complementary relationships between crops and soils, or between crops and animals. Cycles of nutrients, energy, water and wastes have become more open, rather than closed as in a natural ecosystem. Despite the substantial amount of crop residues and manure produced in farms, it is becoming increasingly difficult to recycle nutrients, even within agricultural systems. Animal wastes cannot economically be returned to the land in a nutrient-recycling process because production systems are geographically remote from other systems, which would complete the cycle. In many areas, agricultural waste has become a liability rather than a resource. Recycling of nutrients from urban areas back to fields is difficult. Part of the instability and susceptibility to pests of agroecosystems can be linked to the adoption of vast crop monocultures, which have concentrated resources for specialist crop herbivores and have increased the areas available for immigration of pests. This simplification has also reduced environmental opportunities for natural enemies. Consequently, pest outbreaks often occur when large numbers of immigrant pests, inhibited populations of beneficial insects, favorable weather, and vulnerable crop stages happen simultaneously. As specific crops are expanded beyond their "natural" ranges or favorable regions to areas of high pest potential, or with limited water, or low-fertility soils, intensive chemical controls have to overcome limiting factors.

We harvest as much as possible of all the productivity. When we use machines to get more, even if they destroy soil and relationships of living beings, we force the system to a less productive state, although we might maintain it with a great number of inputs of fertilizers and biocides. Harvesting is limited to cultural choice. We choose not to harvest dandelions or sowbugs, ants or spiders. These new systems are based on ecological systems that have been rearranged for human purposes (food). However, they still depend on solar energy, photosynthesis, biogeochemical cycles, stability and movement of the atmosphere, and the services of nonhuman organisms. They are subject to the laws of ecology.

6.1.3. *Cultural Consequences from Agriculture*

How did agriculture affect culture in early Mesopotamia, for instance? Just as a result of irrigation? Did it push changes in religion, from otherworldly gods to specialist gods? There are many general associated changes from shift to agriculture; they can be considered cascading effects from positive feedback loops. For instance, clearing larger areas of land and irrigating to transfer water to land lead to technological improvements in the channeling and manipulation of water. New tools extended efficiency. More crops required new ideas of storing foods. There were more innovations in general. Domestic animals were used to haul loads and then work in the fields for preparation or harvests. This required new kinds of digging sticks and new kinds of harnesses. The kilns for ceramics required more wood, which often came from newly cleared fields or transport from remote forests.

The creation of more kinds of material goods led to the accumulation of more material goods, that is, more things. Things had to be measured and tracked, and that required counting and sorting. Records of exchange or trade had to be kept. A currency of exchange had to be invented to allow things to travel less and be more still, in place (Table 613-1).

Table 613-1. Agricultural Effects

Change	*Economic change*	*Social/political change*
Seeds/resources	Trade	Standard value, writing
Manipulation	Increase size	Domestication dependence
Personal fields	Ownership, limits	Conflict, Protection / taxes
Working	Increase in hours	Changes in status
Water needs	Canals	Cooperation
Timing	Calendars	Schedules
Tools	Technology	Specialists
Specialization	Specialists	Pay, records
Distribution of crop	Pottery	Standard sizes, records
Surplus accumulation	Storage places	Protection, buildings
Sedentary	Field exhaustion	Field expansion
Permanent fields	Settlement	Mobility decrease, Growth
Permanent settlement	Cities	Concentration, critical mass

There was an increase in the size of labor input into agriculture. There were specialized occupations related to tools, specialized occupations related to trade, and specialized occupations related to conflict, protection, control, and project management.

There were changes in distribution of food substances and things. Not only things, but people concentrated into villages and towns. Luxury goods and wealth accumulated. Society may have stratified first by specialization, some of which had more prestige, then later by prestige itself. To protect things and places, new specialists in protection were developed. Control and conflict increased. At some point control of social activity lead to control of the poor, control of women, of animals, and control of wild areas and animals.

Because of problems with increased disease or insect resistance in large monocrops, new cultivars have to be developed. Stability in modern agriculture hinges on a continuous supply of new cultivars rather than a patchwork quilt of many different varieties planted on the same farm. The need to subsidize monocultures requires increases in the use of pesticides and fertilizers, but the efficiency of use of applied inputs is decreasing and crop yields in most key crops are leveling off. In some places, yields are actually in decline. There may be several underlying causes of this phenomenon. Yields may be leveling off because the maximum yield potential of current varieties is being approached, and therefore genetic engineering must be applied to the task of redesigning crop. Or, the leveling off may be because of the erosion of the productive base of agriculture through unsustainable practices.

Cultural differences between ecology and agroecology include: Different perspectives, for instance, human-managed systems; different goals, such as productivity and efficiency; and, different principles, like subsidization. Crop ecology for agriculture is limited by intense labor. Special cultural practices are developed to engage the work and celebrate its successful completion.

Table 613-2. Other Consequences of Agriculture

Psychological consequences	Increase in compliance and obedience
	Stress due to uncertainty of yield
	Increase in hard work
	Reduced food choices, malnutrition
Sociological Consequences	Sedentarization of people
	Altered relations, status competition
	Change in world views
	Increase in movement of goods
	Rise in central authority, hierarchy
	Use of irrigation to increase yields

6.1.3.1. Agriculture & Population

Agriculture did produce one unexpected change from hunting and gathering. Initially, farming peoples suffered from increased sickness and mortality. But, they also saw greatly increased fertility. Populations in Europe increased one-hundred-fold. Of course, agriculture allowed people, by virtue of remaining in one place, to have more children than they could previously, in hunting bands, carry or travel with. So, the sedentism of agriculture allowed larger populations to exist in place. Furthermore, the nature of work in agriculture meant that more children were useful for labor.

Population increased. Perhaps the fertility of women increased when they stayed in place. Being in place may have removed those controls from prolonged breast-feeding or sexual abstinence. Agricultural populations increased and spread, bringing their crops with them, pushing hunters into the periphery where crops could not grow. Once the initial agricultural startup costs were paid, such as truncated diversity and nutrition, as well as decrease in human size and health, other advantages accrued, such as specialization, creating a different form of political control, which allowed armies. Agricultural society now had a massive social advantage over foraging societies.

Perhaps related to population growth and size, have come changes in cultural status, especially related to equity, distribution, and dominance. Status has to do with standing in society, and with appearance and ownership. Status may come from longevity, of the self or ancestors, as well as from the results of good decisions, from hunting for example, or from owning more than others, or just more things or more people. Status is a powerful human need, and may drive the growth of goods or populations. As distribution becomes more unequal and as conflict occur more between groups, dominance and slavery appear, and are both related to status.

6.1.3.2. Population Size

The maximum number of individuals that an environment can support is its carrying capacity, which fluctuates with various factors. Physical limits may be absolute or flexible. Population control can either be accomplished through crowding, by the food supply, or by natural resources. There tend to be as many people as there are utilized natural resources for, and unpolluted room and food for. The greatest number of people over time implies that the living population be limited to biological carrying capacity. Any permanent destruction of carrying capacity to allow a larger living population implies a future reduction in population indefinitely, or until ecosystem restoration (if possible).

Table 613-3. Summary of Agriculture

Change	*Economic change*	*Social/political change*
Seeds/resources	Trade	Standard value, writing
Manipulation	Increase size	Domestication dependence
Personal fields	Ownership, limits	Conflict / Protection / taxes
Working	Increase in hours	Scheduled work
Water needs	Canals	Cooperation
Sedentary lifestyle	Field exhaustion	Field expansion
Permanent fields	Settlement	Mobility decrease, Growth
Permanent settlement	Cities	Concentration, critical mass
Timing	Calendars	Schedules
Tools	Technology	Specialists
Specialization	Specialists	Pay, records
Distribution of crop	Pottery	Standard sizes, records
Surplus accumulation	Storage places	Protection, buildings
Property accumulation	Larger homes	Protection

Many of these are intricately related and developed out of previous changes. Trade, for instance, expanded from a few necessities, such as seeds or ochre, to many forms of tools, clothing, and luxuries.

6.1.3.3. Property

Agriculture, by creating permanent places, allowed people to accumulate far more property than they could carry or put on a horse or buffalo—or move. This new property allowed people to have things that were luxuries rather than needs. It let them collect things that might normally be given away or reworked. Agriculture set in motion many kinds of physical and technical changes, that resulted in further social, economic and political changes (the consequences of agriculture are summarized in Table 613-3).

6.1.4. *Disadvantages of Agriculture*

Disadvantages of agriculture include a dramatic increase in work hours, especially during harvest time. All the work that was previously covered by natural processes, from propagating to irrigating, was now accomplished with human labor. In addition, there were requirements for tools and storage devices. Despite this, there was a decrease in nutrition, as the overall diet was less diverse and less complete. There was an increase in fertility and a population increase, perhaps at a rate thirty times as fast within generations.

The form of agriculture, from simplification of the system to an increase in scale of the system, not to mention intensity of energy and use, resulted in the degradation of ecosystems, including erosion, siltation, salinization, and an explosion of pests. Modern agriculture replaces the biota, or transforms the ecosystem into an artificial subsystem. Furthermore, with fertilizers robbing foods of nutritional values, more of each food is required to meet nutritional needs; for instance, the nutritional value of broccoli has declined almost 500% in 50 years, which means we have to eat 5 times as much as our grandparents.

Highly specialized systems are accelerating the change from 'paleotechnic' to 'neotechnic' agriculture. This change minimizes costs and maximizes profits, but it also narrows the ecological basis of world food production and decreases the range of human livelihood. Life on the planet cannot afford the continuous genetic narrowing generated by agriculture. The application of modern agricultural techniques in tropical areas disregards the local realities, and is socially and ecologically disastrous. Traditional ways have operated successfully for thousands of years, although not without serious problems of their own. But, these problems may be overcome, unlike industrial problems, which have fundamental flaws and cause rapid conversion. The scale of agriculture—its ubiqiutousness in converting and simplifying large areas of land— is now having global impacts, as wild ecosystems are converted to simplified agroecosystems that contribute to positive carbon imbalances and to negative water holdings.

6.2. *Global Design Factors: Adaptive Patterns—Technology*

Technology basically creates extensions, as tools, to our bodies, letting us access new resources and create new things. Something as simple as a harness can replace human labor with animal labor. Something as simple as a knife can replace the muscular effort of chewing large pieces of food, which can be rendered more tender by another tool, fire.

The Greek root words, from which the word 'technology' was taken, meant art and study. Technology can be broadly defined as the material entities created by the application of mental and physical effort to nature in order to achieve some value. In its most common use, technology refers to tools and machines that may be used to help solve problems. Technology is a technique that lets us use resources to produce products and solve problems; this technique feeds back into culture.

As tools increase in complexity, from knives and levers to computers and space stations, so does the knowledge needed to support them. Complex modern tools require libraries of information that has to be continually increased and improved, then spread. Technology first simplifies life, then complicates it. Digging sticks led to plows and tractors. Lean-tos lead to pit houses and balloon-framed houses. Domestication led to horses and to horse wagons. Paths led to trail and highways. The engineering of an infrastructure lead to massive buildings, monuments, and fortifications.

6.2.1. *Considerations of Technology*

Technology is defined by tools, as well as by its processes for handling materials, energy and wastes. Technology is also an intentional practice based in a culture that incorporates changed perspectives from the use of tools .

6.2.1.1. Materials

To be constant and stable, a culture has to be productive, to be able to convert energy and materials into foods and structures for survival. As culture extends human ideas into place, humans use energy and materials to create different structures in place. Materials were first limited to plant and animals. These materials cycle above and below ground, between the atmosphere and trees, between trees and insects, and squirrels and fungus. The material aspects are the physical products or imprints of culture. These range from paths and plant patterns to tools and structures. Tools start simply as choppers, scrapers and cutters. Structures include pots, clothing, and houses. Found materials gave way to modified materials and finally constructed materials, that is materials rearranged from elements with the use of energy. In fact, the extraction of materials, and later energy, became a primary economic activity in many cultures. The processing of materials became secondary.

6.2.1.2. Energy

Technologies require energy, and many kinds are available: Solar, nuclear, fossil, fire, animal, and human. Each has dominated some historical epoch. The industrial revolution increased the quantity of energy, but decreased the variety of energy resources. Carbon products are the largest source of energy. The earth is also a source of energy from tides and hot springs. The discovery of other forms of energy, such as fossil fuels, lead to technologies that could leverage them. Technologies require energy. The industrial revolution increased the quantity of energy, but decreased the variety of energy resources. Since phosphorus and fossil hydrocarbons may be in short supply, a good power source would be required, perhaps solar or nuclear. The three main uses of energy for industrial civilization are motor traffic, heat for buildings, and manufacturing, all of which produce other forms of energy as waste.

6.2.1.3. Waste

Nicholas Georgescu-Rogen described the economic process as entropy-producing, where entropy is visible as heat, waste and pollution. Every life process generates waste that is recycled or temporarily trapped in biological or geological cycles. Nature wastes countless lives and materials. Resources may lie buried for millions of years by landslides or volcanic eruptions. Unfortunately, some technological waste is different: Many materials have no processes or organisms to break them down and recycle them—no solutions have evolved; sometimes the quantity, of a toxin for instance, is immeasurably greater than natural toxins. Even natural disasters, such as volcano eruptions that devastate whole areas, are recolonized from outside. The impact of human eruptions around the globe mean essentially that there no longer is an outside. Humans have the capability to fill the entire atmosphere with radioactivity or organophosphates.

There are no sinks on the earth where waste vanishes. Things are only moved around; eventually they return. Early technologies dealt with waste by moving and storing it. Some things are dissipated into the earth's environment, the cosmos, which is an energy source and sink. Even this large environment may not be inexhaustible, as many analysts such as Eric Jantsch claim it is. Later technologies tried to burn waste to break it down into component parts that could be sifted out of ashes; the burning, however, resulted in air pollution and some toxic wastes that had to be isolated. Pollution is a symptom of imbalance and improper resource utilization. A serious problem is our lack of understanding of the extensive, long-term effects of pollution on the atmosphere. More recent technologies have found ways to separate out valuable components of waste. Others have found ways to neutralize toxic wastes with chemical treatments.

6.2.2. *Technology as Extension*

Technology can be considered as an extension of human body, e.g., knives extend teeth. Or, it can be an extension of animal labor, such as the harness that allows single and multiple animals to pull a heavier plow than a man. Technology can be considered also an extension of fire: Fire herded animals and made grasslands. Wood fires cooked food and provided warmth; wood fires also shaped metals and provided steam for power; coal fires provided electricity, and oil fires provide electricity and motion. Steam donkeys and steam engines provided work, heat, and motion.

A tool is an extension of the individual into a new kind of specialized animal (perhaps because it has a new essential property it can be a new pseudospecies). Neither the ecosystem nor the animal knows what it ought to do, hence the explosion and chaos. For humans, this is what a new ethic and cosmology is needed for: to tell us what to do. We need direction. Technology must become an art again to make good places.

6.2.3. *Technology as Intensification*

Technology intensifies. There has been an intensification of tool-making during the past 3000 years. The agricultural revolution was a technological revolution. The industrial revolution, by definition, was a technological revolution that resulted ultimately in humans being replaced by machines. Only the Luddites faced this limitation, unsuccessfully. Human labor is increasingly dispensable. Industrial culture confuses mechanical with personal power. According to W. I. Thompson, industrialization is really an intensification of civilization.

Table 623-1. Parallel Events in the Recent History

Ideas	
	Mechanization (Clocks)
	Quantification (Grades)
Technology	
	Inventions of tools: Telescope, Microscope, Camera
	Communications tools: Printing Press, Telegraph
Management	
	Bureaucracy
	Social Science

Because of the exponential growth of technological exploitation, more primary metals have been consumed since 1940 than in all human history before then. Technology is bound intimately with the exploitation of a convenient source of energy, oil. Unless the trend is changed, reserves will disappear. There is a finite limit on actual numbers of molecules of a given resource in the earth's crust, but the practical limits to exploiting the potential are a function of technological activities. So we are importing materials from the past (oil) and the future (soil), for now. Humans are hunters and gatherers of materials whose renewal times are geological.

Recent industrial history reflects new tools, new livelihoods, changes in settlement and behavior patterns. All tools, from the simplest word to the most complex computer, are disturbers and rearrangers of primordial nature and reality; they are implements for working on something. And, they have addicted us to purpose. We look for purpose in everything—to seek an explanation of nature, and to justify the seeking. Humans are tied to their tools and machines. The basic difficulty with the quality of life resides in machines. Machines pollute air, water and earth. Machines of war threaten human lives. Machines displace forms of life; they take up space. They are a competitive species, whose members die, reproduce, evolve, and sometimes think.

6.2.4. *Effects of Technology*

What are the effects of tools on human cultures? The complexity of tools leads to rules for their use, and for those who uses them, such as trade unions and clubs like masonry. Society is very adaptable to technological change, according to Kenneth Boulding. Perhaps too much so, according to Rene Dubos, and the risk is shaping human behavior to the tools.

The use of technology has a great many effects; these may be separated into intended effects and unintended effects. Unintended effects are usually also unanticipated, and often unknown before the arrival of a new technology. Nevertheless, they are often as important as the intended effect. The most subtle 'side effects' of technology are often sociological.

They are subtle because the effects may go unnoticed unless carefully observed and studied over large areas and long periods of time. These may involve gradually occurring changes in the behavior of individuals, groups, institutions, and even entire societies. A nation needs to address the effects, all of the effects including unwanted ones, of technology on business, culture, management, and the environment.

New technology has been a primary force for change for decades; but some technologies, like computing or genetic engineering, may lead to enantiodromia. The clock itself, one of the basic parts of a computer, was developed by monks to regulate and limit the hours of prayer, to serve God better, before it was used for secular purposes, beginning in France, to control the trading hours of merchants. The use of new tools can be expected to have unexpected effects. For instance, mass-produced computers may lead to individual autonomy (or slavery).

The implementation of technology influences the values of a society by changing expectations and realities. The implementation of technology is also influenced by values. There are major, interrelated values that inform, and are informed by, technological innovations. These realities and expectations may alter the world image of a culture, especially as regards efficiency, bureaucracy, or progress. We should use new technologies, but as Peter Drucker says, make sure that we know that the technology matters less than the changes it triggers in substance and content. It should not replace an ecological perspective and critical thinking. And, we need to remember that knowledge itself, with a shift in consciousness, can trigger change.

6.2.5. *The Promise of Technology*

Under what conditions can the effects of technology not be contained? Does technology always escape and produce its effects on the nonhuman environment as well as on other cultures? If so, then technology is always ecological, that is, it is always part of the environment. It always generates some change in the environment that it is part of. It is not the same environment after the introduction of the extension of technology. Any addition (or subtraction) is a change, and any change has many effects on everything. The conditions of survival for all change.

Technologies change institutions and the relationships between them. As an institution adapts a technology, its view changes. A new technology threatens other institutions, which have competing technologies, as the whole mass has considerable momentum and investment. As the nature of institutions changes, the nature of communities, cities and cultures, changes. Thus, technologies change the form of tools and whatever they shape, then change the quality of response to those changes.

Technologies change the structure of things with new metaphors. As metaphors (and totems) are good things to think with, technologies become things to think with. Technologies based on organic metaphors have the potential to change the quality of the built environment and it supporting wilderness.

6.3. *Global Design Factors: Urbanization & Civilization*

A city is a place where a large number of people live permanently. The classical city-state was a place where the citizens depended on and maintained the whole, which cared for and outlasted the individual. The Stoics declared the cosmos to be the great city "of gods and men." The citizen became related to the cosmos as a whole, in the same way. For those in Mesopotamia, the whole city, and not just the temple, was conceived as an earthly imitation of the cosmic order, a sociological middle cosmos, established between the macrocosm of the universe and the microcosm of the individual. Through the priesthood, the one essential form of all was made visible. The early Sumerian temple tower, with a hieratically organized city surrounding it, became the model for the Hindu world mountain Sumeru, for the Greek Olympus, for Aztec temples, and even for Dante's Purgatory. The Sumerian city was organized in the design of a quartered circle. This design has been a favorite for cities and utopias, as well as for many cosmologies.

Cities have distinguishing characteristics, such as permanent buildings, specialized buildings, monumental buildings, and large populations, which have increased over the millennia, from 2000 people to 50,000 or millions of people. Another characteristic is the density of the population, as a result of the shape, size and number of buildings. Cities in general are not self-sufficient; they rely on outlying areas for food and resources. Cities are places with surpluses that can be traded for things from other groups or cities; cities become central places in an area that provides services for outlying areas. The specialization of occupations in a city promotes trade of special goods. Specialization and unequal distribution allows people to become stratified in distinct classes, based on specialization and differential rewards. A city is characterized by organizational complexity, with universal rules and central institutions.

As people are attracted by the advantages and excitements of cities, the size and number of cities increases. The spread of cities increases. Their areas are added to that of the vast agricultural lands, which together make up the physical impact of human habitation on the surface of the planet. The characteristics of cities change also, as their sizes and shapes are formed by desire and consumption. They become more "ideal" and more uniform, and with less and less to make them different and unique, they start to resemble ideal noplaces.

6.3.1. *How did Civilization Arise from Cities?*

A society based on cities, with a complex social organization, engages in a whole series of changes. Rather than reciprocity, economies become based on a centralized accumulation of materials. Social status is changed through tribute and taxation. Formal records-keeping arises, from knotted strings to cuneiform. A state religion develops, where the leader takes an important role, as for instance as god-king. Table 631-1 is not able to show multiple causal chains or how changes lead to or influence other changes.

Cities are an intensification of trade and agriculture, and the things that surround them. Gravity is a fruitful metaphor for intensification, for desire or crowding. Gravity is a universal long-range force. It is centripetal, where the center of gravity is the center of the city. For the earth, the center is the sun. But, the sun is part of another gravitational sphere. As a metaphor gravity might explain why people are attracted to and move to cities:

Intensity. Opportunity may increase due to the concentration of people. The number of links dramatically improves the possibility of better or more communications. Although gravity may explain the intensity of compression or miniaturization, it has trouble explaining the intensity of expansion. The metaphor raises some questions: How is danger related to intensity? Is it being exhilarated by the closeness of death? If the populations had become more dense, would intensification have been necessary?

Urbanization was the result of permanent settlement and population growth. The growth of the settlement and intensification followed. There was specialization and engineering of a more complex infrastructure, with canals, larger buildings and massive monuments, and fortifications. Religion and trade enlarged in scale. As a result of surplus food and larger population, special people can create a flow of specialized objects. The population has to be large enough to support a market.

Table 631-1. Urbiculture Summary

Change	*Leads to*	*Which creates*	*And changes*
Permanent crops	Irrigation	Salinization, exhaustion	Kinds of crops
Permanent buildings	Storage, property	Possessions, greed	Movement
Massive monuments	Status	Competition	Relationships
Trade	Common value	Standards	Shortages
Managers	Rise of elite	Taxes, power skew	Hierarchy
Transportation	Roads	Crowding	Perception
Water/Baths	Increased use	New reservoirs	Shortages
Walls	Protection	Separation	Inside/outside
Centralization	Concentration	Intensification	Obedience
Culture mixes	Violence	Laws	Behavior
Ecosystem replacement	Degradation	Protection	Invasions, disease
Unsustainable use of water and wood	Distribution	Drawdown, money	Money
Specialists: Artists, clothiers masons	Luxuries	Redistribution	Production patterns
Crowding density	Disease	Immunities	Health

Labor shortages for harvesting crops lead to recruitment and some specialization, especially with tools and irrigation (engineering). The surplus of crops, with its necessity for allocation and storage lead to record-keeping and perhaps writing. With labor specialization and records came further specialization, especially with crafts (art) to make standard containers for distribution and professional art to provide necessary images, decoration and luxuries. Economic interaction shifted from reciprocity to formal exchanges. Trade expanded to include special products, tools and artworks.

Concentration in cities permitted and promoted these changes. Permanent settlements contained working houses. Supplies and control required a new infrastructure of massive buildings, better roads, and fortifications. This paralleled the rise of a religious elite to control the unknowns of weather and crops. And, this was followed by a military elite, which took over protection and combined it with universal gods, which lead to the rise of royalty and kings. Heroic buildings increased to provide palaces for royalty. Warfare was necessary to procure foods in times of famine or to protect stores from less fortunate cities.

The increase in personal property, combined with the redistribution of wealth, lead to social hierarchies and classes. Public ideologies were developed to attune the people. Civilization provided immediate advantages, including supplemental animal labor, more property for everyone, especially the opportunity to have luxury items, the use of records instead of memory, which allowed verification and less misunderstanding, some leisure time for doing nothing, and the production of ale, as a mind-altering substance. Unfortunately, there were disadvantages, such as an increase in the amount of work, not only for production, but also for public projects. Leisure was reduced overall. Living required more work and materials for records, as well as trade and trust with a larger group of people. Personal property had to be stored and protected.

The changes required for living in cities promoted further changes in the cultures of cities, in the form of an emergent civilization.

6.3.2. *Changes from City Living*

A city is a complex structure characterized by buildings, roads, residents, density, division of labor, air-conditioning, domestication, partnerships, patterns of movement, numbers, concentrations, intensity, and miniaturization. Who could produce a city just described—over a hundred millions of years ago? Termites.

Termites have a division of labor. Several million photophobic insects have special jobs. Workers, with no wings to cool themselves, build the tower. The tower has microclimates and air-conditioning due to the tower effect or chimney effect—hot air rises and is replaced with cool air from the subterranean levels. Mounds are created particle by particle, over years, and get to be 10-12 feet high, but may last centuries. They can reach 120 feet deep into the soil. The principle cost is the tower. There are no other costs associated with cooling. There can be interior farming of fungus, like leaf cutter ants. The fungus grows without weeds or diseases. Termite mounds in west Africa have cooling fins. Some mounds use mud, or wood, some use excrement. Termites also make roads on tree trunks and on the ground; some of these are covered, where different species come together they make traffic circles. Termites develop domestication and partnerships (with flagellates to digest cellulose, and fungus). Termites do not consciously design and plan their city mounds. The structure is assembled by many millions of workers following simple individual rules.

Human cities have many similarities. The development of cities from encampments and villages to cities is like that of tidal lagoons, where groups of algae ended with communities. An unorganized, homogenous ensemble transforms to an organized structure that cycles energy, materials, and information, and provides benefits to its residents. Human beings have characteristics, however, that make their cities more complex, diverse and mobile. We can sometimes design cities consciously.

The city is a consolidated area, a permanent part of the landscape, with stable home sites and larger, permanent houses. There are impressive public buildings and monuments that can lead to civic pride and use. The city offered opportunities for specialization, for choosing a mate from a wider pool of candidates, for excitement and stimulation, and for wealth. The city has a critical mass for inspiration and invention (in art and science). Of course, the city offered better protection from invading groups and it offered a more stable food supply.

Why should termites or human beings live in a city? To band together to survive droughts? To trade in one place? To worship together? To promote specialization? To increase excitement and inspiration? To defend wealth? To change the planet? Because it's genetic? Because it's inevitable? Why continue to have cities, now that technology can provide the intensification in rural communities, or urban problems seem insurmountable?

With cities come unanticipated or unwanted effects, sometimes erroneously called 'side-effects,' although they are equivalent to the intended main-effects. The new city ecosystem, that replaced a native ecosystem, is greatly simplified; there are fewer plant and animal species, and lower diversity leading to homogenization, especially when cosmopolitan or favorite species are present. Plant productivity declines, due to fewer plants and lower rates of photosynthesis. Connectivity to the surrounding matrix is lowered—the matrix itself is minimized by increased patches and corridors, such as roads, which perforate the landscape and also act as barriers to plant and animal movement. The number of patches increases, which decreases interior species and increases edge species, such as squirrels, raccoons and coyotes. Native patches and corridors, such as woodlots or streams, are reduced or eliminated. The agriculture around cities is more homogenous, with decreased fallow areas. Stream corridors are degraded or destroyed, making a city more vulnerable to floods. Sewer systems route more water faster to an ultimate sink, lakes or the ocean. Household wastes affect the landscape directly, if they are buried or burned. Nutrient and mineral cycles can be disrupted. Local weather can be disturbed. And, the environmental can be degraded.

Cities change their own microclimate, with heat islands and dust domes. The masses of materials used to build the city are used inefficiently. The energy to run the city is greatly concentrated—thousands of times more than in a native ecosystem—and the energy is used inefficiently. Unless the infrastructure, from buildings and power lines to sewers and roads, is kept up, it can decay and cause greater inefficiencies and problems. A budget crisis, from loss of tax revenue or improper use of funds, can affect the infrastructure and most amenities of a city. The disruption of supplies, due to social and political actions, such strikes or attacks, can lead to other problems, from displacement to disease. Even in small, well-managed cities, there is an increase in violence, sickness, drug use, crime, and impoverishment, all of which require some response from the political structure of a city. Ian McHarg noted that with crowding, there was an increase in mental and physicals illness from stress.

The human system in the city, with imported food and water, has a smaller system of carnivore predators, such as fleas, lice and bedbugs, and decomposers, such as bacteria, fungi and gulls. The surrounding native system of primary productivity is based on depauperate system with few trees and layers and a simple food chain of rats, birds and squirrels.

Living in a city also had disadvantages. It first meant one had a smaller living space, lower standards of living, and a less varied diet. There was a greater chance of disease, nutritional deficiencies, and crime. The larger population meant an increase in competition and possibly a decrease in personal rewards. Public art styles could be limited. Due to the large populations, cities tended to ecologically degrade the surrounding areas. Although cities were fine adaptations to the climatic and environmental changes as the ice age was ending, they were vulnerable to larger groups of enemies and to longer environmental problems such as long droughts over ten years, or other series of changes.

6.3.3. *The City as an Ecosystem*

The city was an adaptive exploitation of shifting environments. It was an adaptation to an ecological niche and a cultural niche. At first, cities allowed for the coexistence of hunters and herders with the local farmers and residents of the city. The city is exploitation of a geographic site, which has a multilevel history from geology to plants and humans. The structure of a city might be like a cell, a specialized structure with a transmissible memory in the nucleus. Or like a sponge; the city cannot use the sun to get energy but must use surrounding environment (plants) and other organisms in the water. Sponges must circulate food brought in, using energy from that food. A city has own metabolism, that is, a network of circulatory structures used for exchanges. Water and wood (energy) are carried by channels to cells of organism (homes in this case). Channels also carry wastes.

As an ecosystem, a city has fewer plant and animal species. Agriculture, by taking over an ecosystem, allowed a short-term increase in biodiversity followed by a long-term decrease. To increase control, new tools such as hoes and plows were developed; the fields themselves were engineered with added irrigation systems. Gradually other ecosystems were taken over. Land use became a formal ownership to reflect the investment in all of the above. Land ownership was a logical step with permanence, as individuals dedicated themselves to a relatively small area. The technology of tools advanced, as did the engineering of fields and water systems.

Many factors influence its balance with its environment. Water flow is a factor affecting the landscape. Household wastes are another factor. A network of corridors perforate the landscape; the number of small patches increases, and there is a reduction in other kinds of patches and corridors. Flows include energy, information, people, materials, and pollution. The net productivity of the city ecosystem is negative, due to massive imports of food and energy.

The size of a city can grow, apparently without limit. During the mass migrations from 1800 to 1991, urban population in developed countries rose from five percent to seventy-three percent. In a mass migration in less-developed countries, from 1940 to 2004, the city population rose from three percent to over fifty percent. As cities increase in size, there is less flexibility for change. Land use planning and design becomes more important.

This size expansion has caused problems, effects, and side effects—that is, main effects that are unwanted or unanticipated. Villages lower connectivity to the landscape by increasing patches and corridors. Agriculture gets more homogenous; fallow areas decrease. Stream corridors are destroyed by environmental degradation. Connectivity is lowered, the matrix is minimalized. The nutrient mineral cycles are disturbed. The atmosphere is disrupted, resulting in drought and storms. Microclimates change, with heat islands and dust domes. There is lower photosynthesis and productivity, with lower diversity leading to homogenization (with cosmopolitan species) and inefficiency of use of energy and materials, and decaying infrastructure (roads, sewers, buildings, houses).

Urban ecosystems and agroecosystems, however, are less resilient than natural ones, due to the constant expenditure of human and fossil energy to maintain them. Cities need the environment for resources, food and water. People in cities tend to organize the environment by controlling markets and transportation on which the agricultural systems depend. Cities also produce large quantities of waste that have to be absorbed. Cities pollute air and modify climate. They are heat traps from the absorption and production of heat.

6.3.4. *The City as Advantageous Cultural System*

The advantages of urbanization included consolidated areas and stable home sites, with larger, permanent houses. Public buildings and monuments became more impressive. This formed a critical mass for inspiration and invention, including art as well. Measuring and writing, inventories and commercial dealings followed. There were advantages to social changes as well. People could expect uniform laws and protection from theft or violence. The stratification provided stability and identity with place or specializations. There was a greater diversity of jobs and places than ever before.

This lead to many personal advantages. People had more property. It was not necessary to make everything for one's self, or know how to. One could trade for needs or luxury items. There was a new kind of leisure time, for doing nothing, as opposed to joining societies and telling stories. Ale was on tap for the entire year, to permit voluntary dizziness as a recreation; one no longer had to wait for trees to provide fermenting berries.

But, these advantages led to disadvantages. A worker could be conscripted to work on public projects or to serve in the army. Workers had to pay taxes in the form of percentages of food or wealth. Social stratification could deny one access to luxuries and other things, and the stratification was not always fair. Bureaucrats, as well as medical workers or farmers, might have higher or lower status at different times. Power was also distributed differentially in society. In the larger population of the city, people were more vulnerable to new diseases and to violence.

Furthermore, more work was required, especially to contribute to public projects and taxes. There was less overall leisure time. Trade for things required trust, which was a more difficult commodity between strangers. Records had to be kept of all the new kinds of transactions. Extra property had to be stored somewhere and protected. The distribution of luxuries and necessities was skewed, so some people had much more than others, in terms of things and respect.

There was a limit to public styles of art, ecological degradation of surrounding areas, and increased vulnerability to collapse. There seem to be limits to personal space and levels of tolerance to human intensification, also. Urban intensification leads to the question: Is there a limit to human numbers? Perhaps space, but is there a psychological limit? People in cities seem to do well with high-contact, high-proximity living. What happens when people are crowded or feel crowded? Physical complaints, emotional complaints, sexual dysfunction, or feelings of fear, seem to be expressed often. There may be limits of crowding. Are there social limits, in terms of the number of people one can tolerate? We may have requirements for personal space, home space, and wild space. Psychological limits may be the basis for some of the great failures of human life, for instance, the "failure of perception." We cannot see slow change or anticipate it. No one really seems to see the incredible interdependence of humanity and nature, of diversity and success. We do not seem to be able to see others as feeling human beings.

6.3.5. *Intensification & Civilization*

Many phenomena interacted during the Neolithic Revolution. Not simply agriculture or urbanization, but profound economic and social shifts occurred. Permanent settlement resulted in more permanent buildings, as well as in massive buildings and monuments, fortifications and religious centers. This led to an increased infrastructure to supply water, access, transportation and waste. Sedentation and surplus allowed larger populations and increased fertility. The subsequent trade in foods required better paths and transportation. Food storage and trade become concentrated in cities.

There were dramatic economic shifts that included trade, craft specialization, professional art, record-keeping, writing, direct engineering (pottery), and standardization. Personal property increased dramatically; one no longer needed to carry everything one owned. Records were needed to supplement the memories of individuals, since many individuals were required to keep track of stores, trade and rations. This required specializations in new trades, from potters to smiths and artists. Managers were required for recruit labor for fields and hydraulic engineering. Labor shortages on public projects required recruitment of labor from within the city or from outlying areas. Animal labor was applied to some activities.

Social and political changes were equally dramatic. With the distribution of power and materials, a political religious elite arose. And, to protect that, there was a rise of military organization, which allowed royalty and kings to replace or diminish religious leaders. Public ideologies replaced tribal or personal beliefs. Social hierarchies became more pronounced, and wealth was redistributed according to rank in them. Warfare became necessary for protection, or to acquire needed resources, or to control the social hierarchy.

Social political changes include the rise of political religious elite, then the rise of military organization, then the rise of royalty and kings. Public ideologies followed, as did social hierarchies and warfare. Increases in personal property paralleled rationing and the redistribution of wealth.

6.3.6. *Discussion of Cities & Civilization: Ideal or Trap*

Is the city a human ideal? An environmental ideal? It can offer ideal environments, as well as different kinds of physical environments, from streets, and squares, to religious monuments and parks. What is it about a city that commands awe? Increasing populations can lead to intensification of production, through labor or mechanization. Is the city a trigger for intensification? Interdependence becomes overconnected and then a trap. First cities were of bricks and concrete. John Thackera thinks that cities are held together now by human attention spans, which may be more gaslike than solid. The technology that dominates attention, such as the wireless infrastructure, just adds a new layer, as people still live in brickworks. Certainly, the city has always been an incubator of new forms and ideas. And, the medium for cultural transmission has been ideas, more than genes or bodies. And, there may even be standard units of cultural transmission by imitation, such as memes (Richard Dawkin's phrase for the unit of transmission; see section 7.8 for a more detailed discussion), of which cities, agriculture, and fashions are examples.

How did cities start? Was a town formed by neighboring villages? Thucydides used the word 'synoecismus' to refer to the union of several towns and villages under one capital city. Was the city a result of technology—The wheel, cart, or metallurgy? According to

Rod Brooks, cities started from a subsumption architecture of organization, where higher levels of behavior subsume the roles of lower levels to take control (also called bottom-up organization). So, people start with villages, and get the kinks worked out; who lives where? Who does what? This fits with the idea that cities were adaptations to permanent siting, slow overpopulation, and changing environmental conditions.

When the villages are working, you can make a few towns. Coordinate the logistics of streets, sewers, water, lights, and law. When the towns are successful and reliable, you can make a capital city, adding a layer of law, taxes, schools, maybe trading and heroic institutions. The cities can be combined into a state or empire, which has new responsibilities, such as taxes and international affairs and defense. The empire subsumes the other levels, but lets them operate independently. Of course, there are advantages in the group. And there are further emergent structures. Especially international trade and forms of education. Of course, at some point, the cities are no longer adaptive to the environment.

How do cities end? Abandonment? Collapse? If the top level collapses, the others can continue to function. This is what happens with certain kinds of collapse. How does civilization steer? Does it push or pull? Pushing can result in a backlash or revolt. What is best for the individual is not always best for the species. What is best for the person is not always best for society.

Is it possible to have cities without states or vice versa? A city is an adaptation to keep economic surplus in one place. A state is a political unit governed by a central authority. Like a city, a state has to delineate rights and responsibilities for citizens, regulate social relations, e.g., marriage and family, support a religion or ideology, integrate networks of communication and transportation, control redistribution, control punishment, and have a monopoly of police, military forces, and weapons.

How is size important? Is it centrality important? Ancient big cities included Uruk (10,000 to 40,000) and Harrappa (20,000-25,000). Mohenjo-daro of the Indus Valley Civilization was one of the largest, with an estimated population of 41,250. Later, Nineveh and Carthage each had 700,000. Alexandria was large (~400,000 by 32 PE). Rome had an estimated population of 1 million by 5 BPE. Baghdad exceeded a population of one million by the 8th century PE. The largest cities now include Tokyo (28,025,000), Mexico City (18,131,000), Mumbai (18,042,000), Sáo Paulo (17, 711,000), New York City (16,626,000), Shanghai (14,173,000), and Lagos, Nigeria (13,488,000).

The best cities are no longer the largest. By 2004, the best are considered Vancouver, Copenhagen, Zurich, which are usually less than 2 million. For a long time cities required larger numbers of people to be intense enough for stimulation and creativity. But, now new technology provides the stimulation and could allow cities to be significantly smaller, perhaps as small as 10 or 20 thousand. A growing population creates environmental resistance to itself, in the form of reduction in the reproduction rate as the population approaches carrying capacity. Due to various time lags, e.g., to increase when conditions favor or to react to unfavorable crowding, the density can overshoot the capacity. Human population is controlled to some extent by self-crowding. The overshoot has to be on a local scale, never on a global scale. The Russian geochemist S. Vernadsky concluded that the property of maximum expansion is inherent in living matter as it is for gas expansion or heat distribution (and ideas in cities?). The pressure of life can be measured in terms of velocity. For cities, immigration can increase fast and cause overshoot and subsequent oscillations.

But, what if all cities were to overshoot simultaneously?

Is there a trend to larger cities? Should it be continued? Should arcologies replace unplanned cities? What about limits or nesting into optimum size groups? The degree of aggregation, as well as overall density, which results in optimum population growth and survival, varies with species and conditions (this is Allee's Principle in ecology); undercrowding, as well as overcrowding may be limiting. Aggregation can enhance group survival. Fish in a school may tolerate higher doses of poison than individuals. Bees can create more heat to survive than individuals. Applied to humans in cities, aggregation is beneficial, up to a point. But, bee or termite colonies can get too big.

How important is connectivity? Cities are unavoidably entangled in global nets, now. Cities used to be limited by the local carrying capacity. With global nets, self-correcting feedback can take too long. Localization makes feedback visible and more immediate. It could make more self-reliant cities.

How can we look at humanity? First we were wolves, catching animals and eating them. For thirty thousand years. Then we were cows, standing in places eating grasses, for ten thousand years. Now we are termites, swarming over everything in furious dances of labor and status, for the past five thousand years.

Are we urban by nature? Have we changed from hunting to urbaning? Of course, we may be preadapted for cities. We are clever social animals. We prefer edge habitat so as to move between other habitats. Urbanization is a characteristic of an edge species. Civilization produces edges that people like. Wilderness is fragmented into islands and patches. So, there is no more deepness, no more interior to wilderness. Then, there are more edge species: Raccoons, coyotes, crows, and rats. Are humans edge species?

We are foragers and predators. What are the needs in human nature that a city answers? Perhaps the city is what wilderness was, according to E. Eisenberg, a place of passage, a place to be brave and test yourself. Humans have always worked to abstract their specialness. The city seems to be another myth of separateness and independence from nature. The city is the laboratory of human creativity, kept apart from the mother of nature. Lewis Mumford saw city life as a compromise between the hunting stage and the farming stage. The female principle of home is wed to the male principle of predation. Perhaps the city is a throwback to hunting. People are more likely to wander, less attached to a place.

Are cities unnatural? Is urban living a preadaptation? We are of course social animals. We prefer edge habitat. We are hunters and foragers. Why is the city growing everywhere, especially in Africa, South America and Asia, while parts of some cities are being abandoned.

Are cities declining? Certainly, there has been a decline in the quality of living spaces, irrespective of energy or resource use. Some cities have declined in population as areas of a city are deserted. The decline of cities due to the replacement of creative architecture by architecture that lacks organic order and connection, may be due to a declining interest in planning, as a result of economic values, suggests Eliel Saarinen.

Are cities the ultimate creation of civilization where people can enjoy culture free from want or physical extremes? Or, are cities a gross alteration of nature that destroys human life and dignity—a gross ecological error. As long as cities grow without negative feedback, the second will occur. When ecology helps the city ecosystem fit in the surrounding ones, then the achievement is worthwhile. The city depends on its environment.

6.4. *Global Design Factors: Civilization & Industrialization*

By the end of the 1200s, the Mongols brought China into direct trade with Europe, and they developed paper money to make the trade easier. Their empire had its own transcontinental highway, as well as sea trade routes with the Chinese. At that time, the European cities were being changed by guilds, trade and gothic architecture. Colleges were beginning to replace monasteries as centers of knowledge; local languages were replacing Latin. By the mid-1300s, there was an economic downturn in Europe and China, which was related to plagues across Asia and then Europe. The regions were linked if not interdependent enough to influence each other. After a series of local disasters and political changes, China unplugged from the trade system. Did this, or population growth, delay a Chinese industrial revolution? China had many advancements around 1000 BC: Papermaking, moveable type printing, paper-money, guns, gun powder, compasses, underwater mining, umbrellas, hot-air balloons, rockets, and laws of motion. But, there was no shift to industrialization.

Then European commerce began to flow past local boundaries. But, the commerce had to be protected from pirates, so laws and agreements were needed. There was a slow transition to regional commerce. Specialization went beyond nations. The Dutch East India Company followed economic goals rather than political ones, although it was closely linked to political and may have become a tool for political objectives.

In the 1300s in Italy, most cities did not know how many people lived in them. With the plague, people began to know by counting dead bodies. In the 1300s, Florence had a large industrial group of people. A third of the population was employed by the textile industry, as beaters, washers, carders, combers and laborers. Another third was classified as paupers. Companies in Italy started banks, so that there was capital for long-distance trade and development. Did changes in class and equity lead to first private gardens, then public gardens, to areas walled off from others? In the 1400s, the printing press (1455) was part of another transformation that included the Renaissance (1470), the formation of the Spanish nation (1492), and global exploration (1492-1550s).

The English encouraged trade to increase wealth. This led to Mercantilism, government regulation of the economy to ensure growth by granting monopolies. And, that led to the accumulation of capital from mercantilism. Capital required more energy and new technologies. Capitalism changed production (goods are privately owned yet there is separation of people from land and resources, e.g., the 1650 Atlantic triangle of slaves, sugar, and cloth. Other factors helped England keep a lead over France or other countries: Lower internal tariffs, weakened guilds, intercourse between aristocracy and middle class, relatively less conflict and war (isolation of the island), and a geography conducive to commerce (access to the ocean).

The impulse for better sources of energy, and the challenges from using coal, led to many new inventions, such as the water pump and steam engine. To produce these things on a larger scale required capital investment, special designs, regulated labor, free materials, directional flow, and sufficient environmental services for renewal. These inventions also transformed society, along with the modern university in Berlin, the institution of science, and the American Revolution.

Table 640-2. Agroecological Sequences Pointing to Industrialization (Read down)

Fewer species	*Settlement*	Human labor	*Deforestation*
Control of land	*Population increase*	Tools/technology	*Erosion*
Competition	*Specialization*	Animal labor	*Water pollution*
Conflict	*Big religion*	Machine labor	*Salinization*
War against humans	*Big trade*	Slave labor	*Soil loss, wood scarcity*
War against nature	*Urbanization*	Energy slaves	*Species losses*

Early cultures obtained energy from food or from a few domestic animals. Cultures practicing intensive agriculture were also limited by energy, but were able to obtain more food by mixed crops on engineered terraces. With the advent of machines, more energy, from wood or coal, was required. And, with the change of scale in industrial production, more concentrated fossil fuels were found and consumed. Another watershed of change occurred in the 1900s, with the ascendance of Japan and the United States, the invention of the computer, and the US GI Bill of Rights, which made a university education available to many more people. Some countries, such as the USA and Japan, were able to use double the energy of other nations.

Industrialization changed many cultures. The culture of consumption has developed from the industrial large-scale production of commodities. It is the psychological switch from being to having. The packages and advertising become part of the commodity. Consumption has private and public aspects. As the production of art became commoditized, the mass production of entertainment by a culture industry, it also became a tool for pacification of a relatively poor population conditioned to 'having' the surplus products of capitalism dumped on them. People, however, regard consumption as an 'empowering' act. And, of course, they personalize things.

Humanity is calculated by Norman Myers and others to be using over 40% of the ecosystem productivity for the entire earth. Later calculations, by Stuart Pimm and others, indicate over 55 percent. Humanity influences virtually every ecosystem to some extent, destroying some, interfering directly with many, and exposing the rest to exotic chemicals and materials. Species normally use a percentage of system productivity without disrupting the processes of production. The human species interferes with the processes.

Based on limited scientific and cultural perspectives, humanity fails to value those beings and communities for which no use is known. But, as Aldo Leopold (1949) notes, the majority of the beings in nature have no human uses. Even some ecologists cannot think of uses for many large birds and mammals. The real danger is genetic loss, which is grossly underestimated. As wild areas grow smaller, even wild species interbreed. As species are lost, the ecosystems become simpler or start to collapse. Our perspectives seem to be limited by metaphors, and metaphors can drive the direction of activities. Possibly, a post-industrial metaphor might be more useful in designing changes on a global scale.

6.4.1. *Industrial Growth*

Mesarovic and Pestel stated that "the issue for the economy is not to grow or not to grow; it is how to grow, and for what purpose." They claim that if a workable world system is to emerge, it must be after the establishment of an organic pattern of growth. Due care is devoted to describing such a pattern and contrasting it with other, tragically inapplicable patterns of growth. Their treatment of the world system itself was regionalized and multileveled. They recommend that the establishment of organic growth was necessary with no need for special no-growth policies for populations or economies. They assume that further industrial growth will continue, that economic growth is good, and that this growth solves human problems as long as it is organic. Exponential growth is said to be bad, and organic growth is said to be good. In fact, although organic growth is better, there is little difference during a world crisis; both reach asymptotes of suffering. One need only regard the population crashes of lemmings and others to see how organic growth can go wrong.

Economics became enamored of growth during a critical time in history. Rapid European expansion occurred at rates rarely exceeding a growth of one percent per year, and with unparalleled opportunities for expansion into sparsely settled areas, such as North America, Australia, South America, and South Africa. Many cultures now do not have these opportunities; the continents are claimed, and violent population growth may have wrecked their hope for development by ravaging every resource.

The economy has been growing almost constantly since it has been studied. We have been trying to force it to grow, rather than let it stabilize or contract. Even if it stopped growing, the economy could still develop. Mesarovic and Pestel, as well as many others, confuse growth with development. J.S. Mill did not. In the organic world, growth is healthy only when the rate of change is decelerative in the long run; cancer and population are constant or accelerative. Mesarovic and Pestle fail to realize that continued economic growth in any form is a threat to the stability of the biosphere.

6.4.2. *Industrial Intensification*

There was an intensification of tool-making in the past 3000 years. Population increased and new areas were exploited. The agricultural revolution was a technological revolution. The industrial revolution, by definition, was a technological revolution, which resulted ultimately in humans being replaced by machines. Only the Luddites faced this limitation, unsuccessfully. Human labor is increasingly dispensable. Industrial culture confuses mechanical with personal power. According to W. I. Thompson, industrialization is really an intensification of civilization.

Table 642-1. Important Cultural Revolutions

Date	*Development*	*Effects*
12000-3000 BC	Domestication	Animal things & labor, weaving, animal diseases
11000-2000 BC	Agriculturization	Sedentization specialization, accumulation
5500-0 BC	Urbanization	Cities, architecture, trade, metallurgy, writing, armies, calendars, disease concentration
500 BC-300 AD	Cosmologization Thought systems	Religion, ethics
500-1500 AD	Mechanization Science / Banking	Machines, wind/water power, literacy
1700-1800 AD	Industrialization	Steam power, assembly rules

Industrialization is really an intensification of civilization, which is still an ektropic process. In each case of cultural absorption, there was an attendant process of miniaturization. The forest was miniaturized in clumps of trees; animals were miniaturized in artistic image; time on a lunar tally stick; plants in a garden; women in a household;

nature by culture in 1800, under the glass roof of the Crystal Palace; and now by the new consciousness surrounding the old. What is intensity?

Intensification brings cultures together faster. Conversion increases, technology and industrialization increase. Intensification is a gigatrend that could lead to violence. For instance, intensification leads to urban living, which increases creativity, as well as some kinds of illness, which leads to physical weakness, which leads to changes in population, which leads to intensification of resource use, which leads to the potential for conflict, which can lead to dislocation and violence.

Urbanization concentrates people in a smaller area. Does that leave more room for wilderness? Just squeezing in does not mean better conditions. There has to be enough energy, sanitation, water and other things. In cities, industrialization, in the form of increased wealth, can bring about a demographic transition. As health and wealth increase, people have fewer children. What is the actual trigger? The desire or opportunity for self-actualization after reproducing heirs?

The industrialization process has led to a dramatic extension of cities and buildings, as well as growing extents of machines and increases in energy use. Furthermore, people, property and machines are much more mobile, which requires more pathways and more energy. This has increased the impacts and pressures on ecosystem productivities. Design has not been able to effectively deal with this kind of runaway process.

6.4.3. *Problems of Industrial Civilization*

Our modern problems reflect an unbalanced and immature image of the earth, the earth as a machine, for instance. People sometimes constructed their worlds from preconceived notions, and many of these worlds did not survive, because they could not adapt to the environment. Our modern cultures are defective for this reason. The modern attitude toward nature as a resource has resulted in pollution and depletion of resources. It has allowed humans to overpopulate their habitats. Recent productivity studies indicate that the optimum sustainable human population is far below the current world population.

Even worse, decisions regarding resources are still made exclusively on short-term economic rationalizations and lead to material shortages and environmental degradation. The crises of environmental degradations are crises of cultures. Monocultures of the industrial kind lead to 'dedifferentiation,' that is, the decomposition and destabilization of complex structures. A species or culture that destabilizes its ecosystem through misbehavior risks its own extinction. Human beings make changes to systems that endanger themselves.

Industrial society is constantly mobilized for emergencies, in the battles against, noneducation, poverty, diseases, and terrorism. Industrial development has never been nonviolent or respectful to people. Industrial production has its own unique style and scale.

Is the industrial city a jungle? Herbert Spencer saw the world as a jungle, where life was nasty, brutish and short. Spencer coined the phrase 'survival of the fitter'. He based it on the competition in industry, where entrepreneurs fought for money and power. Spencer thought the weak should be eliminated, so he opposed poor laws, charity, sanitation, education, clean water, pure food, etc. Rioting is lashing out at the cage, when people cannot leave cities that do not meet their needs.

One problem in industrial culture is the production of flatscapes. Our attempts at social improvements have proceeded without order, without sufficient insight and perspective, without sufficient confidence, without a comprehensive plan, and without a great dream. Our politics has been corrupted by special interests. The structure of our civilization comes from anonymous builders and mediocre designers, minimal engineers and rapacious financiers. We work within the rules as they have been for decades, rejecting any alternatives as too utopian. The rules themselves have been shaped by centuries of social metaphors and utopian ideals. They do not exist in place, either a human place or an ultrahuman place. They are designed to be no-place, without weeds, storms, or hard ground. Because they are nowhere, flatscapes lack any reference point.

Speed, so beloved by industrial cultures, can be a problem in archaic cultures. The Kelantese people in the Malay consider haste a breach of etiquette and ethics; slowness is important. George Beard, in *American Nervousness*, coined the word 'neurasthenia,' to describe mental illness caused by the increased tempo of life.

Information pervades society, but it is for an information market. Between uncoordinated information and the acceleration of activity, the social fabric gets fragmented. Projects are fragments of work. Industrial information work is bad for physical and psychological health, from bad physical conditions, high pressure, and low control. The information economy can lead to disconnection, loss of identity, and loneliness.

Physical laws create patterns in space, as well as in human history. There are simple kinds of patterns. A linear pattern tends to be interpreted as progress or regress. This is the dominant concept of modern history, unending progress. Despite the chaos of individual events, there seems to be a direction of gradual improvement. Marquis de Condorcet suggested that civilization will always move in a desirable direction (1795). People become frustrated when it does not.

6.4.4. *Possibilities for Industrial Civilization*

Perception is a large part of patterns. And, we perceive the direction as being towards more complexity and more integration until we have a global society, coordinated on several levels, within a more complex biosphere. The local should maintain its diversity, and the local will be integrated into new global forms. Most approaches to design and the global are dualistic (wilderness-industry) or triune (wilderness-design-industry). A better approach would show how these interweave so extensively it is hard to just use boxes or circles. The same is true for humanity and nature or science and action ethics.

The cosmologies of archaic cultures have been limited to historical places and by human perception, tradition, and technology. Small cultures have built-in checks; furthermore, their cultural definition of good helps to maintain balance between other species and the use of ecosystem productivities. Historical smallness, even lacking natural resources, has not been an obstacle to wealth for many countries, for instance, the sovereign German states of Hamburg or Bavaria. The merits of urbanization do not require a large population. Local concentrations of artists, philosophers, and scientists are capable of creating a distinct civilization. Cities fifty times as large as classical Athens or Florence have not been fifty times as creative.

6.5. *Global Problems: Conversion & Interference*

We exploit resources, plants and animals too fast for natural renewal. We exploit minerals and fossil fuels too fast for the wastes to be integrated in cycles. We create novel substances and use them too fast for the substances to be integrated in natural cycles. There is a conversion of planet from wild to urban ecosystems. The global system used to be wild with wild humans, but is now going towards one domestic urban system.

6.5.1. *Cultural Conversion of Places*

Agriculture converts ecosystems into simplified ecosystems that have to be maintained with large amounts of human labor to keep the system from diversifying and maturing.

6.5.1.1. Conversion of Land to Fields

In North America, which held the largest extent of forests on earth, forests were considered wilderness, to be tamed and converted to agriculture—although no one really expected the conversion to be so rapid or dramatic. Traditional agriculture proceeds by substituting selected domesticates for wild species in equivalent niches, or by manipulation of the ecosystem, whereas modern agriculture replaces the biota, or transforms the ecosystem into an artificial system. Margalef pointed out that all agricultural systems are laid out for low maturity, to increase production per unit. Traditional agriculture changed the pattern of ecosystems. Modern agriculture simplified those systems dramatically. From the perspective of a balloon or airplane, agricultural fields are easily identified, as circles, squares, rectangles or parallelograms, with a more monotone color and texture than surrounding wild areas.

To achieve even greater efficiency, we have increased the speed of our activities, converting materials and cultures into new designs without consideration of the meaning of, or need for, efficiency. The speed of our economy is too great for many cultures to adjust to; and the thoughtless transformation of cultures may result in great, irreversible mistakes. The speed of our conversion of wild habitats to domesticated lands is too great for many species to adapt to.

Although our behavior may not be qualitatively different from our remote ancestors and the worst pathologies of wild animals, which usually result from miscommunications under certain circumstances, it is quantitatively different. More and more activities affect larger and larger parts of the planet; many problems have global effects now.

In tropical areas in the past, people practiced land use that permitted the vegetation to maintain itself despite human exploitation and the constraints of soil and climate. With population and production pressures, tropical areas everywhere are rapidly being exploited. The consequences may be disastrous.

Size is almost always the greatest threat. In spite of the fact that many Buddhists planted trees regularly, the Buddhist traditions of wooden temples and funeral fires contributed to the denuding of large areas of forest. It is our misfortune to live at a time when the accumulated effects of the conversion of nature for human ends are becoming obvious and cutting into the survival potentials of many other species.

Modern agriculture replaces the biota, or transforms the ecosystem into an artificial system. The application of modern agricultural techniques in tropical areas disregards the local realities, and is socially and ecologically disastrous. Traditional ways have operated successfully for thousands of years, although not without serious problems of their own. But, these problems may be overcome, unlike industrial problems, which have fundamental flaws and cause rapid conversion. We exploit resources, plants and animals too fast for natural renewal. We exploit minerals and fossil fuels too fast for the wastes to be integrated in cycles. We create novel substances and use them too fast for the substances to be integrated in natural cycles.

6.5.1.2. Conversion of Land to Cities

There is a conversion of planet from wild to urban ecosystems. Cities convert ecosystems into cityscapes, a special artificial ecosystem with fewer plant and animal species, disrupted water flow as factor, household wastes as factor, a network of corridors that perforate landscape and cut off wild flows, an increase in the number of small patches, and a reduction in other kinds of patches and corridors, including woodlots and streams. Flows include energy, materials, information, people, and pollution.

In a converted ecosystem, there are three imposed ecosystems with minor linkages: (1) a natural system of primary productivity based on depauperate system with few trees and layers, a simple trophic structure of birds, squirrels; (2) a human system, with imported food and water, smaller system of carnivore predators, such as fleas, lice, and bedbugs, and decomposers, such as bacteria, fungi, and gulls; and (3) a distant support systems for food, materials, and energy, but also smaller emotional support system of pets, such as cats, canaries, and fish.

The daily inputs for city, in terms of sunlight, atmospheric deposits, water, food, fuel, manufactured goods, new buildings, roads, and infrastructural support, are tremendous. The daily outputs, including heat, water, sewage, solid waste, and pollutants, are likewise tremendous, although they are skewed to unusable wastes, including heat. Inputs and outputs involve a much larger surrounding area in urban functions.

These extra inputs and outputs have effects, side effects, or rather main effects that are unwanted or unanticipated. By thinking in terms of side-effects, we have been unable to manage the side-effects of our massive technologies. They are in fact unmanageable in a mindset that thinks of them as side-effects. A holistic rationality or neologic might be better to use, where everything is an equal effect, and we manage out technology to have all the effects. Land is taken over and covered, but idle land may total 28 percent of an urban area.

Villages lower connectivity to the landscape by increasing patches and corridors. Agriculture gets more homogenous, decreased fallow areas. Stream corridors are destroyed, environmental degradation. Connectivity is lowered, matrix is minimized. And, these things happen: Disturbance of nutrient mineral cycles; disruption of atmosphere, drought, storms; changed microclimate, with heat islands and dust domes; lower photosynthetic productivity; lower diversity leading to homogenization, with cosmopolitan species; inefficiency of use of energy and materials; decaying infrastructure, roads, sewers, buildings, and houses; disruption of supplies, due to social and political actions, e.g., strikes, breakdowns, attacks. Budget crisis from loss of tax revenue; increase in violence, sickness, drug use, crime, and impoverishment; and, increase in mental and physicals illness from stress. It is almost as though human beings are major agents in desertifying the planet.

6.5.1.3. Industry & the Artificial

Artificially created environments are cultural environments. Nature thus acquires characteristics from agriculture and social institutions as well as from geology and climate. The practices of environmental conservation must be complemented by careful policies of environmental creation. Societies have images of the future that influence their policies, and those images can be shaped by knowledge and persuasion. Human beings can and have created new ecological values by collaborating with, or following the laws of, nature.

Many ecosystems in the temperate zone are artificial. The tame character of ecosystems in England, for instance, results from human intervention. English parks are based on an imperfect understanding of natural systems, and on their potentialities, as well as on a series of happy accidents. Much native vegetation is a social artifact. In Scotland, for instance, forest cover was reduced from 55% of the total area to 5% by primitive stock-keeping and agriculture; moors decreased by half, but meads increased eight-fold. The soil was more fragile, so the accidents were not happy and the forests did not grow back. Some forest plantations have been started. Rene Dubos mentioned Kentucky, Western Europe and Japan as examples of radical conversion from the native fauna without disorganization.

6.5.2. *Humanity as a Global Agent of Change in History*

What are the forces of history? Certainly, we should include geological processes, as well as solar system effects, such as the output of the sun or meteorites. Certainly, we should include the environment, such as climate and the distribution of resources. Especially important are human impacts on ecosystems, such as deforestation, identified by John Perlin as very important, perhaps the reason for the decline of the Hittites and Babylonians. Another impact is desertification, according to Uwe George and others. Disease patterns, according to W. H. McNeill, are crucial. To disease, or germs, Jared Diamond adds steel and guns as forces that have shaped human history and societies. Then, there is simply luck, the position of a culture in the stochastic chaos of nature.

By their activities, human beings change the places they live. Much of the change is easily incorporated in the cycles of renewability of the ecosystems. However, humans often change the directions of such systems by simplifying or degrading the systems. In this case humans act as agents of interference.

6.5.2.1. Humanity as Biological Agents

Humans have had a great impact on nature, and should be considered themselves as a force of nature and history. One could consider humans as special agents. One analogy of humans as special agents is as a parasite: A consumer feeding on another living organism, usually inside, drawing nourishment and weakening the host. States acted like macroparasites, according to William McNeill, but becoming less violent or unpredictable over time, as they adjusted to their host populations.

As crowding increases competition, there is more pressure on remaining reserves. The system parasitizes humanity and nature. Humanity becomes an autoparasite, a new pseudo-species. Technology enlarges the number of niches for us; tools fit humans to different habitats, displacing other species. We steal from animals and plants, from the earth, from our own descendants. Hobbes foresaw this war of each against all. The systematic destruction of human beings and animals is not an isolated peculiarity. A fat parasite often kills it host and then dies itself. Perhaps, humanity is an agent of a different sort, a systems agent that encourages only positive feedback.

Perhaps human expansion is like a cancer. Alan Gregg (1955) compared the world to a living organism and the explosion in human numbers to the proliferation of cancer cells. He sketched other parallels between cancer in humans and humans' cancer-like impact on the world. Cancer cells proliferate rapidly and uncontrollably in the body; humans continue to proliferate rapidly and uncontrollably in the world. Crowded cancer cells harden into tumors; humans crowd into hardened cities. Cancer cells infiltrate and destroy adjacent normal tissues; urban sprawl devours normal open land. Malignant tumors shed cells that migrate to distant parts of the body and set up secondary tumors; humans have colonized just about every habitable part of the globe. Cancer cells lose their natural appearance and distinctive functions; humans homogenize diverse natural ecosystems into artificial monocultures. Malignant tumors excrete enzymes and other chemicals that adversely affect remote parts of the body; humans' motor vehicles, power plants, factories and farms emit toxins that pollute environments far from the point of origin.

It is not in a tumor's self-interest to steal nutrients to the point where the host starves to death, for this kills the tumor as well. Yet tumors commonly continue growing while the victim wastes away. A malignant tumor usually goes undetected until the number of cells in it has doubled at least thirty times from a single cell. The number of humans on Earth has already doubled thirty two times, reaching that mark in 1978 when world population passed 4.3 billion. It is over seven billion now. After thirty-seven to forty doublings, at which point a tumor weighs about one kilogram, the condition is usually fatal—that would be the population equivalent of 5.4 billion people. We have exceeded that; the question is if it has been fatal—large complex systems may take a long time to collapse—or if the system has more flexibility than an organic body.

The metaphor of cancer may be more appropriate than a footprint. After all, a footprint can stimulate some kinds of ecosystems, such as short grass prairie. What humanity does is transform the ground under the footprint into a fragile human system.

6.5.2.2. Humans as Ecological Agents

Every species exploits its environment to the extent that it can, with no regard to consequences. Usually, each species is checked by another, because there are so many competing for the same food, and equilibrium is maintained.

Partial knowledge and technology has allowed us to exploit our environment beyond what is desirable for us or for other species. While continued, moderate exploitation is necessary to live, massive, unbalanced exploitation is unwise. A wise use of resources would not make the world less habitable. We are part of the system and must protect its health as a whole.

By distorting the equilibrium, we have destroyed whole species and favored many others, many wild as well as domesticated. Rats and mice have been carried to all parts of the world and live in direct competition with humanity, invading our buildings for food and shelter. Crows and coyotes have also profited from their human association.

Basic principles need to be examined in relation to human ecology. Populations are maintained at optimum levels demanded by the ecosystem; this maintenance is achieved by the production of excess young and the elimination of the weaker, the least fit to survive;

mating and parenthood are denied to the young, by instinct in most species, until a territory sufficient to raise, feed and protect offspring has been acquired. If the population becomes excessive, glandular conditions activate to induce stress, which reduces population.

6.5.2.3. Humanity as a Geological or Climactic Force

No single change is exclusive to humans as a species, but they are excessive, rapid, compounded, and large-scale. There is movement of soil, but also massive erosion. There is movement of minerals, but also disruption of mineral cycles. There is the addition of novel elements into the atmosphere, but there is also a massive release of carbon.

When people use more of the earth's supplies in a certain period than can be replenished in the same period by the sun, they are eating into the natural capital. Humans have caused the extinction of hundreds of species. Rhinoceros, buffalo and crocodiles are disappearing. Getting timber for fuel and construction, clearing land for agriculture, has destroyed whole habitats. Demand for timber has been insatiable, for houses, ships, paper, and fuel. Trees have been cut from vulnerable watershed sites, with resulting floods, erosion, and diminution of rainfall and water table. Domestic animals inimical to growth were introduced, such as rabbits and goats. The introduction and maintenance of sheep in Spain, Italy and Cyprus has changed whole ecotypes.

Vegetation holds soil in place, reduces wind speed at the soil surface, and improves water absorption and transport in the soil. Erosion destroys soil and makes it difficult for plants to be reestablished. Recovery, if it occurs, may take decades. Erosion is an ecological catastrophe on a planetary scale, causing thousands of higher plant and animal species, and countless lower species, to be lost forever. This is what is planned in Brazil and South America. It is not known how massive deforestation through overgrazing, firewood collection, and timber exploitation will affect terrestrial and atmospheric systems. Perhaps we should just accept erosion. Erosion is picturesque. Cezanne's paintings of France are striking. The abstract terrain of Greece is pleasing to many.

Only in the nineteenth century beginning with G. P. Marsh, did people start to realize that humanity has done as much to change the environment as the environment has done to mold human history. Marsh, the first U.S. ambassador to Italy, was one of the first to study the role of humans in changing the face of the earth. When he visited the near east, he was shocked to find deserted cities, silted harbors and wastelands instead of flourishing civilizations. He concluded that ecological errors had led to the deterioration of agriculture in Mediterranean countries. He advocated agricultural conservation practices.

Environmental factors have shaped the course of human history to a greater extent than had been realized. The decline of Rome is a study in forest ecology. There were previous and later catastrophes in the Tigris and Euphrates valley, Greece, Khmer, Maya, Midwest United States, and the Australian outback. Many people did not change their behavior in time to solve the problems. Worse, the current civilization is global, not local; so, there will not be a migration to unaffected lands. Ecologists have not unraveled enough mysteries, so the long-term consequences of most human interaction can only be predicted generally.

6.5.3. *Interference with Places & Processes*
Humanity is exploiting nature recklessly, by converting ecosystems without paying minimal attention to their health. Many ecologists, such as Eugene Odum, have observed that complex communities have existed for thousands of years in relatively stable environments, even though these environments are characterized by regular disturbance and constant exploitation. As a result of our growing population and increased use of technology, these environments are now vulnerable to human *interference*, which is a different thing from disturbance or exploitation. Disturbance, by definition, is an event that can be caused by climate, biological entities, or other actors. Exploitation is the normal use of a resource or of a species by another species, including the human species (this ecological definition differs from a sociological definition, which means 'selfish or unethical use,' although it may suffer from negative connotations due to the latter); in fact, ecological exploitation has a rejuvenating effect on populations.

Interference is an activity that can degrade, destabilize, or destroy entire ecosystems. Interference is not a form of disturbance, exploitation, or competition; it is destruction without gain to any species. Sometimes it is caused by planetary events, such as volcanic eruptions, but in the case of human interference, it is the destruction of the structures and processes of evolution for a large-scale, one-species, short-term gain. Interference behavior that characterizes the nonecological activities of the dominant human, industrial culture. The pandominance of ecosystems by humanity is related to the biological and cultural characteristics of the species. Ignorance and indifference are identified as major reasons for continued interference.

Although rare large-scale or novel disturbances can interfere with ecosystem processes, the term 'interference' is reserved for constant large-scale or novel effects. The destruction of ecosystem processes in nature by the action of one or more species is rare; any species that did so would become extirpated or extinct, unless it was not dependent on a single ecosystem, as is the case with wolves. Many commentators have accused mammals, wolves for instance, of overkilling their prey. It is fairly well established now, by David Mech and others, that wolves will take prey in excess of their immediate needs. This behavior has been interpreted as useful in maintaining not only the wolf but also secondary predatory and scavenging populations, for example, foxes and ravens. Native informants are aware of this aspect of the wolf's excess kill, but they attribute to the wolf sufficient foresight to kill an excess of caribou near the den site in order to have an adequate food supply when the caribou are absent. Regardless of the wolves' intent, excess kills of caribou by wolves seem to be linked to the pup-rearing part of the pack that follows behind, as well as providing some food for the reverse seasonal migration—wolves can eat the remains of kills that are up to a year old.

Like wolves, human beings interact with the individuals of other species or with entire species. Like other mammals, humans change their habitats to suit themselves. Humans have modified animal and plant associations in a different way from other mammals, simplifying patterns of energy and chemical exchange and solidifying themselves at the end of many food chains as a dominant species (a dominant is a species with greater influence than any other in its biotic community, changing the lives of other species and the character of the habitat).

Human populations have increased exponentially, with billions in giant urban ecosystems. Agriculture has produced monumental yields, but only at the cost of tremendous erosion and great subsidies of fertilizers and pesticides. Dams have been built all along rivers, and riverine forests have been cut, altering rivers and fishing grounds. Changes have been made without regard to the long-term impact on the ecosystem or on its human population. We dominate entire ecosystems.

6.5.3.1. Pandominance of Humanity

This pandominance—that is, dominance of every system—has major effects on ecosystems: Transient perturbations in energy relations, from oil spills or burning, for instance; chronic changes and shifts of systems, from dams, irrigation, or chemical wastes; species manipulation, from the import and export of exotics; and, interference competition with wild species. None of these effects are exclusive to humans as a species, but they are excessive, rapid, compounded, and very large-scale. Humanity has upset the balance of nature in favor of its own needs. Animals, plants, and habitats are being destroyed because of short-sighted, short-term economic interests.

Human beings have contributed to the extinction of species and to the destruction of ecosystems. Human hunters are hypothesized to have wiped out the most of the large mammalian species of the Pleistocene through overhunting—not for future food, but rather from the style of hunting—by driving herds over a cliff. It is possible these populations were vulnerable due to changes in climate and food sources and may have become extinct without human predation. There are other instances. In the 1880s, soldiers and cowboys slaughtered buffalo as a political strategy to reduce the resources of native peoples. Farmers and loggers destroyed the dense forests of Ohio and other states. Settlers and industrialists in the Amazon are destroying vast tracts of rainforest, as part of a political strategy to move peasants out of cities. Industrial forestry in the Northwest America is content to take a high percentage (well over 90 percent) of a forest for wood and pulp, destroying the basis for the continuity of the forest, as well as all beings that depend on the old-growth, fungi, and physical properties of the forest to live.

The biomass of the human species probably exceeds the biomass of any nondomestic mammalian species, and that biomass is supplemented by the tremendous biomass of domestic animals, which is far greater than the human biomass and consumes much of the same food as humans, including milk, fish, and grain. The domination of humanity is related to other characteristics as well, its large annual population increase (over 2 percent), high structural organization (of information and matter), and high energy use (globally 13 times the total of all other mammal equivalents).

Human exploitation at the tremendous physical scale that occurs in industrial states is different from exploitation by other species, because it results in the destruction of the entire system, the very basis for renewal of a system that human beings, as well as other species, need for life. Human actions are damaging global biogeochemical cycles, such as the carbon or nitrogen cycle. For instance, deforestation, burning, wetland loss, and industrial processes are releasing massive quantities of carbon dioxide into the atmosphere, which disrupts the carbon cycle. Although the destruction of large species, from whales to frogs, has a dramatic effect on ecosystems, the destruction of microbes, which generate oxygen and recycle nutrients, has a critical impact on the entire food web. These actions are global, like a large volcanic eruption, but, unlike a volcanic eruption, they are constant and hourly. These pandominant human activities are best referred to as interference, and may be related to our industrial style.

6.5.3.2. Industrial Style

The cosmologies of archaic cultures have been limited to historical places and by human perception, tradition, and technology. Modern technological cosmology, beyond being another kind of order, more linear and abstract, is wrongly considered the evolutionary successor to traditional cosmologies, and is displacing them rapidly—although we cannot afford to suppress the diversity of thought necessary for adaptation to the diversity of environments or to eliminate ecosystems and the societies adapted to them.

Our modern problems reflect an unbalanced and immature image of the earth, the earth as a machine, for instance. People sometimes constructed their worlds from preconceived notions, and many of these worlds did not survive, because they could not adapt to the environment. Our modern cultures are defective for this reason. The modern attitude toward nature as a resource has resulted in pollution and depletion of resources. It has allowed humans to overpopulate their habitats. Recent productivity studies indicate that the optimum sustainable human population is far below the current world population (Wittbecker, 1983).

Even worse, decisions regarding resources are still made exclusively on short-term economic rationalizations and lead to material shortages and environmental degradation. The crises of environmental degradations are crises of cultures. Monocultures of the industrial kind lead to 'dedifferentiation,' that is, the decomposition and destabilization of complex structures. A species or culture that destabilizes its ecosystem through misbehavior risks its own extinction. Human beings make changes to ecosystems that endanger themselves.

Humanity is calculated by Norman Myers and others to be using over 40% of the ecosystem productivity for the entire earth (56% by 2004, according to Stuart Pimm and others). Humanity influences virtually every ecosystem to some extent, destroying some, interfering directly with many, and exposing the rest to exotic chemicals and materials. Species normally use a percentage of system productivity without disrupting the processes of production. The human species interferes with the processes.

Interference has been a rare phenomenon on earthly ecosystems; it has happened in the past as the result of global catastrophes, such as meteor impacts. Now, interference, as opposed to more limited and predictable disturbances or exploitations, is threatening the stability of all ecosystems. It is dangerous to interfere with the processes of ecosystems because it disrupts the communities on which other species, and ultimately human communities, depend. Furthermore, in the deepest sense, it violates the idea of living together with other species on the planet. The proper relationship of humanity with nature should include competition and exploitation and mutualism, but not interference.

We kill millions of animals in laboratories to insure our safety, we kill billions of plants and animals for food and clothing and products, while indulging in the sentimental preservation of some individuals of other species. Animals do not need to be saved from natural death, a great regulator of life, but from unnecessary suffering, experimentation, and premature extinction. The world would not be a better place without sharks, silverfish, rats, cockroaches, or hyenas. They need their own places. The places, entire ecosystems, need to be saved. If we diminish variety in nature, we debase its stability and wholeness. To save ourselves, we must preserve and promote the variety of nature. Perhaps we should reconsider our unconscious role in nature as agents.

6.5.4. *Practicing Noninterference*

Exploitation, in the ecological sense, is necessary and beneficial to biological populations. A machine metaphor approach, with its assumptions of interchangeability and quantity, apparently has difficulty distinguishing between exploitation and interference. An ecological metaphor, that is more receptive and reverential, may be more appropriate to understanding organisms and nature in general. Such an approach would stress noninterfering observation rather than controlling manipulation.

Applied to nature, human intelligence could discover the significance of natural rules of interaction and exploitation. The reverence for beings as they are could result in a rule of noninterference (Wittbecker 1984). A rule of noninterference states that human beings ought to avoid behavior that disrupts essential ecological processes or destroys biotic communities. As Paul Taylor states his rule of noninterference, it requires a "hands-off policy" for whole ecosystems and biotic communities; the rule stated here is concerned with limited and sustainable exploitation of ecosystems already shaped to some extent by human activities. Many other ecosystems, perhaps covering 50 percent of the land area of the planet, would be reserved by law for predominately natural ecosystems or adapted first nations. Noninterference also means "letting be" (after Martin Heidegger), or "letting alone" in the words of E. O. Wilson. Noninterference is not indifference, which is diffuse. It is caring. Noninterference will not lead to chaos, poverty, or stagnation. It permits the rational exploitation of resources.

We need to practice the rule of noninterference so that all beings can enhance their lives and habitats. Noninterference can be derived from nonviolence (or taoistic nondoing, a metaphoric expression for the nonbeing of nature) or even from English Common Law, which is well-established in Western law; it includes a precept: "Use what belongs to you in such a way as not to interfere with the interests of others" (*Sic utere tuo ut alienum non laedas*). This rule could be defined by positive laws and by negative restraints on behavior. This attitude would entail using what is necessary, exploiting some ecosystems completely, changing a place to fit human aspirations, and killing plants and animals for sustenance. But, it would also mean limiting humanity and its technological effects, limiting human use to local impacts, and letting other beings live without interference. It is not necessary to dominate or to terraform the earth completely.

6.6. *Designing Adaptive Patterns: Agriculture to Industrialization*

Previous adaptive patterns have extended beyond the range of their adaptation, in time or space. For instance, it is unlikely that modern cities will ever be able to survive a ten-year drought, much less a twenty-year or fifty-year drought, or a hundred-year series of droughts. It is unlikely that industrialization, or industrial agriculture, will survive the decline of fossil fuels. Possibly our adaptive technology will not survive its effects on humanity or on the planet. So, we have to design many of our adaptive patterns, from agriculture and cities to technology and industry, to fit a changing planet.

Agriculture determines what we eat and how often we eat. But, agriculture requires the conversion of many wild ecosystems over vast landscapes. People are no longer scattered over those landscapes, but concentrated in cities, trading for foodstuffs from elsewhere. What if design tried to concentrate agriculture in the cities themselves? What if the fields on and around buildings were multi-level and complex? What if we reduced our reliance on grasses, like corn and wheat?

Cities hold well over half of humanity. How well could cities withstand three 20-year droughts in 100 years? Could they have farms on roofs? Could they make vats of food? Could they store enough food in cans or freezers to last for 20 years? Could cities limit their populations?

Technology is evolving on its own, without goals, plans, or management. We might decide what we want technologies for, then assess them critically, as part of the overall shape of civilization. With management, we might refuse many technologies as too dangerous, expensive, or silly. We might try to balance technology with the goals for cultures and ecosystems, and integrate it into the forms that we desire.

Industry has brought great benefits to many people and cultures, from simply increasing the number of clothes that people have to producing incredible machines that allow materials and food to be harvested, processed and shipped almost anywhere. But, industry has also produced destruction, pollution and waste on a massive scale, as an integral part of its production. The creation of a whole industrial ecology could reintegrate industrial processes with ecological ones.

6.6.1. *Calculating Optimum Global Human Populations*

A number of studies have suggested that the human population of the planet could be much larger than it is now—70 billion instead of six and a half billion. Several other studies have recommended lower population numbers based on resource availability or other factors. All of these studies are concerned with finding a *maximum* human population. Yet, as we know, maxima in natural systems are rarely stable. Human populations are limited by the biological constraints of ecosystems, by biogeochemical cycles, by our knowledge of these systems, and possibly by human psychological and cultural limits. Therefore, an optimum human population is calculated, using a deductive, synthetic, conceptual model based on data generated from research on net primary (NPP) and net community (NCP) productivity. A deductive approach is used because accurate measurements of trophic level productivities in most ecosystems are lacking. Its synthetic character is more appropriate to integrate quantitative and qualitative data, which are both present in human studies. The model is conceptual because of the inherent fuzziness of the systems, which can change scales way too rapidly for adjustment.

6.6.1.1. *Assumptions & Considerations*

Ecosystems result from the interaction of all living and nonliving factors of the environment, according to Arthur Tansley. These ecosystems are profoundly affected by both random and purposive physical and biological factors. As a result, habitats change and organisms adapt. By modifying their habitats in the process of living, organisms change the characteristics of the system and force further adaptation. More important, organisms are limited by the productivity of the system in varying degrees. Human populations (*Homo sapiens sapiens*) inhabit specific ecosystems and rely on them. They are adapted to and limited by the productivity of ecosystems.

The total amount of biomass or energy produced by populations through growth and reproduction is the productivity of the system. Gross Primary Production (GPP) is the rate of energy storage by photosynthesis (equal to photosynthetic efficiency) in autotrophs (plants). The maintenance and reproduction of plants is paid for by the energy expenditure of Respiration (R). The amount of energy stored as organic matter after respiration is identified as Net Primary Production (NPP), which equals plant growth efficiency. The calculation of NPP is shown by:

$$NPP = GPP - R$$

NPP accumulates through the history of a system as plant biomass expressed as kilocalories per square meter ($Kcal/m^2$). The kilocalorie is used as a unit of energy flow and production; it is a useful common denominator for these calculations. The biomass minus the decomposition in a system is the standing crop biomass of that system. The problem of confusing production (amounts) with productivity (rates) is avoided by considering all values per unit area (m^2) over the entire year (m^2/yr). The energy stored in heterotrophs (consumers) is referred to as secondary production (SP) or assimilation. The storage of energy or organic matter not used by heterotrophs is Net Community Production (NCP). The relationship between productivities (where R_a=autotroph respiration and R_h=heterotroph respiration) is of the order shown by:

$$GPP = NPP + R_a = R_a + R_h + NCP$$

In a balanced ecosystem, NPP equals respiration; in an accumulating system, NPP usually exceeds respiration by 1 to 10 percent. Although stable ecosystems tend to produce a maximum GPP, species, biomass, and the production to respiration ratio (P/R) continue to change long after the maximum has been achieved. In fact, as the GPP approaches an asymptote, respiration increases. In a balanced system, tropical rainforests for instance, NCP approaches zero, as adapted heterotrophs become more efficient at using production. In accumulating systems, such as grasslands or young forests, NCP can range from 20 to 70 percent. A balanced system is integrated and self-perpetuating, where production (the photosynthetic fixture of carbon) is balanced by respiration (the oxidation of carbon). As a system becomes balanced, the pressure of selection of organisms shifts; the capacity to live in crowded circumstances with limited resources is favored. Populations that depend on rapid individual turnover (r-selection) are not as successful as populations of large, long-lived individuals (K-selection). As an ecosystem ages, pressure is put on some populations by other populations. Competition and predation become more complex.

Mammals are the best regulated of highly evolved species. Their behavior is controlled and population regulated through the use of space. Most populations, furthermore, regulate their density well below the limits of the food supply, often by as much as 50-70 percent. Territoriality can be correlated inversely with trophic levels and productivity. But populations can also be limited by: Specificity of prey or plants, the size of prey or plant populations, predators, and natural events or catastrophes.

Human beings are mammals—omnivorous, social, bipedal, featherless, symbol-using, tool-making, game-playing, neotonous, bilateral-hemispheric, generalist mammals. Furthermore, as Woodwell put it, humans live as "one species in a biosphere whose essential qualities are determined by other species." Mammals are bound by biological requirements that must be met if a population is to survive. These functional requirements are rather minimal for humans, however, being only food, clothing, shelter, and reproduction. Other requirements, such as respect, comfort, and self-fulfillment, depend on adaptive sociocultural systems.

Like other mammals, humans change their habitats to suit themselves. Other mammals alter their habitats through chewing, digging, and burrowing. Rodents can dislodge earth at a tremendous rate (18-120 m^3/ha/yr). In many cases these activities improve the conditions for the growth of vegetation. Mammalian grazing promotes regrowth and the movement of seeds. Bison and prairie dogs were responsible for much of the character of the American plains. Rodent caches may account for 15 percent of Ponderosa seedlings. Beavers and other rodents create their own microsystems. Wide-ranging caribou transfer energy between systems.

Humans have modified animal and plant associations in a different way, simplifying patterns of energy and chemical exchange, solidifying themselves at the end of many food chains as a dominant species. A dominant is a species with greater influence than any other in its biotic community, changing the lives of other species and the character of the habitat. By its influence of all ecosystems, humanity has become a *pandominant* species. As such, humanity reclaims, overgrazes, clears, depletes, and wastes at a level that threatens the stability and existence of many systems. One of the ecological consequences of human activity is the degradation of wild habitats for human developments (food, housing, and recreation) and the introduction of novel elements into the biosphere—elements that have not been added slowly over time as the result of natural processes. The biomass of the human species probably far exceeds the biomass of any nondomestic species, and that biomass is supplemented by the tremendous biomass of domestic animals, which is four times greater than the human biomass (Borgstrom, 1975). This biomass forms an equivalent population that consumes much of the same food as humans, such as milk, fish, and grain. The domination of humanity is related to other characteristics as well: A large biomass (6 x @10^{14} @ Kcal), a large annual increase (2% or higher), a high structural organization (information and matter), and a high energy use (globally, 13 times mammal equivalents). This pandominance has major effects on ecosystems: Transient perturbations in energy relations (from oil spills, burning); chronic changes/shifts of systems (from dams, irrigation, chemical wastes); species manipulation (from the import and export of exotics); and, interference competition with wild species (as opposed to exploitative competition, which can be stabilizing). None of these effects are exclusive to humans as a species, but they are excessive, rapid, compounded, and very large-scale.

Minimum viable populations for mammalian species, usually considered on the order of 500 individuals, have been calculated and discussed. For the human species, it is unlikely that the lower limits will be approached in the foreseeable future. There are several other lower limits to keep in mind, however, as shown in Table 6611-1. These limits are conservative estimates.

Table 6611-1. Minimum Limits (revised from Wittbecker 1970)

Genetic minimum	5,000
Fertility	50,000
Ideomass	500,000
Social contact minimum	1 million
Evolutionary advantage	10 million

A maximum carrying capacity for humanity can be calculated. The carrying capacity is the population sustainable on a long-term basis of renewable and nonrenewable resources or energies. For humans, this capacity must include domesticates, as human equivalents, since many domesticates compete for protein consumption. Domestic animals can extend the carrying capacity somewhat, since many of them consume agricultural wastes or use lands marginal for agriculture, but they are not as efficient as wild populations. Technology could expand the carrying capacity to some extent, with higher yield crops and resource substitution, but also it could reduce the capacity with unforeseen side effects—through the use of pesticides, for example. War and social disorder reduce the ultimate capacity. Furthermore, the capacity decreases as the *per capita* use of energy and resources increases. Carrying capacity calculations often just consider food energy, but all needs—clothing, shelter, transportation, information generation, aesthetic satisfaction, and others—must be included. Given the current political and technological situation for humanity, it is difficult to imagine how equilibrium could be reached without a significant reduction of human populations.

6.6.1.2. *Previous Studies*

Many theorists have estimated maximum (rarely optimum) sustainable populations for humanity. C.T. DeWit estimated the maximum human population at 1 trillion, 22 billion (1.022×10^{12}), based only on areas for protein. With 750 square meters added *per capita*, for forest and recreation, this number would be trimmed down to 146 billion. With consideration for animal protein in diets, 73 billion. These calculations are based on very simple variables—the light scattering coefficient (.3), leaf area index (5), and a mean synthetic rate. Apparently, there are a number of simple assumptions, also: Ideal photosynthetic conditions, a strict monoculture without any natural habitats, and human occupation of the first consumer level of all food chains, thus entirely eliminating *all* competing wild animals. An exclusively human earth would confront its sociological, technological, and aesthetic limits immediately.

Colin Clark (1967) put the population of the earth at 47 billion, at an American standard; 157 billion on a Japanese standard. Who knows how many could have been crowded in with the lowest standard? Earlier, Clark (1958) had foreseen a population of merely 28 billion, using a Dutch standard of productivity and density (365 people per square kilometer). Apparently, he neglected to account for the ghost acreage used by the

Dutch. Furthermore, he assumed a very large total arable land area—in fact, 63 percent of the total surface area of the planet, by counting the tropics twice.

P. Burlingh et al. estimated the absolute maximum food production of the world at about 30 times the production of 1970 (and presumably an equally high human population). They arrived at this figure on a basis of quality of soil, climate, and water. It does not seem that any biological factors were considered. Weinberg and Hamilton presented a steady state model of 10 billion at 400,000 Kcal per day for the year 2050, but made no mention of how the population would stabilize at that level or what kind of economics would support it or for how long.

Most of these optimistic studies see the limits of world food supply as being determined by the physical limitation of land, water, light, and chemicals (Pirie) or by the logistics of transportation and conscience (Moore and Lappe; Gabel). They assume that areas of cultivation can be expanded into planetary biological support systems, that efficiency can be enhanced (at the risk of genetic instability), and that novel sources of food will be used (ignoring cultural limitations). These requirements may never be met, as others have realized.

A few studies seem more realistic. H.R. Hulet assumed that plant and animal products were equally necessary. By making them equal requirements—animal and plant production at 4.2×10^{15}/Kcal each—he suggested that the earth could support an maximum population of 1.2 billion. Considering the Law of the Minimum, he offered a series of maximum populations as a function of resources (Table 6612-1). Note that aluminum is a bottleneck and would limit the population far more than wood. He concluded that as technological and agricultural systems expanded, population could also. But, the rates of use for the minimum items he provided were not renewable or slow; they were based on American standards of consumption. In America, energy use is increasing at 6 percent per annum; three times faster than the population. Therefore, resources would be limited long before a maximum population was reached.

Table 6612-1. Population Function (after Hulet)

Function of	Population
Wood production (4×10^6 cal/yr/cap)	1 billion
Energy rate	600 million
Fertilizer rate	900 million
Aluminum rate	500 million

Arthur H. Westing estimated a global carrying capacity based on five areas of renewable resources (Table 6612-2). His estimates range from 1.5 to 3.9 billion. These numbers are for a maximum population, however, not an optimum. It is important to remember that an optimum is almost always less, much less, than a maximum. Note also that his paper, written ten years after Hulet's, when wood production had increased significantly, gives a doubled figure for a population limited by the availability of wood. In fact, neither Hulet's nor Westing's rate is sustainable. Annual timber cutting in the United States in 1963, for example, exceeded annual growth by 50 percent. Most cutting since then has exceeded growth by various percentages. Furthermore, wooded areas are still being cleared for agriculture, housing developments, and industrial areas. Westing recognized that most renewable and nonrenewable resources fundamental for human life are used in direct competition with wildlife. He commented that most studies did not consider wildlife.

Table 6612-2. Population Estimates (after Westing)

Function of	*Population*
Total land	2—3.1 billion
Cultivated land	1.5—3.3 billion
Forest land	2—2.9 billion
Cereals	1.7—3.3 billion
Wood	1.9—3.9 billion

For a straight energy calculation of an optimum population, assuming the unavailability factor has been subtracted first, refer to Table 6612-3. The French *Per Capita* energy use is approximately the same as the world average. Portuguese energy use is the same as agricultural trade. The main difference between this model and earlier ones is the *pattern* of utilization as well as the assumptions of minimal waste and *no growth*.

Table 6612-3. Optimum Populations (1980 Per Capita Use)

Nation (Energy per cap)	*Population*
United States (120 x 10^6 Kcal)	189 million
France (4 x 10^4 Kcal)	567 million
Japan/Argentina	1.13 billion
Portugal	2.84 billion
India/China	5.27 billion

Whittaker and Likens have suggested that an agricultural world, where humanity lived as peasants, could support at least 2 billion, perhaps 5 or 7 billion. The current high levels of population, at a large range of standards, can only be maintained through the constant takeover of natural habitats for arable land, or through the drawdown of fossil fuels, and by economically cheating the poor and powerless. Since the quantity of wild lands and fossil fuels is quite limited, either human populations must adjust to renewable resources or technology must provide substitutes, to avoid a population crash.

Eugene Odum suggested using land area as a measure of human carrying capacity. The minimum per capita acreage requirements, with temperate Georgia as a model for a quality environment, is 5 acres (2.02 ha). The percentage of areas is broken down in Table 6612-4. The natural areas are based on minimum space needs for watersheds, as estimated by land use surveys. Food-producing land includes acreage for domestic livestock. Extrapolating this technique to the entire planet, assuming that wilderness area has been considered in the calculation, and converting for the differences in productivity of ecosystems, the population calculation comes to 3.969 billion. This figure is close to the 1970 world population.

Table 6612-4. Acreage Per Capita (after Odum)

Food-producing land	30%
Fiber-producing land	20%
Natural support area	40%
Artificial areas	10%

Samuel Eyre, L.E. Rodin et al., and others have calculated the potential productivity of the wild vegetation of the earth at around 1.19 x 10^{11} metric tons per year. Eyre attempted to describe the wealth of nations in terms of NPP, with nutrition equivalents in NPP for mineral resources. He contended that one must know the productive capabilities of land in its original vegetation to compare with productivities under human management. He found, for instance, that most wild lands are more productive than most agricultural acreage. What is left out of his considerations is the amount of healthy ecosystem necessary for cycling and renewal. Furthermore, all productivity is treated as economic, to be dispensed with by the nations that occupy the land, at will. Although Eyre's NCP model is more reasonable than most models, it still puts humanity in competition with any remaining wildlife for productivity in every ecosystem.

6.6.1.3. An NCP Model

It is possible, however, to calculate a sustainable human population in balance with healthy ecosystems, using NCP instead of NPP. The population for this model would be much lower since NCP is generally lower. For instance, in tropical and temperate grasslands, NCP may approach 60 percent of NPP, although 30 percent is much more likely. Temperate forests may approach 30 percent. For tropical forests, however, NCP approaches 0 percent. Tundra and much of the ocean environments are also very low. When NCP is used to calculate a *maximum*, the measurements are consistent with the low figures of several studies. Refer to Table 6613-1 for calculations.

Table 6613-1. Simple NCP Calculation of Population

Vegetational Unit	*Area 10^6 km*	*NPP 10^9 mt*	*NPP 10^{15} Kcal*	*NCP 10^{15} Kcal*	*Population 10^9*
Trop. Rainforest	17.0	47.4	195.5	0.187	0.17
Trop. Raingreen	7.5	13.2	55.5	0.052	0.47
Temp. Summer	7.0	7.0	32.2	2.24	2.04
Mediterranean	1.5	1.2	5.9	0.03	0.03
Temp Mix	5.0	5.0	23.5	6.35	2.45
Woodland	7.0	4.2	19.6	7.0	7.0
. . .					
Ocean	332.0	41.5	199.2	0.199	1.81
Shelf	26.6	9.2	43.1	2.13	3.87
Estuaries	1.4	2.5	11.3	0.07	0 .06
Cropland	14.0	-	-	12.81	14.63*
Totals				90.87	82.61

* As percentage of forest/grassland in original vegetation, with approximately 35% less NPP. This paper is concerned only with the values of natural productivities. Domestic lands were assigned productivities based on those of the original wild vegetation (which in fact is usually higher).

Adding the NCP of all ecosystems is not enough. First of all, not every system is stable enough to use; other systems should be set aside for various reasons, from services to aesthetic appreciation. Other factors, such as inedibility or waste, have to be considered. Of the NCP produced, 75% is unavailable, 5% is eaten by pests, 65% of that harvested is inedible, 80% of that edible is lost in processing, and 25% is wasted during consumption, resulting in a maximum number of ***903 million*** (from the preliminary figure of 82.61 billion). This figure is almost identical to a flat 1 percent rate of the NPP, subjected to the same loss percentages. Applying a fifty percent rule (Wittbecker 1977) to this maximum figure, 903 million, results in a crude *optimum* population of ***451 million.*** This conservative number would insulate human populations from environmental variables and from fluctuations in productivity. Daniel Kozlovsky intuitively estimated 500 million as an equilibrium population. Lower densities of humans will always be able to harmonize more successfully with biological processes. For the long-term survival of the human species, adaptability to environmental changes is necessary. This requires a wide diversity of gene pools, which is achieved by a relatively large population divided into local, partly isolated groups in healthy regional ecosystems. The optimum size of the global human population is actually the sum of optimums for local habitats.

Before an optimum human population can be put forward as a goal, numerous questions must be addressed, including:

1. How much land should be left in its native state? Enough to save one of each kind of ecosystem? Enough to support atmospheric cycles? Enough for exotic ecosystems? Enough for public service? Enough for extensive recreation?
2. At what level of luxury should humans live (in Kcal/yr.)? Just basic amenities (such as clean air and water)? With the potential of having every technological device available? With an excess of flexibility?
3. What are the physical limits of resources? Should all nonrenewable resources be used, and, if so, at what rate? Should only renewable resources be used?
4. What is an optimum? Laboratory studies with rats show that, with a choice of optimum rat environments, some rats reject the optimum. Should the optimum be set for a majority (by numbers or cultures?) or for some low denominator?

How these questions, and others not asked, are answered determine an optimum human population. Knowing how many humans are alive to feed is easier than describing the basics of a quality of life. In calculating an optimum population within ecosystem restraints, few have considered minimum wilderness preservation, air and water quality, genetic minima, nonrenewable resources, appropriate technological innovation, the importance of cultural frameworks, adventure, research, beauty, uniqueness, and other intangible experiences. If human civilizations were based on balanced ecosystems, they would be more complex. The complexity encountered in trying to imagine them may serve as a Zen koan-work, to bring us to rational breakdown and finally to a thoughtful alternative: humanity as a self-conscious, self-limiting, poetic species.

6.6.2. ***Redesigning Agriculture***

Traditional agriculture proceeds by substituting selected domesticates for wild species in equivalent niches, or by manipulation of the ecosystem, whereas modern agriculture replaces the biota, or transforms the ecosystem into an artificial system. People-powered agriculture works well. Horse-powered and oxen-power agriculture is still harmonious, because living creatures can fit better into biological and ecological relationships than machines can. The health and fertility of one is involved in that of others in the whole system.

Inorganic tools can be inserted into an agricultural order, but only within limits of kind, scale, and power. A tractor, for instance, can have too much power and start the destruction of the system. It also depends on the destruction of systems elsewhere to get its structure and energy. The tractor, farmer, and farm become resources for the industrial economy, run by incomplete capitalist ideas.

Agriculture, growing crops and raising animals, provided more food, but it was less nutritious and less palatable. By increasing the population, agriculture increased widespread hunger. The reduction in biodiversity, by monocropping, undermined biodiversity and caused some ecological crises, that resulted in periodic and devastating famines. If the trends to more and more control, and to greater and greater profits—with the effects of fewer farmers and monocultures—continue, then agriculture may become a form of chemistry.

One goal for agriculture would be a net of no lost areas from the footprints of cities or no lost areas for crops because of cities. If people are concentrated in cities, trade foodstuffs from fields and from wild animal harvests, then their reliance on corn and wheat fields could be reduced. By situating some agriculture on rooftops and lots, and making them more organic and labor-intense, cities would be less dependent on distant areas.

Designing agriculture requires the perspectives of ecological design. This kind of design first recognizes the ecological restraints of a place, the patterns of feedback, the points of disequilibrium, and the peripheral frame of the system. Agriculture has to be place specific and fitness-oriented—it has to make a goal towards a satisfactory or optimum production, rather than a maximum. It has to become part of the regeneration and repatterning of the system—it cannot keep the system stable at one level indefinitely; yields will go up or down, depending on other variables, from weather to species composition.

6.6.2.1. *Domestic Animals*

What is the solution to the treatment of domestic animals? How can we design areas for domestic animals? Based on knowledge about the needs of animals, physical and psychological, they have to be in contact with a natural predominantly environment for most of their lives. Animal places have to be area-limited and standards-limited. In fact, the area would be determined by standards. The number of animals would be determined by total area, especially with social animals like pigs or horses.

Zoning would affect that area. The standard area could be calculated per animal for feeding and privacy maternal behaviors, as well as social interactions. Different areas would be needed for different species. Essentially, the animals would be free-range in a natural environment. Standards would be established to limit crowding, which is not simply uncomfortable but can result in pain and life-threatening stress; in fact, research has been done on crowding in rats and other animals. Drug use could be limited to the presence of diseases and then limited to sick animals.

We also need standards for experimental animals, starting with a limit to meaningless experiments, such as cosmetics, which already have vast human populations being tested informally. Tests would be limited to deadly diseases that are not established in human populations. Psychological testing would be minimized. Caging would be temporary for test and zoo-like conditions would predominate for the test pools of animals. The best approach might be to integrate animals into new systems of agriculture.

6.6.2.2. *New Systems of Agriculture*

Agriculture is a form of ecocultural play. It is nature based and culture based. The design of agriculture has to be based on the development of ecosystems as well as historical traditions. It has to incorporate failure as well as bottom-up action, although it can modify these with to-down restraints. It has to be attentive to consequences of its actions, be perceptive of changes. It can assemble niches with ecological redundancy that can be exploited reasonably for human needs in a long-lasting, sustaining pattern.

Agricultural systems can be classified using two variables: Energy type and diversity of plants. Traditional systems—shifting cultivation, nomadic pastoralism—depend on human or animal labor. Modern systems—plantation, commercial—depend on combustible fuels for energy; these systems also tend towards monocultures. Traditional systems usually incorporate greater biotic diversity, and tend to be more polycultural. Traditional systems are very labor intensive, that is, participatory.

Agriculture started out as a food management system. The first grains may have been status foods, used only at certain times of year, like salmon or other annual foods. Then, agriculture became a labor Management system that required training and encouraging people to work harder and in a special niche.

Later, it became an energy management system. It tried to control the energy sources, the converters, and the outputs. More energy put into crops and more energy extracted. To model energy, we can consider one human being is rated at 0.1 horsepower (abbreviated 'hp'). A team of oxen is 1.2 hp. A 50-hp tractor is rated at 50 hp. In tilling a one hectare field, human power is twice as effective as the oxen and 4 times as effective as the tractor (in terms of the amount of work performed by horsepower. However, in terms of gross costs, such as shelter food and clothing, then human power is 3.45 times as expensive as a tractor and 2 times as expensive as oxen, who require food and veterinary care. Eventually energy surpluses flow from the country to cities.

As a time management system, time constraints are also a problem. Although one person could produce a crop in 700 days, it is more effective to use 70 people in 10 days. Human labor is low in absolute levels of work. Animals constituted a form of energy slaves.

As more effort was put into the land, agriculture became a territory (and perhaps property) management system, finding and dedicating land to crops. One could also consider agriculture as materials management. A hydraulic civilization required tools, dams, pots and labor schedules. Of course, agriculture could be considered a beer management system, catering to the desire for intoxication. Fermentation had an additional nutrient bonus from yeast as a protein. Yeasts were also used for breads.

Agriculture is a novel information system. Because of population density, there is a drop in costs of transmitting information. The brain is more tightly packed. This is advance in information technology. Information is presented in terms of labor, a greater array of goods, and special projects. Information guides energy use. Chiefs give signals that channel energy into projects. The signals are trigger effects, small changes in energy that cause large changes in the cultural output of energy.

Agriculture, finally, is an ecological system, based on ecological limits, based on natural processes, and based on interactions with other systems, including human ones. In its early stages, agriculture is constrained to early stages of succession. That is, it uses nutrients and energy for quick growth and reproduction, rather than invest in efficiency or durability or maturity. Fossil fuels have allowed this artificial condition to continue.

With knowledge of ecosystem processes, traditional agriculture can be modified to allow the collection of significant quantities of food from mixed systems, without landscape conversion and without interference from energy subsidies or biocides. Eventually, agriculture will have to become more mature. Wes Jackson and others are working on making this transition.

6.6.2.2.1. Promise of Regenerative Agriculture

Regenerative agriculture pays attention to the total input flows for agroecosystems: Solar, human, animal, tools, fuel, fertilizer, pesticides, drying, processing, and transporting. Under some circumstances, pesticides and fertilizers might be needed to stop pest populations or give advantage to crops.

Intensification has been a trend in agriculture, but different processes need to be intensified. Exploitation needs to be more intense. Perhaps specialization does this, from secondary products from domestic animals. Agriculture tries to intensify production, to increase yield from land use, as a result of intercropping or adjusting, and to increase yield from human labor. Water control may allow multiple harvests, to increase productivity. It might be possible to breed more rapidly maturing strains.

There are many kinds of specific measures that can reduce erosion, starting with contour plowing. Plowing can be eliminated altogether with seed-drilling. In 1943, Edward Faulkner, showed there was no scientific reason for plowing. Plowing gives a short-term increase in soil quality, by mining the subsoil. Fukuoka's ideas of multi-planting.

6.6.2.2.2. Natural Farming

Masanobu Fukuoka is another of the major pioneers of sustainable agriculture. Professing no knowledge, he presents a farming method that involves no tillage, no fertilizer, no pesticides, no weeding, no pruning, and less labor. He calls this practice the "no-plowing, no-fertilizing, no-weeding, no-pesticides, do-nothing method of natural farming." The idea that people can grow crops is egocentric to him. Ultimately, it is nature that grows crops. He sees modern agriculture as 'doing-this and doing-that' to grow crops, but it is meaningless work. With his 'do-nothing' method he is able to get yields in his rice fields that are equal to the highest yields attained with chemical, do-something agriculture. He accomplishes these high yields by careful timing of his seeding and by careful combinations of plants, in a polyculture.

6.6.2.2.3. Regenerative Agriculture & Permaculture

Permaculture is a design system that aims to create sustainable habitats by following natural patterns. The word 'permaculture,' coined by Australians Bill Mollison and David Holmgren during the 1970s, is derived as a contraction of permanent agriculture, or permanent culture.

The idea of permaculture is considered among the most significant innovations developed. However like nature, the permaculture concept evolves with time making its static definition difficult. Nevertheless, permaculture can be described as an ethical design system applicable to food production and land use, as well as to community building. Permaculture seeks the creation of productive and sustainable ways of living by integrating ecology, landscape, organic gardening, architecture, and agroforestry. The focus is not on these elements themselves, but rather on the relationships created among them by the way they are placed together in place, the whole becoming greater than the sum of its parts. Permaculture also addresses the careful and contemplative observation of nature and natural systems, and the recognition of universal patterns and principles, as applied to specific circumstances in unique places.

Permaculture uses zones to focus efforts. The zone nearest to the house (1) is the location for those elements in the system that require frequent attention, or that need to be visited the most often. The vegetable garden (2) may also have larger scale compost bins or bee hives. The area where crops are grown (3), for domestic and trading purposes, could include orchards. After establishment, care and maintenance requirements, such as mulching, are relatively minimal. Watering or weed control is performed every week. Animals in these zones, such as chickens, can be used as a method of weed control and also as a producer of eggs, meat and fertilizer.

The next zone (4) is considered semi-wild; it is used for timber production from coppice managed woodland and the placement of aquaculture ponds. The fifth zone (5) is actually wilderness. There is no human intervention other than observation of natural ecosystems and cycles. Mollison considers this zone the source of the most important lessons of the first permaculture principle of working with nature, not against it.

6.6.2.2.4. Natural Systems Agriculture

What is the difference between ecosystems and agroecosystems? People? Domestic plant and animals? Not just people or domestics but their kind of actions, that is, their relations with their system. In an ecosystem, people are just one more group exploiting the system. But, in the agroecosystems, people are manipulating the system, that is, they are modifying the system.

The goal of Natural Systems Agriculture is not only to fit agriculture within limits of the ecosystems, but to increase its presence in cities and artificial areas. The Land Institute has worked also for over twenty years on the problem of agriculture, to develop an agricultural system with the ecological stability of the prairie and a grain yield comparable to that from annual crops in a modern, fuel-subsidized field. The Institute collaborates with public institutions in order to direct more research on Natural Systems Agriculture.

Because this work deals with basic biological questions and principles, the implications are applicable worldwide. If Natural Systems Agriculture were fully adopted, it might be possible to witness the end to agronomic methods and technologies from fossil fuel-intensive infrastructures in developing nations.

Natural Systems Agriculture is a new paradigm for food production, where nature is mimicked rather than subdued and ignored. Located in a native U.S. prairie, the Institute looks to the prairie as a model for grain crops. They are investigating the feasibility of perennial polycultures or mixtures of perennial grains.

The functions of a natural system can be achieved by mimicking its structure. With additional research, the Institute is working to show that an agriculture that is resilient, and therefore productive over the long term, economical, such that the need for costly inputs would be significantly diminished, and ecologically responsible is well within reach. The impetus to search for a new agriculture is soil loss and soil pollution. Agricultural chemicals poison soils and waters, which harms insects, birds, and mammals, including human beings. In the United States, after two 200 years of industrial agriculture, about quarter to a third of topsoil is gone. Natural Systems Agriculture would leave the ground unplowed for years and use few or no chemicals, solving many environmental problems at their root.

6.6.2.3. *Industrial Agriculture*

There are many possible ways of getting food: Hunting/gathering from the environment, traditional farming and animal rearing, industrialized farming, meat factories, culturing plants hydroponically, vat grown meats, artificial meats based on yeast, algae or bacteria, as well as food built directly by matter compilers from chemical elements.

Genetic engineering is progressing quickly and so are biological studies. After all, human tissue can be grown in labs relatively easily. So, food could be produced in vats. The food, for instance tomato paste, could be made cancerous, so that it would keep replicating cells. The cells could be kept immortal by keeping the telomeres. At the desired size, it could be prepared, sliced into cubes and canned, or freeze-dried, or irradiated and packed. Growing meats in vats would be more difficult, since a significant part of the flavor results from the muscular movement of the animal as it finds food; other tastes could be introduced through duplication of food source chemicals. Perhaps electrical stimulation of meat cells would make it more flavorful.

Modified algae could be produced in tanks, then textured and flavored by various technological processes. There is a range of possible artificial foods. Any of these solutions, of course, creates new problems, not just in relationships with other forms of life and the environment, but in scale especially. Table 6623-1 compares the total acreages necessary to feed four billion people using different methods.

Table 6623-1. Methods and Acreage

Method	*Area in Ha*	*Percentage of current*
Current production	1,507	100%
Current production, waste eliminated	1,250	82.8%
Feeding all cereals to humans	740	49%
Using the Asian Method	650	43%
Growing all food in greenhouses	60	4.0%
Using industrial agriculture, assuming vegetarianism	170	11%
Growing food hydroponically	6	0.4%
Growing algae in vats	5.4	?
Using leaf protein	0.03	?

Single-celled protein could feed four billion humans using only one-seventh of the oil products waste, worldwide.

A *hydroponics* method offers 500 times the yield with only one tenth the water required; there is no runoff and better pest control is possible.

Although *leaf protein* is not palatable straight and must be machine processed, the machinery is available and the cost is still only one-seventeenth the cost of meat in India. It is more efficient than grasses. It offers new stores of plants for food (300,000). And it is the most suitable kind of harvest in the tropics, with their vulnerable soils.

The *single-cell protein* yeasts or fungi are very efficient and fast; harvests can be measured in hours, not seasons or years. Although it is a fairly expensive process—it must be grown in tanks—it can be grown on petrochemical wastes. And, it produces no wastes and has virtually no pests. SCP is of poor nutritional quality.

A comparable weight of *algae* contains three times the protein of beef. It is also efficient. Algae is also expensive. It concentrates pollutants. And it is amino acid deficient.

Industrial production may be the logical step under the current system. As long as it is constructed as a form of industrial ecology, wastes and resources may be recycled in natural systems, which have reduced impacts and disruptions.

6.6.2.4. *Refitting Agriculture*

Agriculture exists within an economic order. Through ecological design, agriculture can be reformed into an integrative, natural-capital-using, adaptive process. To be less destructive of ecosystems, and to reduce its waste, agriculture has to begin to use appropriate energy and technology, at appropriate scales. Its costs constraints have to be based on physical constraints, such as size and energy, as well as on quality.

Food output per acre has been rather stable throughout history, but it is increasing rapidly now, with the use of industrial measures, like fertilizer, large capital outlay for new equipment, and new technology. It may be feasible to irrigate large parts of the desert, if certain problems, such as salinization, could be solved. The per-acre yield, however, may be reaching an asymptote. Humanity is fiercely competitive and exterminates any species that robs fields. There is no real balance of nature on farms—too much is artificial in the cultivation and irrigation, which requires constant attention and control.

The agricultural revolution that began in England in the 1700s grew up with science. The other half of the revolution was capitalism. The two have not quite been compatible. They have different logics and different goals. Many times capitalism forces environmental destruction, due to the limits of the system. The gamble is to win big or lose big.

Conscious learning has reformed natural ecological organization into the conscious and elaborate design of agriculture, according to Jantsch. Humanity entered a lower order of nutrition with invention of agriculture.

It may be possible to manipulate the entire biocenotic environment to prevent pest problems. But it cannot be manipulated meaningfully unless agriculture is decentralized. But, decentralized agriculture is no solution unless efficiency is greatly increased. In the U.S. alone, there is 21 million tons of leaf waste from carrot and bean tops, bean and potato plants; that protein could be extracted for food. Although it may not be very palatable, it costs less than one-fifth as much as soybeans in India. Breeding is unlikely to eliminate all waste. In a few leafy vegetables, such as spinach, everything above ground can be eaten. Some plants, like potatoes, in which leaf and root growth are simultaneous, out yield others, like sweet potatoes, where tuber growth is only starting when leaves are failing.

Balanced land use means management based on sustained yield over a long term, inclusive of forests and marshes, also. The future depends on ecologically scaled projects, not on giant industrial land or water projects, and on the separation of large-scale industrial management from optimum-sized applications.

Since humanity is still part of the ecology, its actions can be examined in that context. New human niches have depended on this savings of capital of the earth being withdrawn for a temporary gain. Humans should not take the Net Primary Productivity (NPP) of a system, but the Net Community Productivity (NCP) or a smaller yield—that fraction which it is feasible to remove and use without destroying the basis of productivity. For grain or forest products, this portion is about 30% of the NPP (as dry mass per unit area and time). Higher efficiencies might be possible under very favorable circumstances, but the best calculations will have some uncertainty and lower yields should apply to most species. For wild animals, the kill must be lower than the trophic-level efficiency—usually less than 10% or 1% with some birds and fish. There are things that can be done to make agriculture sustainable and successful:

1. Diversify crops, especially adding drought resistant varieties. Grow wild lupine to combine with soybeans for food. Convert from intensive cattle raising to antelope farming. Grow more varieties of apples (reduce imports of apples from outside the area). Increase self-reliance on most foods (except those that cannot be grown there).
2. Develop new products from existing crops, e.g., oils, drugs, and fuels. Rapeseed, for instance, is used in hydraulic fluids, plastic film, nylon, Lorenzo's Oil, as well as vegetable oil; certainly, there are unforeseen applications.
3. Use appropriate technology (solar power, field drilling, organic growing); import less energy, possibly export some. Stress low-input agriculture; low-fertilizer and low-pesticide may result in lower gross sales per area but in higher net revenue per area.
4. Process the crop (for example, sell noodles and noodle products as well as wheat).
5. Market the crops and products locally; package them, advertise them, and distribute.
6. Form cooperatives, especially for specialized market or low volume products (beets, for instance).
7. Create a land trust to protect farm land from pressures of development, even as its market value as a nonfarm increases. A land trust could funded by property transfer tax. The land trust could lease the development rights on farmland.

For a global and regional approach to agriculture, we must calculate all set-asides first—that includes wild and restored areas, and common areas used for foraging and herding cultures. What remains is the area we can use for cities (often located on fertile soils and near rivers) and agriculture. That area should be divided into appropriate use areas, for regenerative agriculture or for large monocrops of corn or wheat. Monocrop areas, whether for corn, coffee or bananas, must be reduced. Some of those species can be intercropped in natural systems. Others can be limited by the area permitted for them. The diversity of agricultural plants needs to be enlarged by planting different strains, especially older, more traditional ones. If agriculture in converted or subsidized (by water or energy) systems should prove to be less than needed to feed the current (likely over the optimal) human population, then agriculture needs to expand into city areas, especially into vacant lots and onto the rooftops and balconies of buildings. This kind of approach assumes that the distribution systems and the will to use them already exist or can be employed.

We depend on vegetation for more than food: it makes up the content of much of our newsprint, construction, furniture, clothing, and packaging. Of course, much of the straw and slash should be left so that the system can regenerate. Furthermore, with shortages of minerals, many substitutes are expected to be organic. The ecological design of agricultural systems has to be responsible to the living communities and ecosystems. It can do that with strategies for a flexible living order that address fitness and inclusion with caution and knowledge with its power. Working within natural systems can be inspiring. Exploiting systems in ways that increase health and biodiversity can be equally inspiring.

6.6.3. *Redesigning Cities*

Cities are the chosen domiciles of most human beings. Yet, we rarely think of planning them. We need to think about cities as a form of ecosystem that can be made more self-sustaining and complex.

6.6.3.1. *Designing & Redesigning the City*

Much design has to do with solving one problem or a set of problems. Very rarely is a city redesigned to solve problems. Few cities are designed to avoid recognized problems.

One challenge for a city is to balance its inputs and outputs to minimize the effects on the residents and the environment. For example, G.T. Miller notes that for a city of a million people, there are daily inputs: Sunlight (higher or lower depending on size and shape), atmospheric deposits (), water (625,000 tons), food (2,000 tons), fuel (9,500 tons), manufactured goods (), and buildings (high or low depending on area and height and very importantly the success of the city attracting new people or businesses). The outputs do not always balance inputs: Heat leaving is often greater because of the use of fossil fuels; water may be less due to evaporation or use in processes; sewage may be high (500,000 tons) and include water; solid waste/refuse may be high (9,500 tons); and, pollutants may be significant (air only, 950 tons).

Because cities are so concentrated, and occupy a relatively circumscribed area, they require distant support systems for food, materials, and energy, as well as a smaller system for pets (monkeys, cats, canaries, or fish) and support machines, such as automobiles. This requires constantly increasing inputs and outputs.

6.6.3.2. *Refitting Old Cities*

Many cities were expansions of old trading villages or fortified garrisons. The Romans, for instance built many small military towns in France, Germany and Britain. When Spain colonized much of the Americas, the Spanish built new towns based on the Sante Fe model (in the general shape of a cross) from 1492. In old cities, corporations and individuals have built new buildings that use new strategies, such as source reduction, waste treatment, recycling of materials and water, and a shift from inorganic to organic. A building may be designed as an artificial ecosystem that can be incorporated into the surrounding ecosystems.

Many scientists and economists regard cities as wastelands, but surprising amounts of food can be grown in cities on rooftops, terraces, and empty lots (idle land in cities is commonly over twenty percent of the area). Biologists are just beginning to study wild animals and plants in cities.

6.6.3.3. *Building New Cities*

Building a new capital city is often the first thing a new nation does. The Aztec capital of Tenochtitlan was built on a island in Lake Texcoco, possibly due to concerns with territory and defense. Beijing is an example of a new city built for the purpose of starting over. In Renaissance Italy, new towns were planned and built on utopian or geometric designs. Saint Petersburg, Washington, Canberra, Tehran, and Islamabad were built as planned cities. Many of these planned cities, Adelaide for instance, were planned with a foursquare grid layout that was imposed on the site. Several cities in the Netherlands were built when an inland sea, the Zuiderzee, was reclaimed to increase territory (and reduce flooding). Many of them were placed in fertile valleys or wetlands. Brasilia was placed in the 'empty' center of Brazil. Dimitrovgrad Bulgaria was planned as an industrial center. In Canada, many new cities, such as Medicine Hat, were built where the railway company decided to put tracks. New towns were started around Hong Kong to house the booming population; many of these were planned with public housing and rail transport considered. Ireland planned several new towns in the 1960s to accommodate a growing population and new industrialization. In the same period, Japan started a series of new towns, such as Senri New Town and Tama New Town, based on the English Garden City tradition.

Many visionary architects have designed ideal cities. Le Corbusier (born C.E. Jeannerct) built cubical models of Paris. Frank Lloyd Wright designed a suburban paradise in Broadacre City. Garden cities have been proposed by Ebenezer Howard and Patrick Geddes around 1900. Some were built, often as rings around an older established city, such as Washington or London. Most of these new cities are based on the prevailing assumptions of old cities, such as having as much energy as possible and using as much land as is wanted, for buildings, roads and parks. Many of the new towns, particularly in England and the United States, were created with automobile-oriented layouts. Roads, for instance, were designed and built with no knowledge of road ecology or the native ecology. Many of these cities once were planned for an optimum population in their area, but today are proudly 'still growing!'

Growth is a problem for most cities, especially those that seem idyllic with many amenities and opportunities for work or pleasure. Unfortunately, by not limiting growth, those cities attract so many new residents that the infrastructure and amenities start to fail.

6.6.3.3.1. A Standard New City

Peachtree City, Georgia, in the United States, was chartered in 1959. It was designed to have four separate villages, each with facilities for education, recreation and shopping. It was located at the intersection of two state routes. As part of the layout, a system of golf cart paths was integrated with roads to connect homes and schools (giving the city more golf carts than any other in the world).

The city area is about 60 square kilometers (24 sq mi), with over 30,000 residents (and a density of over 1300 inhabitants per square mile). Many of the public or corporate buildings are low or one-story, as are many houses; the feel is horizontal. It could be a suburban paradise like Broadacre City.

In order to attract business, the city established an industrial park. And, companies like Panasonic automotive systems and Cooper Lighting have based headquarters or large plants there. One of the constant problems with new cities is the volume of traffic, Although golf carts were suggested to avoid some of the problems with traffic, this city has some cases of golf-cart gridlock.

Like many cities, water use has to be scheduled or rationed, and waste channeled and moved; garbage has to be collected and transported somewhere else. Areas are zoned for activities. Transportation has to be planned and replanned due to growth and changes in patterns. Police have to monitor order; crimes have to be solved. Murders, rapes, and robberies do not seem unusually high or low for a city of its size.

6.6.3.3.2. An Ecological City

The ecological city proposed by Paolo Soleri, Arcosanti, is a prototype arcology. Arcosanti is being built around a central concept: Arcology, the fusion of architecture with ecology. Arcology is one way to deal with the problems of urban life—pollution, waste, energy use, scarcity, crowding—using known physical and biological effects. Soleri is using: The greenhouse effect, which is the collection of heat behind glass; the horticultural effect, the control of select plants for shading, eating, and amenities; the apse effect, the use of shape to influence micro-climate to provide cool air in the desert in the summer without using energy; and, most important, the urban effect, the concentration of human potential through complexity and miniaturization, that has drawn constantly drawn people to cities.

Ecological cities, arcologies, are different from traditional cities, which depend on chance for amenities and build on suffering and waste for their wealth. Traditional cities have sprawled around trading or religious centers, occupying river valleys and fertile soils. Arcologies would disturb fewer ecosystems to support human populations. Being built vertically and not horizontally, and being built on less productive lands, such as deserts, scrublands, mountainsides, they would occupy less land than a similar population in an accidental city—less than one-tenth as much land. This would save established farmlands as well as native marshlands, watersheds, and grasslands. Paradoxically, because of their density and intensity, such cities leave more and better land for farming and wilderness; recycling is made easier; and transportation is shifted from motor to foot. Heavy industry and automated production is restricted to the central bowels of the city. They can be built to contain their own agriculture and waste recycling.

The construction of Arcosanti began in 1970. It is planned to be twenty-five stories high on thirteen acres, holding five thousand people. So far, but thousands people, students and professionals of diverse ages, races, and backgrounds have participated in the building the base, which includes, residences, foundries, meeting halls, green houses, studios, schools, shops, a fine arts amphitheater, visitor center, and dining areas.

Architecture is more than just a frame for keeping the weather from furniture and appliances. Soleri employs it to sensitize people to their humanness and their part in the food chain, indeed, the whole ecological network. Arcosanti is the apex of architecture and environmental design, but it is also a center for innovative thinking—through meetings, conferences, and celebrations that address political, scientific, technological, theological, and artistic issues. Arcosanti attempts to mirror the complex workings of individuals and societies in an ecological framework. It is not a single-vision solution to all things. In Soleri's words, it is an "urban laboratory" where people can learn how cities work. Soleri is the first to consider the supporting matrix, the ecology, of cities, and the first to address more psychological needs. His plans are not perfect, nor are they designed to replace all cities. But they are a first step to bring humanity into harmony with the limits of nature.

6.6.3.4. *Thoughts on Where & How*

A city could promote appropriate technology to manage resources for its region. Dangerous technologies could be reduced through wholesale substitution, if not of materials, than by labor-intensive solutions. In many old and some new cities, traditional housing should be preferred, since its form and design are integrated into the culture, it is adapted to the local climate and is usually less expensive, due to use of local materials. Much of traditional architecture is authentic and unselfconscious; its forms fit the context of place and develop in response to place.

With arcologies, and their urban ecologies, the city could change its relationship with nature; an arcology is a good solution for an urban culture, as it solves the problems of waste, resource-use, scale, obsolescence, and segregation. The placement of a new city is important. It should be sited away from flood plains and other geological threat areas. It should located be away from fertile fields, as well as from wetlands or wilderness areas. Surprisingly, the use of a single ecosystem for living, working, growing food, moving around, and creating things, disposes of many of the problems from the artificial separation of human and nonhuman systems. The city becomes an integrated ecosystem more self-reliant and stimulating.

The properties of good places could be used to help guide designs for cities. Action, for instance has to be appropriate for the scale of the city as well as the environment. Because of the complexity of interrelationships, the program of actions has to be coordinated. Ecological designs become actions to create good places, such as urban places, within a good environment modified by good cultural practices. Good places have individuality, which makes them unique. Design needs to reflect that uniqueness in all its productions, to insure diversity at the urban level. Diversity can lead to richness, which is also an important quality of good places. Good urban places offer the circumstances necessary for conviviality, that is, for all residents and beings to live together. The consistency of a place permits residents and beings to anticipate changes and disturbances. When this happens, health becomes more of an attribute of living in that place. Design needs to address health above all else at the level of good places and good cities. Healthy systems can be enhanced by ecological design.

Figure 662-1. Orchard agriculture at Altazor Forest (based on M. Fukuoka) 1999

6.6.4. *Redesigning Industries*

Industries were developed to produce material needs on a large-scale, so that more things could be supplied to more people. The scale had the effect of lowering the costs of items, so that almost anyone could afford things, such as clothing or toys that had been out of their economic reach.

Industry has special requirements that have to be met for it to be profitable. It requires capital investment, special designs, regulated labor, free materials, a directional flow, and free environmental services for renewal. Industry has effects other than low-cost or profit, which can seem like costs: People have to act as identical, replaceable machines, and they have to be regulated, due to disrespect and violence; pollution and its sometimes required, sometimes expensive cleanup responses; negative changes in the health of workers or consumers; and, the samenesses of the products.

Industrial culture has been a package deal, complete with Christian conservative virtues and Newtonian physics. The package inflates many luxuries into needs, so that the cost of a simple car becomes a need, even in a city with advanced mass transport. We can compare this package with archaic or industrial attitudes. And, we need to take apart the package to keep what is valuable and replace what has been harmful. We might take an artistic or ecological approach to rebuilding the package.

6.6.4.1. *An Artistic Approach*

The architect and designer William Morris reacted to the plain aesthetic of industry and the replacement of art labor by machinery by starting the English Arts and Crafts Movement in partnership with Edward Burne-Jones and D.G. Rossetti. The movement was a reaction to the 'soulless' machine production that resulted from the industrial revolution and a search for authentic and meaningful styles for a new approach to production. He applied his theories of hand-craftsmanship to the designs of churches and houses, as well as to designs for textiles and wallpapers. As a pattern designer, he was concerned not only with patterns based on a close observation of nature, but also patterns of work and accomplishment. Morris was concerned with preserving what was valuable in the natural and 'built' worlds, the very things that were threatened by the faceless movements, such as industrialism and modernization, with the attempt to control everything from production to prayer.

While the Arts and Crafts Movement was a reaction to industrialization, it was not specifically anti-industry or anti-modern. Quality production could be accomplished with a design, labor, tools, and machines. Workers could use machines to produce furniture and other things. The difference was in the control of the designer in all stages of production and the use of machines to supplement labor rather than replace it. Designers and workers would work together to develop higher standards of handicrafts.

Morris actually designed artifacts for machine production, as long as the process did not involve the complete division of labor and indifference to craft talent. In building a desk, for example, one person or team would handle all the legs of the piece and another all the panels; a third person or group assembled the parts, and a fourth handled the finishing work, such as paint and varnish—all according to a plan of a furniture designer, who would or would not participate in making the item. Machines would be used appropriately. The Arts and Crafts movement sought to reunite what had been ripped asunder in the nature of human work, having the designer work with his hands at every step of creation.

Although dismissed as a romantic, Morris stimulated a movement towards artistic sensibility based on ideals and principles that many people find true. His work had effects on western architecture, cottage garden design, and on the Garden City town-planning movement.

6.6.4.2. *An Ecosystematic Approach*

Paul Hawkin and others have suggested the possibility of an industrial ecology that could mimic a mature ecology in its use of recycling and wildness. Industrial designers and managers need only reduce the capital use of energy and streamline recycling. The Danish have created an example in Kalundborg. Statoil sends most of its byproducts to industrial neighbors. Sulfur to a sulfuric-acid plant, heat to local greenhouses, gypsum to a wallboard plant, gas and wastewater to a coal-fired electric utility, which sends its waste steam to Statoil and fly ash to a cement company. A flowchart with boxes and arrows might make it resemble the charts of mature ecosystems.

One problem with an industrial ecosystem might be how it fits with natural ecosystems. A related problem might be the total energy and material in the industrial system—that is, the scale might overwhelm natural ecosystems accustomed to solar energy budgets. Although we can expect many species to invade or exploit an industrial ecosystem, we need to choose them carefully so that they do not overwhelm the system.

We can use the properties of ecosystems to consider design concerns with industry, starting with 'Course.' Living systems do not display homeostasis—constant value—so much as a particular course of change in time—homeorhesis (from the Greek meaning 'same flow'), according to Conrad Waddington. The course is stabilized, not the constancy. Changes to a system are symbolized by trajectories in a multidimensional phase space or landscape. Homeorhesis is a significant phenomenon in evolution. Waddington applies it to the tendency of a process to continue in its original pattern, even if disturbed. Homeorhetic mechanisms protect the system from many disruptions. Negative feedback counteracts the effects of change to maintain the system in a steady state or homeorhetic state. A mature community is self-perpetuating and homeorhetic, with a balanced energy-matter budget.

The course exists in a natural topology with valleys and hills. The valleys occur in various shapes. Some could be very narrow canyons, others large meadows, similar to old mature earth forms, with meandering rivers. The name for a characteristic of an attractor surface in multidimensional space is a chreod, not a valley. The cross-sectional shape of the chreod describes the reaction of the system to fluctuations. With a steep slope, for example, it is difficult to divert the developing system from the bottom of valley; even with a strong force the system will return immediately as soon as the influence stops. With a shallow slope, like a flood plain chreod, it is easy to divert the system; it meanders before returning. But actually the perturbations alter the landscape itself, making a steep valley again, not just shifting the river. As the environment changes, the system changes with it.

Ecosystems have many properties and are affected by many environmental conditions. Their changes are symbolized by trajectories in multidimensional phase space; orderliness can be described in terms of constraints on trajectory courses, and these constraints are visualized as attractor surfaces. If the system starts from any condition, represented by a point in multidimensional phase space, the trajectory will move to nearest attractor surface and then move along it. If industrial design can be fit, with proper scale and energy impacts, into the order of ecosystems, then the whole system could function with minimal disruption.

Another property is identity. An ecosystem has an identity as a whole. The ontology of any living system is the history of the maintenance of its identity as a whole through continuous self-making, or autopoesis. If there were no identity, there would be no differences and so no relationships. Ecosystems are part of an unending, imperfect process, without any final state. Furthermore, the human attempt at perfectibility through self-improvement causes disharmony, which is part of the same imperfect process. Each system is a practical application to place. Unknown factors determine a large part of the operation of any system. Furthermore, there is chaos in every system; there are plagues and random frenzies. Industrial ecological design has to accommodate the uncertainty and imperfection. In grassland, industry has to be part of that grassland.

Diversity is an emergent system property. The environment has been constant enough for organic evolution, but variable enough for natural selection to be challenged. Variability challenges organisms to adjust and thrive. Variability, even in small ways, leads to diversity. Diversity, as a measure of genetic variability in ecosystem, enlarges information. A mature system needs less information, since it works toward preservation. The limit of maturity allows maximum variability between systems with slight external differences.

The industry has to enlarge the system, and increase diversity, but help the system stay within the limits of variability to preserve its basic structures and functions. The variation of climate, for instance, an external disturbance, can change the physical and chemical parameters of the forest. Acid rain causes biochemical and soil chemical reactions, which in turn provide in-*form*-ation to other organisms, which use it to regulate their physiological processes which can effect the forest, e.g., insect damage changes the level of seasonal growth of trees. Damage to trees from pathogens, or disease agents, is an internal disturbance. Industry can produce some disturbance, like any natural phenomenon, but it has to be limited to the stability and resilience of the system. The use of energy has to keep pace with the process of maturation of the system.

The property of Coconstruction suggests that the organism and environment are co-implicative, co-defining, and co-constructing. They engage in a process of self-assembly, where the complete self is the organism-environment system. Construction requires participation, complexity, and development. The process of construction involves a self-presentation offering new symbiotic relations and novelty. Novelty always enters with environmental change, which serves to maintain the openness of the system. Novelty enters with fluctuations. The “strategy” of ecosystem development is increased control of, or homeorhesis with, the physical environment and novelty—probably to protect itself from perturbations. There is a fundamental shift in energy flows, as increasing amounts of energy are used for maintenance. As more and more energy is used for maintenance, the net community production (NCP) approaches zero. The mature system becomes more efficient, as it supports a larger biomass with the same amount of energy. The food chains become more weblike, dominated by detritus chains as opposed to linear grazing. Construction depends on diversity for the reciprocal constraint. Local context allows for more rapid construction. The constraint forces species to change. Industry, when young, resembled pioneer ecosystems—as it matures, and is shaped by ecological design, it may more resemble a more mature system, with less gross productivity and a more scaled and directed productivity that fits within the limits of the ecological framework.

The property of stability is the ability to maintain the identity of a system under the flow of external forces and disturbances. Stability can be refined through the specifics of constancy, resistance, resilience, and accommodation. Stability can be related to ideas of compartmentalization, communications, richness of interactions, and connections. Ulanowicz suggests that stability might be explained by diversity flow topologies, where flow topology is a descriptor of how ecosystems develop. The stability of ecosystems, as originally proposed by Eugene Odum, becomes the result of regular flows of energy and materials. Growth and development are characterized by a qualitative formalism of increasing ascendancy, which explains the drive towards coherence, efficiency, specialization, and self-containment. Industry cannot kick any of these properties out of their courses or limits.

Productivity, the final property, is the ability to convert energy into living forms and the ability to incorporate materials into living forms. Productivity, in general, depends on the vigor, or strength or vitality or health, of the system. Health is the overall ability of a system to maintain itself under a normal range of environmental conditions (which may include hurricanes, volcanic eruptions, or fire). Health is a dynamic measure of ecosystem organization, vigor, and resilience. Organization is described by diversity and connectivity; vigor is related to the amount and speed of productivity; and resilience is a measure of reaction to stress. Too much stress, for example, leads to unsustainable patterns of behavior; continuous stress leads to a breakdown of processes that becomes irreversible—the system dies. To relate health to growth and productivity, we could say that the capital of an ecosystem would be its physical environment and its gross primary productivity; interest would be the net ecosystem productivity. Our measurements of productivity, however, are not adequate. We are measuring over a year or two only to establish a growth rate or productivity. We should be measuring over centuries.

The production percentage would be the amount necessary to keep the ecosystem healthy. Obviously, a pioneer community may change the conditions to favor a new level of the system with new components. With a goal of maturity, an industrial ecosystem could furnish some of those new components, as long as they fit into the processes that lead to productivity. This may limit the scale of industry, so that economic scales may become less important than the ecosystems scale, with its limits and long-term changes.

An ecological industrial system would be concerned with the interrelated design of the movement of things and energy, and with the creation of power and waste. If resources stayed in place then the culture in each place could specialize in value-added economics, instead of moving the raw resources around. The system could optimize the scale and style of mass production, so that some needs, such as clothing and transport, could be made efficiently and inexpensively, but to be high-quality and long-lasting (within the constraints of the need for change and fashion). The system would emphasize repair, reuse, and reassembly; in fact, this part of the system could be extended to local shops and crafts people or engineers, which would involve local populations.

6.7. *Global Problems: Global Technology*

The purpose of technology is to create a tool to solve a specific physical problem. But, this can create other problems, if the tool is inappropriate or has deleterious effects. There may be a disjunction between the effects of technology on human activities and its effects on the ecosystem or atmosphere.

There is an obvious difference between local and global problems. Garrett Hardin makes the distinction between ubiquitous problems and global problems. Although many problems, such as potholes or firewood shortages, can occur in many nations at the same time, they are ubiquitous rather then global. For a problem to be truly global it has to cause changes in a global phenomenon, such as climate or the atmosphere. A change in scale of ubiquitous problems, however, such as firewood, can lead to a global problem. For instance, if too many forests are cut for firewood (or land clearance for agriculture or for shopping centers), then the climate will change.

Global problems can be subdivided into physical and cultural problems. Although it is tempting to divide physical problems into natural and human generated, given the scale of human influence, it is too difficult to separate them definitively; humans contribute to natural trends and some trends add to human problems. Humans themselves create carbon dioxide and wastes, by breathing and excreting, and also by concentrating, burning, recombining, and synthesizing. Our activities, from hunting and growing to deforestation, transportation, urbanization, and industrialization, produce more wastes, on a larger scale than most other animals. For instance, 25-50 percent of all aerosols, that is anything ejected into the atmosphere, are put out by human activities, from deodorants to coal-powered energy plants; volcanic action adds a significant percentage.

Pollution is a cultural concept, also. Dirt is a form of pollution based on cultural classifications, according to Mary Douglas. The dictionary definition of pollution is 'contamination.′ To contaminate something, like water, is to make it unfit for use by introducing undesirable elements, such as sulfur, phosphorus or lead compounds. What makes these elements undesirable is their excess. The generation of excess wastes aggravates the capacity of biological systems of the earth to absorb and recycle wastes. So pollution, or excess waste, ruins forests, crops, and fisheries; destroys whole species and the productivity of local biological systems; and impairs the health of ecosystems and children.

Agriculture, for instance, simplifies, concentrates, and changes physical and chemical balances, which result in salinization, dirt, and evaporation. Roads and hard corridors interrupt cycles and allow increased access to the isolated interiors of ecosystems. Transportation, from horses to horseless carriages (cars), with silly choices, inefficiencies, production scales, and scrap islands, creates many forms of emissions and pollutions. Deforestation increases the scale of erosion and water pollution. Intensive meat production causes tremendous organic waste and water and air pollution.

Urbanization results in more novel elements and concentration. Common soil contaminants are chlorinated hydrocarbons (CFH), heavy metals (such as chromium, cadmium--found in rechargeable batteries, and lead--found in lead paint, aviation fuel and still in some countries, gasoline), MTBE, zinc, arsenic and benzene. Ordinary municipal landfills are the source of many chemical substances entering the soil environment (and often groundwater), emanating from the wide variety of refuse accepted, especially substances illegally discarded there, or from pre-1970 landfills. Industries increase concentration in chemical plants, coal-fired power plants, oil refineries, nuclear waste disposal activity, incinerators, large animal farms, PVC factories, metals production factories, plastics factories, and other heavy industry.

Cities expose people to new people, new ideas, and new pollutants. Is creativity increased in cities? Is the death rate higher in cities? Does madness increase? Can people control urban environments better? Can people design cities to mimic natural environments?

The ecology of cityscapes is typified by fewer plant and animal species. Water flow is a factor. Household wastes have a significant impact on the landscape. A network of corridors perforates the landscape. The number of small patches increases. There is a reduction in other kinds of patches and corridors, such as woodlot or stream. There are three imposed ecosystems with minor linkages: A natural system of primary productivity based on depauperate system with few trees and layers; simple trophic structure of birds, squirrels; a human system, with imported food and water, smaller system of carnivore predators, such as fleas, lice, and bedbugs, and decomposers, such as bacteria, fungi, and gulls; and, a distant support systems for food, materials, and energy, but also smaller system of pets (monkeys, cats, canaries, fish).

6.7.1. *Several Consequences of Technology*

The whole idea of technology, according to Evan Eisenberg, is not to eliminate work or to replace nature with synthetic artifacts; it is to restore the balance of work and leisure that hunters understood—it is to find the best way for food between the dirt and the mouth.

As technologies developed, human relationships with animals and plants changed. Hunting, grazing, and agriculture provoked large ecological disturbances. Early domestic animals were revered, but nondomestic animals were considered competitors or nuisances. Now, animals are treated as processed commodities, and wildlife is regarded as useless.

Machines are part of human ecology, like other tools. They too contribute to flows of elements, such as sulfur and nitrogen, although the machine contribution may exceed the total of all natural living and nonliving sources. Machines also increase flows of rare elements, such as lead or mercury to tens of times the natural flow. Machines also create new compounds that are suddenly introduced into a system that has no pathways to deal with them. They displace wild ecosystems, modify food webs, and create new energy flows within the system.

6.7.2. *General Problems with Technology*

Due to the increasingly widespread use of ever more complex technologies and the frequently unintended consequences, problems may arise in their use that are unrecognized or only partially addressed. Technological innovation, combined with accelerating population growth, lead to clearing of many forests for agriculture. Technology also promotes land degradation, e.g., plowing causes erosion.

The combination of cheap goods and complex tasks can lead to sweatshop slavery and unsolved wastes. Some problems are solved, but new ones are created by unconsidered use—problems such as toxic waste or radioactive waste. Time and leisure are needed for technological innovations. People stressed or starving rarely invent their salvations.

Technology has unintended effects. Technology has reduced the globe to a single, closed system, which humans can share according to their financial resources. Our direct experience of the world has become shallow, in spite of faster travel. Travel used to broaden the mind, but now it narrows it. We travel in sealed corridors like boxed goods, comforted by homogenized foods and several 'world' primary languages. Technology has distanced human experience from the meaningful time and extent of experiences. Technology or social structure can mask the internal stress from fast economic growth. Technology has made the suffering of many domestic animals invisible to consumers of animal products.

Technology can dominate other value systems. We often arrange cultures in a taxonomic scheme, sometimes based on the technologies of cultures. Thus, we have the stone age being replaced by the bronze age, then the iron age, and steel age, the industrial revolution and the post industrial and computer revolution. Lewis Mumford suggested three basic divisions: Eotechnic, paleotechnic, and the Neotechnic. Neil Postman defined three different divisions: Tool-using culture, Technocracy, and Technopoly.

Tools and technology are the chief instruments of progress. They improved our material circumstances. They were supposed to bring superstition and suffering to an end, but they can be used to increase those things. Technologies depend on information. They also control information. They were supposed to order information and let us be wise. New technologies advance to compete with old ones for dominance in a world view, so now we have too much conflicting information. Can we control or contain technologies?

6.7.3. *Physical Problems with Technology*

Is pollution a problem? What is pollution? Usually pollution thought of as materials, but what kind of materials? Things that are useless? Side-effects? Things that don't fit? Resources out of place? Things that cannot be cycled by a system? Contaminants? Poisons? Ugliness? Anything not wanted, such as light at night or noise during the day? In many cases pollution is a difficulty with density or distribution. The activity of the atmosphere generally keeps gases diluted and distributed, although particles like dust can cause problems. To some extent the activity of the ocean dilutes and distributes particles and chemicals. Land-based particles and compounds have a greater likelihood of clumping, although wind and water can spread them somewhat, for instance, when runoff dilutes salt from evaporation.

The planet has a long history of concentrating or diluting particles, as well as changing the composition of its spheres. Volcanic eruptions have added carbon dioxide, sulfur and water to the atmosphere, and molten stone to land and sea. The 1991 eruption of Mt Pinatubo in the Philippines ejected 20 million tons of sulfur dioxide, which caused 0.3C (0.5F) degrees of atmospheric cooling. Through photosynthesis, plants have added enough oxygen, often considered one of the first 'pollutants,' to change the operation of atmospheric processes, such as oxidation. Do ecosystems cause or have pollution? Or, do living organisms eventually use the 'pollution' as a nutrient? Animals add carbon dioxide to the atmosphere and chemical wastes to their habitats. Inadequate recycling of plant and animal matter, over a long time, can lead to peat, coal and oil deposits. Although these materials can be poisonous, because we regard them as resources, we do not consider them as pollution. Pollution seems to have to be a nonresource and nonneutral to be pollution. Perhaps it is the dose, as Paracelsus said about poison.

6.7.4. *Challenges to Technology*

6.7.4.1. Nature-dominated Changes

The dynamics of the planet, from tectonic motion to volcanic activity and storms, creates change and challenges for individual organisms and ecosystems. Climate change can be 'caused' by changes in orbit of the planet. Milutin Milankovitch (finally translated in 1969) identified three principle cycles that cause variability in the planet climate. The longest is the elliptical orbit of the earth around the sun, a 100,000 year cycle. Thus, intensity of the rays varies during parts of the year. In 2004 only a 6% difference between January and July. The second cycle is the tilt of the earth on the axis, which varies from 18 to 24.4 degrees. The cycle is 42,000 years. The third is the wobble of the earth on its axis. The cycle is 22,000 years. At extreme of cycles, variation in sunlight is less than 1/10th of 1 %. But that can change temperature by 9 degrees F. These cycles can cause an ice age only when continental drift puts land near the poles.

The meteor event about 65 million YBP changed the conditions for dominant dinosaur species and permitted smaller organisms to eventually dominate. The 55 million YBP, event, which heated the surface of the planet from 9-18 degrees F. Oceans had become much more acidic, indicating CO_2 was absorbed. There were massive extinctions of forminifera. In 2004 researchers found that 1650 to 3300 gigatons of carbon had been injected into the atmosphere by ocean gas, from 500 PPM to 2000 PPM, from a nature gas release under the ocean. It took 20,000 years to reabsorb the CO_2 mostly by surface plankton blooms.

Maunder minimum of sunspots affects weather. During the period 1645-1715, Europe's temperatures plummeted. Changes in the galactic environment, such as the solar system passing through a dust lane, can contribute to the increased in solar radiation, as the sun attracts more matter.

When the changes are gradual, most life forms can adapt to them. When the changes are sudden or rapid, many organisms and systems cannot adjust and collapse.

6.7.1.1.1. Climate Change

The climate has changed in large, millennial pushes. Some of the pushes, which seem to come from communities of living organisms, can contribute to instability and change, as when bacteria and algae essentially pumped large quantities of oxygen into the atmosphere. Other organic pushes can contribute to climate stability. For instance, about 540 million YBP, living things began building skeletons of carbonate, as they absorbed CO_2 from sea water. This factor alone has made ice ages more rare.

Andy Ridgwell and colleagues argue that the shell-forming plankton of 300 million YBP stabilized the planetary thermostat. Planktonic calcifiers changed the positive freezing loop because they were not tied to continental shelves; they floated in the ocean, which prevented too much CO_2 absorption and further cooling. About that time forests were starting to cover the land. This tied the carbon cycle down somewhat. In another example, modern coral reefs of 55 million YBP drew volumes of CO_2 from the atmosphere. About 1 million YBP, the ratio of forests to grasslands affected the climate, especially water regimes. Even now, in some African savannas, elephants work to keep forests back. Removing elephants will likely shift the ecosystem towards trees.

In the past 12,000 years, climate change, especially after the last ice age, has caused the collapse of many agricultural civilizations. As areas became more open and grassy, there were fewer wild animals. In Europe the tundra was replaced by forests that reindeer did not like.

A shift in the orbit between 10,000 and 4000 BC brought 7-8% more sunlight to the northern hemisphere. Rainfall in Mesopotamia increased 25-30% and increased available moisture by about 700%. But, after 3800 BC the orbit reverted and the rainfall pattern changed. By 3100 BC this forced changes in tilling fields and double-cropping, as well as with specialization and irrigation canals. The city became a key adaptation to drier climates.

6.7.4.1.2. Global Warming

Global warming is an unfortunate term, as it might imply a gentle toasting or tanning. It also implies a comfortable, warm future where plants grow more and people need less heat from coal. Global 'burning' or 'suffocation' might raise more alarms. How we use language influences our priorities. People in glass houses should not throw rocks, and people in greenhouses not throw coal on the fire.

Did the megafauna in North America and Australia die out about 13,000 years ago due to global warming, or from stress or overhunting? In earlier periods, such as the Jurassic and Cretaceous, was it warmer than now? Was that because of global warming?

How stable is the atmosphere? Do coral reefs and forests make it more stable? Do industrial processes make it less stable? Do the characteristics of life cause things to fluctuate more or less? Including human actions? At what point does climate become global warming? Does global warming exist? Is it a symptom, problem, or nothing? Are green houses gases increasing? Is the average annual temperature increasing? Is it a positive feedback system now? Is it too complex to understand?

Is global warming bad? For us? For our companions plants and animals? For the Planet? Should we try to control it? Will it reverse on its own and head towards another ice age? Can we control green house changes? How could we try? How do we know if we can? Should we try anyway? What kind of behavioral changes could we make? What kind of technical things could we do? Mirrors? Ocean Doping? How would they work? What other effects would they cause? What is the worst that could happen?

We can measure overall warming of the atmosphere; it is warming. We can measure the increase in temperature, as well as heat content, in the ocean and on land. Drought, fires, and air pollution have contributed to global warming. Global warming makes ecosystems more vulnerable to long-term changes in precipitation patterns. Inadequate rainfall may lead to more droughts and fires and then to more global warming.

6.7.4.1.3. Carbon Dioxide Increase

The amount of carbon dioxide in the air has changed dramatically over millions of years. In the past, concentrations of CO_2 were much higher, perhaps 12 percent, rather than the 0.00038 percent today. It was quite high at one time, due to volcanic action. It has been much lower as systems matured during and after the ice age. We now can measure human additions to carbon dioxide in the atmosphere. Carbon dioxide is a molecule that can hold heat in the atmosphere, due to its chemical shape and characteristics. CO_2 is also a trigger for a more powerful greenhouse gas, water vapor, since heating allows the atmosphere to take up even more water. Heat travels where CO_2 is effective. If the earth were a black billiard ball, then doubling the CO_2 would raise temperature 1.8 F. However, because it is wrinkled and wet, and plant and cloud covered, doubling the CO_2 would increase the temperature exponentially.

Carbon dioxide is very long-lived, over 100 years, and 56% of it from industrial processes is still aloft. CO_2 interacts with water vapor, methane, and sulfur, affecting how those gases retain heat or contribute to cloud formation. CO_2 is good for some plants, mostly trees. But, plants in extra CO_2 have tougher leaves, less nutritional value, and higher amounts of defensive chemicals. One species that will benefit from changes, especially; mosquitoes will spread malaria rainfall in some places, will be parasites.

The CO_2 is already in the air. We have no way of getting it out. So, the course of climate change is set for next several decades. Significant CO_2 is removed through natural processes, which also generate quantities of CO_2. We could remove quantities, but it would be expensive, and may not be at a scale large enough to be effective. We do not know the threshold for anthropogenic change, but it can only be 2.3 F or so according to S. Schneider.

6.7.4.1.4. Ocean acidification

Oceans are becoming more acidic. This has influences on CO_2 uptake rates and on the health of animals and plants. Applied fertilizer, usually anhydrous ammonia, which is oxidized to nitrates, can acidify the soil. Erosion from these soils can increase ocean acidification.

6.7.4.1.5. Nitrogen Pumping

Although the bulk of the atmosphere is nitrogen, only a few physical processes, such as lightning, and a few biological processes, such as leguminous bacteria, can make it available for plants to use. The rate of removal from atmosphere is many millions of tons per year. The nitrogen cycle pushes nitrogen through the compartments of the vegetation and soil, from the actions of precipitation, leaching, fixation and other processes. The cycle is relatively slow (See Section 3.1.3.1 and 3.2.4). The biogeochemical cycle of nitrogen has stayed within certain limits for many millions of years.

Although we probably will not significantly alter the nitrogen cycle, we can increase nitrogen losses through activities such as clearcutting. Synthetic fertilizers and the combustion of fuels adds another 100% of reactive nitrogen to the biosphere. We can increase available nitrogen by adding fertilizers to agricultural fields.

6.7.4.1.6. Phosphorus Loss

Phosphorus, like nitrogen, is an element closely associated with life, and living processes preferentially concentrate it. Phosphorus runoff is a problem. The phosphorus cycle essentially runs into the ocean, as a sink, at a relatively high rate, and is returned to land surface by geological events or smaller events such as fish predation by birds and animals (See Section 3.2.5). Another smaller sink for phosphorus is guano deposits. Organisms keep phosphorus in a relatively closed system, which keeps it from entering sinks.

Phosphorus is a limiting nutrient for life. Too much of it in one place, or too little, can cause problems. We are increasing phosphorus 12-fold in systems. Waterborne phosphorus and nitrates cause eutrophication of streams and lakes, and even some estuaries and seas (and this can affect the albedo of the planet).

6.7.4.2. Human-dominated Changes
Human activities, especially from agriculture and industry, have the effect of precipitating other changes. Our farms, fields and mines can dominate an entire landscape. Our roads dominate landscape patterns. Even new technologies of wind and solar farms, because of the scale of energy use, are starting to dominate coastal or sunny landscapes.

6.7.4.2.1. Land Conversion
We have converted a large percent of wild forests and grasslands to cropland (currently about 12 percent by area). We have converted wild, old-growth forests to modified forests and tree plantations. We are converting rich estuaries and shorelines into fish farms. Much of the destruction of land can be traced to our ignorance of ecological connections and to our inconsiderate use of gigantic machines and tools, using unlimited amounts of fossil fuels.

6.7.4.2.2. Biodiversity Loss & Extinction Increases
Currently, 100 species per million per year are entering extinction. The extinction of species is certain, and there is a high degree of certainty. Temperatures of mountain habitats are easily measured, as are conditions that mountain species can tolerate. As climate warms cold-tolerant species have nowhere to go but up, and we know the height of the mountains. We know the planet will heat by 2 F this century, or 5 F, if business and industry are conducted as usual. Chris Tomas et al. found that at the lowest degree of global warming (1.4-3 F) about 18% of species are 'committed' to extinction. At higher rates the number goes up: 3.2-3.6 F then 25%, over 3.6 F then 33%.

6.7.4.2.3. Chemical Pollution
Chemical processes driven by solar energy let complex molecules build up. Chemical orders underlie the biological order of life; one self-replicating molecule allows life to continue. The science of chemistry has been able to make wonderful advances in materials, from nylon stockings and parachutes, to replace silk and hemp. Many new materials were based on hydrocarbons from oil. The new molecular patterns, however, did not react by degrading in natural ecosystems; there were no predators capable of consuming the molecules as food.

We are not sure what the minimum or maximum values are for various chemical elements in biogeochemical cycles. If the cycles continue, the elements should be enough. Elements, however, exist in nested environments. Smaller pools of elements are more vulnerable to interactions with pollutants. The pollutants themselves often have longer life spans than complex molecules. Pollutants get concentrated in the environment.

Sulfur dioxide (from blast furnaces) causes tissue degeneration and interferes with enzymes in plants. Sulfur pollution can kill entire forests; the Norilsk Nickel Combine in Russia has killed over 4000 square kilometers of larch forest and serious affected another area of equal size with its sulfur emissions. Sulfur pollution from burning coal and oil in factories in the Midwestern United States combines with rain, fog or snow to make acid rain in New England and Canada (only recognized since 1972), 100 times as acidic as normal, causing declines in crops, sugar maples, and forests.

Although there are a few chemical responses to pollution, such as liming the ground around pines against acid rain, they are expensive and difficult to apply. The prevention of pollution remains the best option.

6.7.4.2.3.1. *Stratospheric Ozone Depletion.* Ozone has an annual metabolic flux of millions of tons. Ozone, with three oxygen molecules, is created from the action of lightning discharges, making a lucky coincidence for life on land; before an ozone layer started forming, the solar emissions like ultraviolet light were too dangerous for animals to move to the surface of the planet. On the ground, however, ozone is a pollutant that can cause tree death by reducing root and leaf biomass. With sulfur dioxide, ozone can influence ecosystem health. Low-level ozone, mostly from electrical and machine discharges, can damage crops like wheat and soybeans (approximately $40 billion in 1988).

Stratospheric ozone can be depleted by a variety of pollutants, such as methyl bromide or chlorofluorocarbons (CFCs). Methyl bromide is used for fumigating logs, as well as tomatoes and strawberries. Lighter than air, it drifts into the upper reaches of the atmosphere. CFCs, originally used as refrigerants, pose another danger, a long-term, broad-spectrum, invisible danger. They accumulate in the stratosphere, where they are broken apart by sunlight and react with ozone. Worse, the CFCs absorb wavelengths that carbon dioxide does not. Far worse, a single molecule of CFC-12 traps 20,000-times more heat than one molecule of carbon dioxide. The marvelous science of chemistry cannot seem to be dissociated from the dangerous of its applications. Although banned in most nations for the past decades, CFCs can last 75-110 years in the atmosphere. Since the ban, the ozone layer is stabilizing.

6.7.4.2.3.2. *Aerosol Loading.* An aerosol is a suspension of particles in a gas. The particles can be molecules, pollutants, or viruses. Insecticides, paints, hairsprays, and drugs are spread with aerosols. Often the propellants, hydrocarbons, are or more dangerous than the particles, creating regional particulate concentrations in atmosphere. Other chemicals used for cleaning medical instruments or electronic parts, especially terpenes, end up in the higher atmosphere. Maximum quantities for these have not been set, although related with ozone depletion.

6.7.4.2.4. Water pollution

Water is a universal solvent; it is such a great solvent that absolute purity is only a theoretical goal; even highly distilled water contains gases and solids. The fresh water we drink contains about 1% solution of carbonates, with various nitrates, silicates, minerals, compounds, and trace elements. These elements in normally pure water are absorbed by plants. Obviously, pollution is the fault of water.

6.7.4.2.4.1. *Biological.* Although many animals, such as cattle and sheep are raised on ranges, they often spend months in feedlots being fattened with grain for human consumption. About 95 percent of this food goes for respiration or ends up as manure, which overwhelms natural forms of recycling. Many domestic animals, especially kept in intensive conditions in feedlots, produce many tons of feces, which piles up in mounds, before leaching into the water table and polluting water. Free range domestic animals can compact soil and seedlings, reducing grass or forest reproduction. Normally, dung beetles or termites remove the feces, although they often cannot cope with the wastes of that scale.

6.7.4.2.4.2. *Runaway Plastic Nurdle Concentrations.* Charles Moore, sailing in the North pacific subtropical gyre (one of 5 high pressure areas in the world) found a floating trash island that went on for thousands of miles (perhaps twice the size of Texas). The gyres cover 40% of the ocean or 25% of the entire planet, and all of them are attracting islands of trash. Much of Moore's 'island' was made of plastic, from fully formed pieces down to small nurdles. Plastic is a petroleum-based mix of monomers shaped into polymers. Other chemicals are added for inflammability or suppleness. Plastic is replacing iron and glass as containers; it is lighter and more easily molded. Every year we produce 450 million kilograms of 'phthalates' used to make plastic soft and pliable (known to be toxic to human reproduction systems). They can leach from packaging and coatings. In some food containers and plastic bottles, phthalates are found with a compound bisphenol (BPA). We produce 3 billion kilograms of BPA every year.

Only 3-5 percent of plastics get recycled. Glass and iron are more easily recycled. PET and HDPE (numbers 1 and 2) can be recycled. Plastic retains pollutant and gives off deadly vapors. Products made from plastic recycling are limited to carpet and boards and jacket linings. Except for some incineration every piece of plastic made still exists. Recycling also uses resources and energy and creates pollution. But it does reuse resources and it is wiser use.

Plastic does not biodegrade, it crumbles into smaller fragments. Plastic can decompose in seawater. And it can contaminate marine live at the molecular level. Samples contain styrene monomers, dimmers and trimers (which seem carcinogenic in mice). Plastic is moving into the food chain. The danger is eating it or becoming entangled in it. There are miniscule pieces of plastic, called nurdles (lentil-size pellets of plastic in raw form), in the water. By weight, it can total 6 times more than plankton. The pollution seems invisible and ubiquitous. They are easily mistaken for food, can be ingested, and can screw up genes. They disrupt the endocrine system, so that some male fish and gulls have female sex organs.

Like sand on a beach, the entire biosphere gets mixed with plastic particles. These particles change the properties of water and soil. Plastics pollution at this level and scale is almost completely unrecoverable for recycling or breakdown (from burning or solution).

6.7.4.2.5. Freshwater Drawdown

Rates of human consumption are tremendous (km^3 per year). Aquifers many thousands of years old are being drained. We are using almost all of peak water in every system. Peak renewable water limits are the total renewable flows in a watershed. Peak ecological water is where, in any hydrological system, increasing withdrawals reaches a point where any economic benefit is outweighed by the ecological destruction caused by the action. Furthermore, the efficiency of use is poor and needs to be improved; in parts of the Balkans, over 50% of the water is lost through broken pipes.

6.7.5 *Cultural Problems with Technology*

Part of the problem with technology is the lack of limits in a culture. We rarely deny a new technology, before we come to depend on it, and thus become trapped by it. Technology has greatly increased the kind and quality of materials used for buildings and machines, especially plastics, aluminum and other light metals and silicon constructs. Yet, the scale of technology produces pollution that reduces the productivity of natural and agricultural systems.

6.7.5.1. Risks & Threats

Effects become problems, if they are too large, cause interference, or are not understood. Problems become threats if they are not solved within a required time frame. Threats to our survival rise from a disjunction between our powerful technologies and the wisdom to understand the effects and limit their use. Threats to human survival include: Environmental degradation, extinctions, climate destabilization, nuclear weapons, terrorists, and use of untested technologies. They seem to become threats when we underestimate the risks of applying industrial processes to global scales.

We are too insulated from small real danger, although not global slow invisible ones. We just do not recognize them. We have problems with scale. We have a human scale, based on our body and images, but this scale is not favored by much of the universe. The problem of using metaphors between scales is that we can miss the significant changes between scales.

6.7.5.1.1. Risks

Natural processes pose risks to every culture or nation that depends on the constancy and stability of the environment. Flood, earthquakes, volcanic eruptions, and droughts for example are not regular or predictable. In the Sahel and Mesopotamia, the argument was that overgrazing and human population caused the droughts. Exposed soil contributed to hot air and changed albedo and no rain-forming clouds. For the Sahel a single variable made most of the difference. Rising sea surface temperatures of the Indian Ocean, from greenhouse gases, was responsible for most rainfall decline. We focus on political, religious and behavior first, but find that sometimes environmental changes are culpable.

Agriculture and permanent settlement increased the risks of drought. The inventive agriculture entailed a transformation of how people change their mode of life to one that entailed a greater risk and vulnerability. Larger sedentary communities subsisted on a few staple crops but these became prone to long-term fluctuations in rainfall floods and weather. These communities also began to impact the surrounding areas through the intensive use of wildlife and wood. This lead to waves of intensification, extensive occasion and the current expansion of the labor force.

Because of an increase in risk and uncertainty by living in a place, religious ideologies and management strategies achieved a reduction of that risk and uncertainties some extent by linking communities in a network. This also led to a disparity in wealth and power between workers and those affiliated with power. This situation has only gotten worse.

Urban centers became linked with religious establishments and administrative institutions quite early in history. The current environmental crisis is bonded to urban agglomerations that were unimaginable in earlier times; these cancerous expansions of urbanization have placed humanity at unprecedented risk. Although the system is capable of serving humanity through judicious integration of food resources and distributions to ensure equity in harmony with ecological resilience, it has in fact led to disruptive, disastrous consequences as certain urban centers, especially in industrial areas, use the world for ruin the short-term gain.

Every civilization encounters a risk spectrum, which may push the civilization to find new increases in the area food or energy. The need to solve such risks pushes the system further from its original state sometimes at increasing speeds. The conjunction of long-term risks can be called a crisis. Human beings often begin by adapting themselves to the dynamic of the environment. Over the long term, however, they modify these dynamics to suit themselves. They appropriate the environment by reducing its complexity in exchange for the increasing complexity of their societies. There does not seem to be returned from complexity. In this sense complexity is a trap. People cannot stop investing in knowledge and the system that they have modified. The current crisis as well as many in the past, is primarily a function of how people trap themselves by coming as close as they can to the limits of the environment. This of course is a form of trap, made worse as risks enter a spiral.

A risk spiral results from the transformation of environmental complexity into social complexity. Human actions therefore can create new risks and risk spirals to occur. The deep-time perspective can reveal proximate and ultimate causes of the collapse of systems. Social and annotations or cultural traditions that may appear in efficient or illogical in the short-term may reduce risk and increase resilience in the long term. The risk is driven by human cultures attempts to cope with risks or to exploit opportunity. The process involves more management of the environment and although different parts of the environment operate in a range of scales, most of the natural dynamics and landscape occur slowly by comparison with human dynamics. As a result humans adapt themselves to the immediate dynamics of the environment at the beginning, but over time cultures serve their own needs by modifying the environmental dynamics. Human cultures thus become dependent on colonized systems, which require certain social institutions, especially those involved in organized production and storage.

Machine technology can reduce risk, as can management expansion. However, if the risks are perceived as smaller, then people take more risks (sometimes a challenge or danger is more fun than a safe, optimum environment). If every hot or sharp surface is labeled or protected, people can be surprised when they get hurt. In one sense, knowing dangerous conditions is enough to encourage people to act in a safer manner. Is technology then a trap also? We are too insulated from real danger, although not from global, slow, invisible ones. Those we just do not recognize.

6.7.5.1.2. Threats

What are the greatest threats at the moment? Climate change or species extinction? Social equity or levels of luxury? Humanity, in most cultures, seems to be treating the threats as problems and pushing them forward to the next generation to solve. Although we act as though we cannot tolerate risk, we are willing to accept a very high level risk for the next generation and the planet itself. Threats to our survival rise from disjunction between our powerful technologies and the wisdom to understand the effects and limit their use. Threats to human survival include: Growth in demand for resources; exponential growth in population; transformation of the atmosphere, geosphere, hydrosphere, and biosphere; conversion of wild ecosystems into domestic; deforestation; release of pollution into land, air and water; environmental degradation through use; extinctions; destabilization of systems and cycles; the release of novel substances into historical systems; the use of untested technologies; the use of highly destructive technologies from giant earth movers to nuclear weapons; uncontrolled genetic changes; economic failures; social failures; cultural error or inflexibility; the use of violence or terrorism to achieve social objectives—obviously, this is not a complete list of threats.

Some of these threats are the result on unconsidered growth of population, demands, and conversions; the scale is far more damaging than just the activities. Other threats have to do with the unconsidered use and scale of technology. Many have to do with our personal and cultural failures to understand the system in which we are embedded. Humanity seems to be amazingly poor at predicting what important issues are going to be important with in the next 30 years. For example, the 1972 Stockholm conference on the human environment did not mention major threats such as mass extinction of species, tropical deforestation, desertification, ozone depletion, or climate change.

6.7.5.2. Problems of Civilization

Civilization has become so beneficial and desirable that we do not question its direction, size or momentum. But, internal problems have major effects on how civilization as a whole, not just its technological brilliance. The external problems affect regions and the planet.

6.7.5.2.1. Growth & Momentum

Unending economic growth is emphasized in some economies and cultures. Yet, growth can cause a community to fall out of balance or scale with its surroundings. And, being out of balance can lead to massive disruptions.

Population growth, even if not combined with technological innovation, can lead to greater deforestation and land conversion for agriculture and urban areas—which pushes the regional systems further out of balance. Economically, we reason that growth is necessary for living standards to rise, and individual self-interest has proved to be a stronger motivation than patriotism, altruism, or recognition. Modern economics depends on economic growth to avoid crisis. The major premises assume that the population will grow, social good is related to equitable distribution of material products, and if resources are limited, technology will erase the limits. A large literature has treated perpetual growth as the only conceivable state of affairs. Kenneth Boulding suggests that it is a short-lived 'cowboy economy.'

According to Boulding the greatest source of the differential is different rates of accumulation of knowledge, capital and organization; the rates are essentially internal properties of cultures. Although a minor element in terms of transfers, it is a large psychological perception, which may need to be compensated for in a global community.

However, gross production may not be as desirable as thought. The world prices of food and industrial raw materials have increased far more rapidly than those of manufactured goods. It can be seen that economic growth is not equal to progress.

6.7.5.2.1.1. *Growth & Stability***.** Most economists assume that further industrial growth will continue, that economic growth is good, and that this growth solves human problems as long as it is organic. A positive linear increase is generally steady, such as food production. Exponential growth is said to be bad, and organic growth is said to be good. In fact, although organic growth is better, there is little difference during a world crisis—both reach asymptotes of suffering. One need only regard the population crashes of lemmings and others to see how organic growth can go wrong.

The economy has been growing almost constantly since it has been studied. We have been trying to force it to grow, rather than let it stabilize or contract. Some have argued that contraction causes losses and suffering; yet, growth has caused exponentially more losses and suffering. Many economists confuse growth with development. Some theorists, like Samuelson, have concluded that growth is necessary to rid the economy of disparities. Even if it stopped growing, the economy could still develop.

6.7.5.2.1.2. *Size & Impetus*. The larger a moving thing is, the more momentum it has. Stars have far more momentum than snowballs. Perhaps big science and big technology have too much momentum. Theodore Roszak acknowledges its schizoid attraction and repulsion, with the twin promises of glorious accomplishment and hideous death. Who could escape being torn between yes and no, if even our end would shine with radioactive, Promethean grandeur? Our image of big science—the scientist as tragic hero, isolated in chaotic nature, but strong in his proud individuality, perhaps driven to research by hubris and madness—is a barrier to any new vision, especially a small vision.

We cannot imagine beauty in the old and messy nature, and we are afraid to try to do without luxuries or to try to sacrifice anything to try to change the momentum of industrial civilization.

The only remaining purpose can be the total destruction of the combatants, as nations, as well as natural habitats. Sadly, the only people who do *not* know this, or admit it, are those in decision-making positions, who are compelled to prepare for what they subconsciously know would be a terrible disaster. Their power has trapped them in the momentum of their nation, afraid to be caught in any criticism. Yet, they direct the money, skill, and knowledge of their citizens into projects that lead to misery, servitude and hideous death, and not to life, liberty, and happiness.

Our civilization is based on its early momentum for success. We could pray it never stops. But, we could stop it and change direction.

6.7.5.2.2. Technology & Technopoly

Technology has reduced the globe to a single, closed system, which humans can share according to their financial powers. Our direct experience of the world has become shallow, in spite of faster travel. Travel used to broaden the mind, but now it narrows it. We travel in sealed corridors like boxed goods, comforted by homogenized foods and a few common languages. Technology can mask the internal stress from fast economic growth.

New technologies compete with old ones for dominance in a world view. The medium of technology contains an ideological bias. Tool attacks tool, according to Neil Postman; printing attacks manuscripts, television attacks printing, painting attacks rock art, and photography attacks painting. Postman refers to this fight for dominance as technopoly, and defines technopoly as a form of cultural AIDS—a cultural immune system is inoperable. The immune system protects the body against invasions and uncontrolled growth of cells.

The change to Technopoly may have started with James Watt's invention of the steam engine in 1765. Adam Smith in 1776 justified the transformation from small-scale, personalized, skilled labor to large-scale, depersonalized, mechanical mass-production. He argued that money, not land, was the key to wealth. In a technocracy, an unseen hand would eliminate the incompetent and reward the efficient. Several years later, Richard Arkwright, a barber, developed the factory system in cotton-spinning mills, where he trained children and others to conform to the regularity of the machine. It was the first mechanization of production. Twenty-seven years later, the power loom eliminated skilled workers altogether. Every ten years a new invention changed industry. Whitehead thought that the greatest invention was the idea of invention.

Technologies, in a technopoly, make other things invisible. This has the effect of eliminating them from consideration. Now, instead of being the most important of things in a culture, the invisible things, like the environment, become the irrelevant and useless. Other things, like religion art and history are redefined. August Compte and others argued that things that could not be seen were unreal and undeserving of attention.

Technopoly is dismissing philosophies and traditions, as well as moral democracy and cultural beliefs. Not having a transcendent narrative or moral order, technopoly has to depend on techniques for control the information from technology. A bureaucracy is one filter. Bureaucracy is a technical solution to the crisis of control. It is administrative not governmental, as de Tocqueville recognized them. A bureaucratic form restricts information to what is asked or can be put in boxes. It is to make the use of the information efficient. Bureaucracy is independent of culture. It is a very low-context extension. It also has no intellectual, political or moral theory. Detachment allows one to escape responsibility for the consequences of decisions.

Humanity becomes an autoparasite, a new pseudo-species. Technology enlarges the number of niches for us; tools fit humans to different habitats, displacing other species. We steal from animals and plants, from the earth, from our own descendants. But, science and technology are spiritually impoverished, divorced from awareness of values and purposes. Technology must be placed in perspective. The analysis of complex problems is beyond the specialist as is the synthesis.

By the time of the Frederick Taylor system of scientific management, in 1911, the primary goal of human labor and thought was efficiency, not the production of goods. Technical calculation is superior to human judgment. Humans are at the disposal of technique and technology.

Why did it work in America? The American character of wonder and frontier life. The audacity of American capitalists in robbing America's past and heritage. Providing people with abundance and comfort. Old beliefs were discarded and history was disconnected from change and the future. Technology was something to believe in. Never made mistakes (only humans did). Antibiotics always cured. Airplanes always flew. Well, maybe not now.

Science and technology are the chief instruments of progress. They were supposed to bring superstition and suffering to an end. Technologies depend on information. They also have to control information. In technopoly, according to Postman, cultural symbols are trivialized by corporate enterprise. Symbols become common place by use in television and movies. The promiscuous use of images may seem like irreverence, but it is worse; it is trivial overexposure. Should all symbols be used for commerce? Is that okay? Technopoly tries to fill the void of dead narratives with its idea of progress without limits, improvement without costs, and rights without responsibilities. Society can be engineered is a thing of technopoly.

Science and technology are spiritually impoverished, divorced from awareness of values and purposes. Technology must be placed in perspective. The analysis of complex problems is beyond the specialist as is the synthesis.

6.7.5.3. Economic Problems

Economics posits rational actors in economically efficient optimization policies who would spend only as much money averting global warming as would be lost to costs. Efficiency here is not about death or destruction but finding the least cost and highest return solutions for the business of life. Saving the commons however is a serious market failure because it depends on morals not profits. Institutionalists argue that more is needed, such as better organizations and norms, which go beyond the market. Climate change could slow progress, and science is uncertain. More cooperation and better organization are needed.

6.7.5.3.1. Consequences & Costs of Pollution

The industry gadfly Dixie Lee Ray claims that the 'side effects' cause us to worry to the exclusion of considering the benefits of a new technology. Her example of the internal combustion engine is ambiguous. In fact, it has had great undesirable effects on society, regions, and the planetary atmosphere. Pollution is not a side effect here; it is an equal effect, along with mechanical power. The costs of air pollution are staggering: $40,000,000,000 in health care and lost productivity in the U.S.; $4,000,000,000 from ozone damage to wheat, soybean, and peanut crops; $5,000,000,000 from acid rain damage to agriculture, forests, and aquatic systems; and destruction of 20 percent of European forests (figures from the Worldwatch Institute, 1988). Other pollutions are as bad. The oil pollution of the oceans from spills as well as the continuous discharge of poisonous sludge (up to 17,000 gallons per month per supertanker, including the BTX compounds—benzene, toluene, and xylene) and toxin-contaminated water kills thousands of animals and fish every month (including salmon and sea birds with concentrations of metals—zinc, chromium, and cadmium).

Airborne pollutants have increased world-wide, according to a 1982 UN report by Dr. M. Tolba, Executive Director of the UN Environmental Program. Although some forms of pollution may have lessened in some industrial countries, the U.S. and Britain, for example, due to lawful control measures, other forms of pollution, such as acid rain, have increased dramatically everywhere, threatening fish, trees, crops, and buildings.

Air pollution, with acidification and toxic substances, has been implicated as a primary factor in 'forest death syndrome, first noticed in Germany and other parts of Europe. There is overwhelming evidence of pollution-caused death in Europe and eastern United States. The fact that there are other causes that work independently or with pollution does not invalidate the other evidence. To argue so, as some scientists do, is based on a logical fallacy, the semantic fallacy of complexity.

The costs of Modern industrial Farming in England, for instance, are applicable to China and other nations: Two billion dollars for removing pesticides from drinking water, damage from soil erosion, medical costs of poisoning and mad cow disease (90% of what farmers earn); $0.4 billion for subsidies to farmers (180%); $0.1 billion for healthcare costs for poor choices (45%); and, $3 billion at least in loss of productive land.

The costs of industry are more subtle, but equally expensive: Unhappy people act as identical replaceable machines; people are tightly regulated (leading to disrespect & violence); cleanup of pollution is prohibitively expensive (especially compared to prevention); Cleanup; health-related problems are almost too expensive (only the complexity of the effects of mixed pollutions prevents a violent revolution against industries); and, the boredom of sameness is impossible to put a price tag on.

6.7.5.3.2. Effects on Human Health & Ecosystem Health

Pollutants can contribute to or cause diseases, including cancer, lupus, immune diseases, allergies, and asthma. Pollutants can cause levels of irritation leading to death. Higher levels of background radiation have led to an increased incidence of cancer and mortality associated with it worldwide. Some illnesses are named for the places where specific pollutants were first formally implicated, for example Minamata disease, caused by organic mercury compounds.

Bad air quality can kill. Ozone pollution can cause sore throats, inflammation, chest pain, and congestion. Oil spills can cause skin irritations and rashes. Noise pollution induces hearing loss, high blood pressure, stress, and sleep disturbance. Contamination caused by pollution can have damaging effects in the brain and central nervous system. Studies have shown that brain of animals actually shrink from prolonged exposure to contaminants in the environment. Humans can become stupid.

Changes to the environment can lead to disasters and collapse. A few human environmental disasters include: Mesopotamian soil salinization, 3300 BC; Chinese soil erosion, 3000 BC; Deforestation of the Mediterranean, 500 BC; Deforestation of Rapa Nui, 1400 AD; and, the US Midwest Dust bowl, 1930s. These are signs of a decline in the health of these ecosystems.

The consequences of land degradation are many. Reduced productivity results, for instance, productivity has been reduced by one-third on half of India's soils. Salinization in the Middle East and on most irrigated lands means that many crops can no longer be grown; for instance, 34% of land in Bangladesh affected, and this has quadrupled since 1990. On-farm expenses have risen 100%. Over 7% of the agricultural productivity in SE Asia is lost. Off-farm expenses balloon. Air and water pollution, road damage, desertification, cleanup costs, and health costs keep increasing. The loss of biodiversity and ecological services continues. Increased energy costs affect personal lives and industrial improvements.

6.7.6. *The Example of Plastics as a Serious Problem of Pollution*

Sailing in the North pacific subtropical gyre (one of 5 high pressure areas in the world), Charles Moore found a floating trash island that went on for thousands of miles (perhaps twice the size of Texas). Much of Moore's 'island' was made of plastic, from fully formed pieces down to small nurdles. The gyres cover 40% of the ocean or 25% of the entire planet, and all of them are attracting islands of trash.

Why didn't the plastic break down in to its component elements? Plastic is a petroleum-based mix of monomers shaped into polymers. Other chemicals are added for inflammability or suppleness. Plastic is replacing iron and glass as containers; it is lighter and more easily molded. Every year we produce 450 million kilograms of 'phthalates,' used to make plastic soft and pliable (known to be toxic to human reproduction systems). They can leach from packaging and coatings. In some food containers and plastic bottles, phthalates are found with a compound bisphenol (bpa). We produce 3 billion kilograms of bpa every year.

Why is there so much waste plastic? Because it is light weight and long-lasting, useful for containers and wrappings, and not much is recycled. Only 3-5 percent of plastics get recycled. Glass and iron are more easily recycled. Pet and HDPE (numbers 1 and 2) can be recycled. Plastic retains pollutants and gives off deadly vapors. Products made from plastic recycling are limited to carpet and boards and jacket linings. Except for some incineration, every piece of plastic made still exists, because no life form can break it down into nutrients. Recycling also uses resources and energy and creates pollution. But it does reuse resources and it is wiser use.

Plastic does not biodegrade, it crumbles into smaller fragments. Plastic can decompose in seawater. And, it can contaminate marine life at the molecular level. Samples of seawater contain styrene monomers, dimmers and trimers (which seem to be carcinogenic in mice). Plastic is moving into the food chain. The danger is eating it or becoming entangled in it. There are minuscule pieces of plastic, called nurdles (lentil-size pellets of plastic in raw form), in the water. By weight, it can total 6 times more than plankton. The pollution seems invisible and ubiquitous. Nurdles and beads are easily mistaken for food, can be ingested, and can screw up genes. They disrupt the endocrine system, so that some male fish and gulls have female sex organs.

Like sand on a beach, the entire biosphere gets mixed with plastic particles. These particles change the properties of water and soil. Plastics pollution at this level and scale is almost completely unrecoverable for recycling or breakdown (from burning or solution).

Should we stop using plastics? Can we? Should we try to collect all waste plastic? What's the alternative? There is one based on cellulose that degrades in a possibly less dangerous way. Would that solve the problem? Would cellulose plastic be edible by zooplankton? Would it degrade completely, especially before it reached the ocean? Or, do we have to invent another one? Most plastic is used for storage items, which could be replaced by glass. Glass has higher costs for transportation, but is safer for food storage or preparation; it is reusable for generations, and it can be blown into beautiful shapes.

6.7.7. *Conclusion: Questioning a Machine Image*

Modern industrial technological cosmology, beyond being another kind of order, more linear and abstract, is wrongly considered the evolutionary successor to traditional cosmologies, and is displacing them rapidly. Using the metaphor of the machine, this cosmology tries to render other images as incomplete. The machine image has allowed tremendous advances in understanding mechanical systems, and even some biological systems, by treating everything as a machine, which can be repaired with replacement parts or improved with better design.

We need to question that image of the machine. Questions widen the narrow field. Hardin points out that concerns about narrow issues, such as pollution, can cause a deep examination of the process, such as distribution theory, that cause the issue. Human activity simply produces things that we want and things that we do not want, such as pollution. As we ask questions about who pays and who benefits, we are able to think or rethink about these things. Bring them into our consciousness.

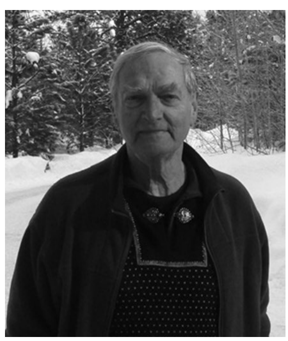

Figure 664-1. Alan R. Drengson walking with minimal technology

6.8. *Design of Global Technology: Wild Lives & Living Technology*

Since we cannot foresee the problems, we do not know what kinds of questions to ask to devise solutions. Therefore, we must always wait until some system fails before trying to correct it. Therefore, we will always be reacting to natural and artificial situations. Therefore, there will always be unavoidable costs in lives and resources before some new working situation is found. There are many examples of this series: We did not clean air until the pollution reduced visibility to a few meters; we did not clean up lakes until the fish were dead, we could not swim in them, or they caught fire—we could not force ourselves to pay for the ounce of prevention, no matter how unhappy we were with the tons of cure. Although the word 'solution' is used for several headings, it is not used in the sense of a one-time, all-time permanent fix. It is meant in the sense of simply an answer, or positive, adaptive, temporary response to challenges or problems.

6.8.1. *Technological Innovation and Mastery of Design*

By Alan R. Drengson

6.8.1.1. Part 1

In Western industrial society, secularization and emphasis on *unending progress* led us to measure efficiency as increasing power, speed, productivity and profit. This encourages continuous technological innovation. Our idea of progress shapes technology and science education through public school systems free from older traditions. Our connections with the past were once through elders, family, community and tribe. These were devalued in our society. Schools teach us to accept radical cultural and environmental change driven by "leading edge" expert scientific and technological innovation. We condition mass producers and consumers to want the most of "the fastest and the best." Entertainment and advertising constantly drive these messages. Society is a collection of autonomous producers, consumers, sellers and buyers. Those who have the most—fame, wealth, and power—are admired as the best. Natural cycles are turned into tangential curves of industrial output that assumes unlimited growth. Technological development as increasing knowledge is a means to an ever more productive and powerful society with an increasing standard of living. Innovation in technology and science are marketed as the best ways to solve the problems of misery, scarcity, ignorance, and disease. There is some truth to these claims, but they also raise serious questions.

Mass education provides useful skills for a rapidly changing society. It ignores skills supporting community, deep self-knowledge and emotional maturity. Music and other arts are grossly underfunded. North American public schools do not inspire self directed learners who realize their potential for non-consumptive personal growth and positive cultural enrichment. This system does not foster a compassionate society free of addiction to possessiveness and competition. Power structures stress specialization and obstruct comprehensive views. Specialized fragmentation conceals a growing need for *holistic reintegration* of subjects at higher levels of synthesis. We need practice of whole arts cultivating unified persons and wholesome communities. We need appropriate designers who can conceptualize appropriate technologies that integrate broader and deeper values, so that they are *ecologically and socially responsible*.

A major problem for our technological society, then, is to design technologies with environmentally friendly technology practices. This philosophy of applied science considers technology design an engagement with the highest responsibility. It involves self mastery and right livelihood for designers so they can integrate and unify their energies with core social and ecological values. Appropriate master designers are innovators who combine multiple priorities, values and commitments.

For master designers technology practices consist of four inter-related dimensions: 1. Technical skill and knowledge; 2. Organizational structure and systems; 3. Cultural purposes and values; and, 4. Resource use, raw materials and the environment. These factors enter into the designer's range of choices and limits. They are related to primary forms of technological innovation.

The four primary forms of technological innovation are: 1. Minor modification, 2. hybridization, 3. mutation, and 4. design of whole practices. We will discuss each of these.

By *minor modifications* over time, a technology is slowly improved and technical problems solved. This same gradual improvement and refinement can be applied to production processes and organization of work; it can be applied to marketing technological innovation. A product can be designed, built, and ready to market, but unless there is preparation in the market for its introduction, it could be an economic failure. Modifications of technical design processes, alteration of the product and the production process, influence and are influenced by markets. Change by minor modification is a primary form of innovation in the development of 20th century technology.

Many products of 20th century technology were conceived in novels, art and comics long before they were technically feasible and economically viable. Submarines, airplanes, automobiles, and space vehicles all appeared in conceptual and artistic form before they were built. Film and television provide ideas for new technological designs. Artists, novelists, and cartoonists often lead the development of technological culture. They lead as heralds, and also prepare our culture for the introduction of new technologies, much in the way that imaginative play helps children to ready themselves for new experiences.

Despite this preparation by conceptual exploration, the actual design and production of technologies follows a slower route. There is a gradual refinement with piecemeal solutions to problems that become evident when design passes into prototype, and then a product for mass production. Many things go wrong in this process, and major problems often arise. These problems can be in the technical details of design and production, or in limits to worker skills, or in marketing, servicing and using the product once it is distributed. The problems can lie in environmental impact, which becomes evident only when the product has been in use for a while. To anticipate all possible problems in the design phase is difficult, even though they can be categorized. For instance, it did not occur to early cars designers that automobiles would be implicated in widespread air pollution, acid rain, lung cancer, and a host of other harmful effects. The problems anticipated by designers tend to be in cost, reliability, efficient production and successful marketing.

Automobile technology provides good examples of innovation by minor modification. The earliest cars were extensions of horse-drawn buggies. In design they copied horse drawn buggies. They used the same brake and wheel systems. They were even called *horseless carriages*. Engine capacity was rated in *horsepower*. As more engine driven carriages were built, the production process and *car* design gradually changed. Problems with brakes and clutches were solved, materials and designs were modified for greater durability, and the production process was rationalized to make it more efficient. Eventually the assembly line and mass production of parts came together through organizational structures still in use. Processes and organization were refined for manufacturing, distributing, servicing, and using automobiles. We created an expansive infrastructure for them. We reached this stage through gradual innovation, involving countless modifications of the basic designs, processes, and techniques of auto use and manufacture. This was an evolutionary, not revolutionary process.

Technological hybridization applies the knowledge and skills from one form of production and technology development to other areas. Hybridization might apply the techniques of biotechnology to a non-biological process. It might marry two technologies to produce a new form of technology practice, such as adapting the steam engine pump to run a wheeled vehicle on rails thereby producing a locomotive. Technological development involves a great deal of cross-fertilization, synergistic interaction, and experiment with how technologies can be applied outside areas for which they were designed. This process combines the usefulness and power of different technologies to yield new combinations. It is not pouring old wine into new bottles.

Design explores how technological hybridization can solve technical problems. Designers brought together aircraft, automotive, and bicycle technologies to produce prototype human powered vehicles practical for commuting on roads in all kinds of weather. Some recent hybrid cars combine photovoltaic technologies with hybrid propane-electric engines. Applying space technology to sailing vessels is another example of hybridization. Hybridization has long been used to modify and 'improve' animal and plant production. Biogenetic engineering techniques are now used to produce new plant and animal hybrids.

In nature, hybrids are often sterile, as are the products of human selective breeding. Hybrid technologies have been very successful in spurring development of new technology practices. By applying knowledge and skills learned from two or more fields, designers stimulate technological innovation, change and development.

Technological mutation transforms a technology to some other form, or for some radically different purpose. The Chinese discovered gunpowder accidently as early as 890 AD while searching for an elixir of longevity. They then used the powder for fireworks and entertainment. By 1000 AD they used it in warfare against the Mongols. The Europeans adopted and further transformed this technology. They used it for armaments and warfare, but they also perfected its use for construction of roads, tunnels, dams, and mines.

Another example of mutation is the development of the fission nuclear bomb in World War II. This short-term, crash program had a narrowly defined military objective. Although based on scientific hypotheses, the bomb had not been shown to work under controlled conditions. Scientists in the Manhattan Project had to overcome organizational, theoretical and practical problems before they produced the bombs dropped on Hiroshima and Nagasaki. Their work laid the ground for the later development of nonviolent, peacetime nuclear technologies such as electrical power generation and medical applications. The A-bomb technology mutated into peacetime applications, and was combined with the technology used for generating electrical power via steam turbines. The mutant was then installed in electric power plant networks and large naval vessels.

Finally, there is innovation in *the design of whole technology practice systems*. These involve mastering design processes that include appropriate human, spiritual, and ecological values. The three forms of innovation mentioned above require mastery of rules and techniques for design and development, but depend on staying with established practices in the dominant industrial paradigm.

Designing appropriate technology practice systems is innovation via integrated *whole system design*. Its mastery transcends our technological context and dependence on it. It opens up opportunities not there before. Mastery is an art that rises above techniques and rules. The master poet is fluent with language and feelings and writes with freedom and spontaneity that transcends the rules and techniques used for teaching language to beginners. Mastery of an art is creative, spontaneous, and relatively autonomous. Mastery in design of appropriate technology practices transcends the 'necessities' that dictate a narrow range of possibilities. Let us consider an example.

It's said, "We can't solve our energy and environmental problems unless we move into large-scale nuclear power generation." This refrain is heard from many developers and designers and even James Lovelock! They approach the problem assuming that *centralized* production and distribution of electrical energy is required to meet *projected* increases in demand for uncontrolled consumption. Two important considerations are overlooked: 1) The possibilities for energy efficiency and conservation with appropriate changes in lifestyle, *and* 2) decentralized, small-scale, on-site generation of energy for cooling, heating, transport and production. Once designers stop thinking in terms of large-scale, off-site generation, and rising consumption curves as necessities, all kinds of alternative solutions are available. One reason designers and planners do not see alternatives is because they suffer from the tunnel-vision of specialized experts. They also resist solutions that alter current structural relationships and the economic status quo. They may be paid to do so!

Innovation in mastery and creation of technology practices is bound up with self-mastery. A deep understanding of nature and the principles of ecology enables us to avoid seeking to control nature to get power over other beings. Self mastery facilitates needed self-discipline to harmonize with natural communities. We give more personal energy to realizing our highest aims without tyrannizing others and nature.

Many see serious threat in human life dominated by technological necessities. The key to ending this domination lies *beyond* technology; it is in actualizing human potentials to master the technological process. We then *subordinate it to higher values* beyond the transient industrial culture.

The mastery process deals with whole technology practices. It honors and respects humanity, creative community, and communion with nature. The design of whole technology practices can be conducive to *ecosophy* (from the Greek roots, meaning "ecological wisdom"). Our overarching purpose is to realize ourselves in good communities with healthy habitats. Ecosophic technology practices facilitate these purposes and realize *technosophy*, that is, the wisdom to design and use practices in harmony with natural, ethical and spiritual guidelines. Wisdom is more than information and knowledge. Creative undertakings go beyond current *limits in our thinking* to open rich possibilities for *high quality of life* with low levels of material consumption and energy use. The new cosmologies lead to *possibilism*, for nothing is rigidly determined. Ultimate reality appears to be creative, conscious and evolutionary. It is possible for us to co-evolve with these living processes.

6.8.1.2. Part 2

The concept of *technology practice* leads us to explore the *ecology of technology* in reflecting on our practices. The phrase "ecology of technology practice" emphasizes that we want to understand technology in all its dimensions and interrelationships as an activity and a whole process. When we approach the philosophy of technology with this ecology in mind, we attend to its four fundamental aspects and the complex relationships between them. Technology practices exist in specific contexts of complex relationships. These relationships are ongoing processes and activities; they are part of the self, community, and society, which are in an ecosphere. Designing technology practices in an integrated, ecologically wise way requires attending to these relationships. The design and study of ecosophic technology practices is trans-disciplinary and cross-cultural; it includes historical, aesthetic, spiritual, scientific, and other normative modalities. The philosophy of technology studies technology practices in an integrated and holistic way, for its aim is wisdom. Wisdom connects with deep spiritual meanings that are self transcending.

There are deep moral and spiritual reasons for making our lifestyles and technology practices nonviolent. Other beings have intrinsic worth. Wilderness is good for its own sake. We have no right—even if we have the power—to destroy the homes of other beings to provide cheap paper products used once and thrown away. As self reflective beings capable of moral improvement, we have responsibilities to ourselves and to the whole ecosphere. It is not our right to manage it. Instead we should *manage ourselves* to be responsible to our larger ecological community. Our completion and fulfillment does not depend on wiping out other species. We can live without destroying other cultures and species. Nonviolent lifestyles and technology practices are available for agriculture, forestry and fishing. We are challenged to use an integrated approach to technology practices to design ecologically responsible management tools. To do so requires *collaborative* work with all kinds of people, from other disciplines, classes, communities and cultures.

Designing ecosophic systems requires answering fundamental questions about our ultimate purposes and priorities as we relate to the Earth. We clearly establish our ultimate values and priorities, and then we design our economy and technology based on these limits and considerations. We design with humility to err on the side of safety. We then create new forms of entertainment, participation, and celebration. We create new forms of education and ways to heal ourselves.

Technological moderation and reappraisal arise when sufficient numbers of people go through changes in attitude associated with earlier stages of technological development. A typical shift might take people from optimism and love of technological development to concern and even to rejection and fears of change. They might try more primitive technologies, and reappraise their attitudes and relationships to their technology.

The back to the land movement in the late 1960s and early 1970s revived earlier farm practices, such as using horses for farming and logging. One of their models was a religious group (the Old Order Amish) with a history going back to Europe. The old order Amish recognized that their way of life would be destroyed if they "modernized" their farms. Although their agricultural practices are from an earlier era, they maintain a good quality of life on small mixed family farms. They have increased their numbers doing so. Their resistance to technological change is based on religious principles, not a fear of technology. Their spiritual principles inform their attitudes toward farm practices and right livelihood.

There is natural and community wisdom in their practices.

The creation of appropriate, ecosophic technologies depends on wise designers and users. A key to sound technology practices lies in solving problems of environmental pollution in the design stage. Wise design of technology practices does not generate hazardous wastes and is not destructive. We can develop transportation systems that do not produce greenhouse gases. Inefficient forms of transportation can be avoided. We need clear standards for wise technology practices. We need a minimum testing sequence for new technologies, and a minimum waiting period before they are introduced. I will outline the main features of appropriate design criteria below.

Appropriate technologies change forestry practices to increase diversity of products and reduce waste. They end clear cutting and use selective ecoforestry practices. They can aim for the same values in agriculture. Good farming increases soil fertility through ecologically sound practices that increase the health of local biological communities. Designing practices to harmonize with nature's processes is the guiding purpose of a *mature* attitude toward the design of technology practices.

Reflecting on the spectrum of attitudes towards technological development deepens our understanding of our relationships with technology practices. It enables us to be clear about our attitudes towards each other, technology, and nature. This spectrum of attitudes runs from ignorance of technology as a cultural process, to technological anarchy, technophilia, technophobia, and then finally to mature wise attitudes that keep technology in its proper place in human life, so that it is not the be all and end all of our lives. Our attitudes condition our perceptions of technological development. Thus, we need to ask these questions: What is our relationship with technology? What is our community relationship to technology? How are these connected with our relationships to nature?

Our attitudes are reflected in our technology practices. For example, the pursuit of the technological fix as a panacea is possible because of our self-ignorance and ignorance of the nature of these problems. Many of the problems we face are not technical ones, but involve human organizations and dysfunctional relationships. Freeing our attitudes frees us from the compulsions of the technological imperative. The way is then opened for us to take control of our technology and to design new practices that will protect the planet and benefit us too.

We can design something less than what we are, and we can produce something that is more than we are. When we work together we can do more than when we are alone if we work cooperatively. Design activity should be unifying. It should bring people together at higher levels of insight than those that generated the problem. When an advanced technological society is in transition, problem-solving and creative activity require a holistic, interdisciplinary art using ecological paradigms of thought, sensibility and action.

6.8.1.3. Part 3

In ecosophic design nature has sacred values in which we participate, such as harmony, fitness, respect, and modesty. For appropriate design, nature is re-sacralized, not by division between the sacred and the profane, but by encounters with the divine. The design activity becomes an archetype of the creative act that unifies us in harmony with the Earth. Spontaneous creative design of appropriate practices fulfills the need for bringing together the material, aesthetic, cognitive, moral, communal, spiritual, and the natural, within a holistic harmonious activity. Rooted in self correction, the design process aligns the designers with transdisciplinary values and the practice of appropriate design. The criteria guiding the development of appropriate technology are that it must be: Ecologically sound, equitable, sustainable, human-scaled, allows decentralization, solves problems of *vital* needs, facilitates human development, improves quality of life and increases possibilities for self-realization.

The ecosophic design process involves an encounter with nature by the human subject. Just as the Daoist Wood Carver releases the form inherent in the wood, so the appropriate technology designer strives to release the forms and patterns inherent in nature in specific home places. These forms resolve problems of human need to promote community and ecosystem integrity. This design transcends the urge to master nature and control others. We do this not by regressing to a more primitive technology practices, but by preparing for the emergence of new appropriate ecosophic technology practices through the education of designers who use deep ecology principles. They understand that we are in networks of planetary relationships. They escape the limits and dead ends of the technocratic industrial philosophy, for they are open to a higher and deeper transpersonal consciousness of spiritual purposes and meaning.

Design Institutes should have close ties with centers for sustainable development, community planning and similar organizations. They should form networks with other workers and researchers. They should encourage the study of whole system design, foster participatory study, and practice of design involving rigorous new standards of quality. These standards reflect present and future concerns, such as ecological values, cultural identity, and technology transfers. These joint actions will tap into the wealth of creative potential available for innovative design of ecologically sound technology practices in forestry, fisheries, range use, agriculture, mining, renewable energy, and solid waste management.

It is now recognized that progress toward peace, environmental harmony, and social justice depend on harnessing appropriate technology practices through interdisciplinary cooperation using a comprehensive and collaborative design strategy. We face a multitude of urgent problems since current technology practices are adversely affecting cultural and biological diversity, the weather, atmosphere and composition of the oceans.

6.8.2. *The Redesign of Technology*
(Being Edited)

6.8.2.1. *Engineering Proposals for Solutions*
Many critics are armed with lists of problems. What about solutions? This work accepts so many of the criticisms and tries to suggest kinds of solution, or at least good responses to many challenges. It is a guide, for suggestions to people who try to resist the global mechanical solutions by default.

Many people offer technological fixes and substitutions. They suggest that technological substitution will be effective in dealing with the increasing impacts of human beings on the system. They argue that technological options are crucial, starting with noncarbon-based energy systems and large-scale geoengineering approaches. In the past, nations responded to environmental change, such as drought or resource depletion, by changing lifestyles (usually reverting to simpler ones) or relocating. These responses are no longer possible in a 'filled planet.'

6.8.2.1.1. The Paths of Machines
How should we design machines or machine interfaces? Will technology, and our knowledge and wisdom, allow us to design artificial beings that will fit into the current evolutionary processes? We need to design better machine infrastructures, to reduce the area they require that replaces natural support systems. We need to control accidental and designed releases from the machines, so those substances will not interfere with natural processes or cycles. We need to design to reduce the mass of machinery, as well as the mass of its energy and material requirements.

Machines have evolved culturally so that they have greater capabilities and are more efficient, but we need to redesign the entire machinomass so that it fits together and within the ecological network. Nanotechnology offers some relief from size and mass, but it also threatens a different kind of unanticipated runaway processes. Should we design machines that interface with living systems, without knowing more about living systems? Should we design robots to replace humans when we cannot even employ all the humans who want or need to work? Certainly machines can function in abiotic reaches of space or perhaps even as they do in very inhospitable earth environments. Should the machines be structured with rules that are anthropocentric, machinocentric or biocentric? Maybe the function of design should also be to limit the uses and kinds of machines, or at least address the needs and uses, benefits and costs, of machines in an ecological context rather than the narrower western economic context.

Machines are part of human ecology, like other tools. They too contribute to flows of elements, such as sulfur and nitrogen, although the machine contribution may exceed the total of all natural living and nonliving sources. Machines also increase flows of rare elements, such as lead or mercury to tens of times the natural flows. Machines also create new compounds that are suddenly introduced into a system that has no pathways to deal with them. They displace wild ecosystems, modify food webs, and create new energy flows within the system. Cars replace horses, and mowers replace deer and other grazing animals in simplified ecosystems. Video games may be the cockroaches, leaf-blowers may be the rats of the new world, taking more energy than they yield benefits. Television may be a form of cancer that encourages the replacement of every living thing with new machines, from guns to more televisions.

Of course, machines are not living yet, as we know, although they follow rules, change and evolve. We apply control to them, but they seem autonomous in many ways. They have many know and unknown effects, that we foolishly call 'side-effects' and these may diminish ecosystems, as well as people (other people, not as dominant or machine-like), or simply proliferate more machines.

6.8.2.1.2. Designing Genes: Biotechnology

The goal of biotechnology in forestry is to select genes that allow trees to furnish our immediate needs for fast-growing, straight trees. Although forestry is close to approximating the agricultural model, the shift from the exploitation of wild forests to domesticated plantations is not complete. Whereas agricultural genetic manipulation emphasizes disease and insect resistance, the primary selection criteria for forest 'crops' are vigor, form, and wood quality (notice that longevity is missing—there is already a case where a genetically manipulated forest is dying after 30 years because the trees were not selected for longevity). Many scientists consider biotechnological applications on agricultural crops to be the best solution for conserving gene pools of wild relatives, multiplying elite cultivars, and resisting pathogens and predators. Russell Haines (FAO, 1994) notes that although there are significant genetic gains for long-rotation species, there has been only a minor impact from biotechnology on the genetic quality of tree plantations. That is to say, trees have important limitations compared to agricultural crops, including long generation intervals, a long juvenile phase before flowering, and difficulty in assessing the inheritance of characteristics. Remember that a lot of early work on genes was with short-lived species, such as annual plants or fruit flies.

Nevertheless, biotechnology is being used to "improve" trees. Haines lists a number of biotechnological applications to tree improvement: (1) Molecular markers (usually isozymes, a variant in size shape or charge of an enzyme, which is a catalytic protein) or DNA can be used to fingerprint mating patterns in trees or genetic variation for a few model species, such as pines or pine-hybrids. Expected to be used in the short-term for industrial species. (2) Genetic engineering is the direct insertion of genetic material from other species into the target species. Suggested applications to forest tree species include: Modifying lignin biosynthesis through antisense technology (strands of mRNA complementary to a sense DNA strand), making the tree more valuable for pulp; inserting insect resistance genes into a very short rotation tree species of pine or tropical hardwood; and, inserting cold-tolerance genes in exotic tree species such as eucalyptus (thus enabling it to take over the planet). And, (3) *In vitro* control of the maturation state through molecular studies can be applied. The goal here is the maintenance of juvenility in clonal forestry, that is, to postpone maturity. Another possibility is to induce early flowering and reduce generation intervals.

Genetic engineering seems especially risky in forestry, since trees have evolved other means of adapting rapidly to pathogens, e.g., mutualistic associations with bacteria that protect the trees from insects. Insect-resistant genes may have the effect of disrupting the mutualism, which would have other chained effects in the forest system (possibly similar to the way fertilizer reduces root mass).

6.8.2.1.3. Designing Micromachines: Nanotechnology

Many new technologies are not managed for their perceived benefits or losses. Nanotechnology, for example, has the potential to clean chemicals and viruses from the human body, but some minute nanos could pass through various barriers in the body and interfere with brain processes or environmental cycles. Nanotechnology is the use of particulate matter at a scale so small that many of its properties are determined by size and surface conditions. It has the potential to 'revolutionize' some industrial processes. It also has the possibility of posing extreme risks to human and environmental health, due to difficulty of monitoring and control at that scale. All aspects of risk need to be managed.

Technology could be used to develop renewable energy and restore damaged environments. Technology could be used to promote sustainable localized energy industries, with solar, wind, hydro, tidal, or biofuels. But, technology has to fit the scale and tempo of the environment. Nanotechnology may not fit. Technology has to be sustainable and improvable. This may be more difficult with nanotechnology.

6.8.2.1.4. Stabilizing Climate: Macrotechnology

There have been several approaches to macro-engineering options for climate change management and mitigation. One was regarding carbon dioxide capture from ambient air to address the problem of emissions. Should we try a high-tech solution? A massive program, like the atom bomb, only on alternative energy technologies? One technical solution to carbon sequestration was to fertilize the southern ocean with iron filings, which is a limited nutrient in ocean water, especially in the south Pacific. The idea is that plankton would grow and then sink to bottom. We know that winds carry iron-rich dust from land anyway. In a few experiments, plankton grew well but did not sink, so carbon would be re-released. Given also the life span of plankton, however, the plan could release the carbon dioxide relatively quickly. Another unwanted effect was some plankton grew and others did not; that could lead to imbalances and losses of biodiversity.

One of the solutions proposed was orbiting mirrors that would reflect solar heat away from the earth. Assuming the orbit would not degrade too rapidly, there would be concerns with the mirrors reflecting more heat to the planet.

The old tropical and boreal forests are not good carbon sinks, actively, but vigorously growing forests are—if they are not cut and burned. Cold seawater holds more carbon than warm or hot. Basic oceans hold more carbon than acidic. On one hand erosion moves carbonates to the sea, but these are far less than emissions in the US. One could argue that clearcutting and erosion will solve the problem of carbon sequestration, but not really, not for long and not effectively. Pumping liquid CO_2 also has bad side effects, high rates of death near the plume. As water turned acidic. So, we need to make the ocean more basic and less acidic. We need to take it from pH 2.90 to 3.25 at least. Soils as carbon sinks will require some kind of management at a global level. Can the oceans be managed as a global thermostat? Will it require an UN commission? It would require cooperation on the use of global commons.

6.8.2.1.5. Neutralizing Pollution: Chemical Technology

Many pollutants can be neutralized chemically, although that might be prohibitively expensive. Other pollutants can be reengineered to degrade in sunlight or water. New starch and corn-based plastics have arrived. The company 2K Engineering in England is making Ecosheets of plastics, with bits of metal or another element in them.

Some forms of plastics, nurdles, for example, have no yielded to either easy clean-up or chemical manipulations. There is an interesting discussion of this problem in Conservation Magazine, 2009. NOAA is also involved in the clean-up of plastic nurdles. The basic problem of nurdles is a physical problem; the pieces have been ground up without being degraded into smaller components. It might be possible to dope plastic with mercury or some other metal that could be fixed by plants in aquatic systems. Or, it might be possible to substitute some ion in the plastic so that it could be eaten by bacteria. Otherwise, collecting nurdles is going to be a very labor-expensive proposition.

6.8.2.1.6. Channeling Energy: Energy Technology

Technology has not only changed the patterns of our energy use, but the use of fossil fuels has increased the use so dramatically that it can overwhelm many energy flows and most ecosystems. The kinds of energy have caused many environmental changes, from mining and strip-mining to various kinds of wastes.

Energy production should leave as few tracks behind it as possible. Nuclear fission leaves burning, long-lasting tracks. Burning fossil fuels leaves pollution and sickness. Even large-scale solar projects, extraterrestrial or earth-based would shift large quantities of energy around with unknown consequences. The sophisticated equipment involved would also cover large areas. Any concentrated energy use for large human populations and manufacturing may be too much. Even wood-burning stoves are causing pollution.

Passive solar heating would be adequate for individual buildings. Photovoltaic cells could provide electricity and power cars. Local energy projects using geothermal sources, winds, tides, or the sun are preferable, since their operation does not introduce new material to local cycles. All of these sources would be characterized by a small scale. Larger scale possibilities include hydrogen fusion, although it is not possible with current technology. This first was proposed by Hans Bethe in 1938; the requirements for production were worked out by John Lawson in 1957. The waste products would be heat and helium. It may, nevertheless, be dangerous.

Buckminster Fuller offers the sailing ship as a masterpiece of the technological use of energy: it goes through the sea without damaging it, employing the ceaseless winds without depleting any stores of energy. Even today, clipper ships would be efficient ways of moving smaller cargoes across oceans. Scale would not be a problem if we changed our consumption patterns and imported or exported less. Energy patterns can be more organic.

The organic pattern of energy can be shown to be parallel to the ideas of the flow of the tao, in the Tao Te Ching. Perfect activity leaves no track behind it; this would be a taoist approach to energy use; small scale and nonpolluting. The tao also presents a society isolated but satisfied. What is rejected by the tao is the technology that goes against the nature of things.

The public service function of nature provides free services to humanity that are essential to civilization. But when the free services are overloaded and breakdown, we have to pay the costs of repair. Further increase in flows of energy through technology will significantly reduce the capacity of the earth to support humanity. George Woodwell notes that use of nonrenewable resources can destroy renewable ones. For example, if acid rain from burning fossil fuels continues in the Midwest, the primary productivity of New England forests may be reduced a net 10%, due to rising soil acidity. This is the equivalent loss of energy from fifteen 1000 megawatt reactors. A new ecological balance could help humanity to develop properly with the achievement of a state of equilibrium and solution of environmental problems. It is almost impossible to estimate the economic value of natural balance.

Peak oil, spills, and high prices, in combination with carbon release, drive interest in alternate sources. People are correctly concerned about carbon economies now. Wind, solar energy, geothermal, and tidal energy are not carbon-based fuels, and except during actual construction, would not contribute much carbon to the atmosphere. Of course, there are other biological and social risks associated with them, but these risks are generally smaller than those from fossil fuels.

For the hydrogen economy, the effects of hydrogen would have to be considered. It is light and escapes easily, eventually to space. It could increase methane by 4 %. It may affect molecules in the stratosphere. Nuclear energy, again except for high construction costs and wastes, would seem ideal for providing large quantities of energy. Isolation of wastes, from living organisms as well as from military uses, would be a significant problem. Hydroelectricity is generated by dams in many areas. Dams unfortunately have finite lives, disrupt water flows and silt up eventually (from five to 200 years).

Human energy, used for walking, picking and lifting, puts some carbon up, but it is generally healthy. In the long-term, there are no renewable forms of energy, just those from long-lived sources, such as the sun. Biomass is taken from ecological systems and disrupted those systems.

6.8.2.1.7. Controlling Things: Information Technology

Information technology is pretty much synonymous with computers, which are controlled by software, which can have 'bugs' or be unreliable or incomplete. For instance, we use software and computers to keep track of airplanes, and more recently, automobiles. But, accidents still happen at all levels.

We think of computers as smart machines. We use information technology to substitute for labor, and the problems of cost or incompetence. Information technologies are proclaimed as a second industrial revolution, with more efficiency and harmony. Information technology can control automating technology, so it has the potential to displace management, also. Unfortunately, many of the implications of replacement have not been identified or addressed, especially the discontinuities in some technologies. By itself as automation, technology perpetuates the logic of machinery. Information technology however has the capability of undermining that logic and permitting a more homogenistic one.

6.8.2.2. *Management Solutions for Technology*

As technologies developed, human relationships with animals and plants changed. Hunting, grazing, and agriculture provoked large ecological disturbances. Early domestic animals were revered, but nondomestic animals were considered competitors or nuisances. Now, domestic animals are treated as processed commodities and wildlife is regarded as useless.

Technology can be used to expand or contract resources. Technologies have the capability to minimize the use of resources, but they also have negative effects. Technology has greatly increased the kind and quality of materials used for buildings and machines, especially aluminum and other light metals and silicon constructs. Yet, the scale of technology produces pollution that reduces the productivity of natural and agricultural systems. Unbridled, unconscious technology has given us benefits, but only at the cost of irreplaceable stocks of energy and environmental degradation. Instead of expecting technology to triple or quadruple our wealth, it is more likely that it has barely had a positive effect. Making technology appropriate, responsive, and conscious may go a ways to increasing its positive impact.

There is no reason not to develop complex instruments to monitor and analyze the environment. Machines do not need to be dismantled. Technological developments are more easily assessed in a small, self-supportive community, where they are not necessary. Necessity was not the mother of invention; curiosity was. And curiosity needs time, not pressure. Small communities could use sophisticated but unobtrusive technology. Evolution occurs in small populations, demes, in which a mutation has taken place. W.I. Thompson claims the metaindustrial village is such a deme. With desk-top computers and libraries, satellite and cable television, advanced science would be possible in the most rural setting. Leopold Kohr states that small firms have been shown to be more productive as separate entities.

Technological processes must be brought into balance with the cycles of the earth. They must not damage or degrade natural cycles. Avoid unnecessary harm. It may be appropriate to use trees or to compete with black bears for tree use, but it is never wise to destroy the ecosystem of trees and bears. Laws on pollution and noxious wastes have been notoriously lax and sometimes wrong-headed. Minimal acceptable tolerances are legal, yet people often prefer zero amounts of many substances. Minimal compliance with them is virtuous in comparison with many companies, but it could lead to higher standards.

Technology makes things easier. The cost of technology makes things harder. Every technology has a benefit and a cost. How are the two balanced? Someone has to list all the effects and then appraise the risks with them. Who does that? When should technologies be denied existence or admission? Who should decide? We need a comprehensive program for evaluating technologies on every level of every dimension for as long a time as possible—perhaps only over one lifetime, but perhaps over the time of seven or more human generations. There have to be high standards for evaluation.

Managerial strategies are needed. Technological solutions are sometimes used to avoid alternative solutions or management solutions that may require changes in lifestyles or luxury demands, but management cannot be avoided. Now that system changes are becoming global, while most technological solutions are still local, management is required. For instance, starvation is a regional problem, often relating crop and distribution failures. Carbon emissions are also regional and large-scale. The green revolution benefited those rich enough to buy and grow hybrid crops using the necessary chemical fertilizers and pesticides, but not those with less buying power.

Technological fixes by themselves are not adequate. Drought and crop diseases could lead to collapses of agricultural and social systems. The uncertainty of climate and stability of ecosystems requires adaptive management. Management can use other tools, such as the precautionary principle. Management can address distribution as well as production and consumption.

To manage the planet, we should probably avoid planetary scale civil works that is macro engineering as a large-scale management approach. In terms of telecommunications and manufacturing are not sure what to say. In terms of managing human health, we have to identify linkages not only from areas but also from parts of the human genome. And of course we have to management the environment and all the resources in the environment. We have to be able to anticipate natural disasters, as well as the mitigate or control them. We have to manage automation. We have to test or fit virtual reality technologies, especially for training in design. We have to consider population trends in population goals. We have to consider worldwide tensions the end violence. We have to assess the possibility of some kind of electronic global village. Then there is the question of some kind of global, language, such as English, used specifically in business science or aviation for example. We have to manage public issues, such as healthcare, genetic screening, the use of energy, and socially significant crime. Then of course we can guess about many of the possible at or probable developments such as increasingly cheaper telecommunications.

Is there a managerial solution for climate change? Could it be as simple as restoring forests and grasslands, and using alternative sources of energy? Could international management create large-scale migration corridors for warm species to ward off extinctions?

Design is not engineering. It incorporates some engineering. But not the perspective of engineering, which is to fix something broken or exceed some limit. Engineers use and sometimes create new technologies. Our situation is not a problem to be solved. It is a context to fit, to learn to live with and in.

6.8.2.2.1. Responsibility

Management solutions require greater responsibility for the effects of pollution on species and habitats. Sometimes that is just a matter of allowing 'enough time' and 'enough space.' If we cannot recapture plastic pollution, we may have to minimize the release of plastics. If we have cut too many forests, we may have to restore forests to some greater extent. Some countries have reforestation programs: Costa Rica, Vietnam, and China. If people are trying to buy dangerous things or exotic species, we have to deny, regulate, monitor, or tax those things. If there is too much demand or too many people, then we have to lower those numbers. Many things would not be problems if we changed our consumption patterns or lowered our populations.

6.8.2.2.2. Goals for Use

A nation has to define the goals of technology, from simple technique to the simplification of chores, as well as to consider the concept of nonharm. Then, it has to analyze the results of technology, not just the mass production of things, but also the effects on human health and behavior. A nation has to discern what is missing from an application of technology, whether it is human scale or appropriateness. Then, a nation has to decide how to manage the technology.

Goals should be relatively simple to define, given the needs of a population and the limits of a home system. We can set goals for the conversion of mature ecosystems into agricultural ones; perhaps the maximum global limit is 15 percent of land, with local goals ranging from 10 to 90 percent. We can set goals for fresh water use, to reduce to 15 to 50 percent of any one system.

Biodiversity cannot be saved in the few, small isolated reserves on the planet, as it is. There are some good local and regional reserves, but no global ones. Ethical reasons for saving biodiversity have to come first, before economic tools of valuation or resource use and policy. Goals for biodiversity can range from reducing the extinction rate from land conversion to trying to save individual species from climate change, in zoos or gene banks.

6.8.2.2.3. Budgets for Elements & Molecules
Several authors have calculated a carbon budget for the planet. Prior to 8000 YBP, the CO_2 content of the atmosphere was 160 PPM (before large-scale cutting and burning of forests). Prior to the industrial revolution by 1800, it was 280 parts per million of CO_2 in the atmosphere. This was equal to 645 gigatons of carbon in CO_2 in the atmosphere (the actual weight of the CO_2 would be 3.7 times more with the oxygen). For 2004, there are 380 PPM, or 869 gigatons of carbon. Tim Flannery suggests a budget of 660 gigatons, but as he states, half would stay in the atmosphere, raising CO_2 levels to 550 PPM or 1210 gigatons by 2100. It might be better to drop to 3 gigatons of new carbon per year. Carbon in living things comes to over 1 trillion tons. CO_2 is 387 ppm now. If we think 350 is safe and we want to bring down CO2 to that number, we should be reducing our output to below 285 until the new goal is reached. Some have formed a active group to reduce to 350, and this is a good start, but we need to be lower as soon as possible.

The benefits of Contraction & Convergence, a suggestion by UK politician Aubrey Meyer, are promising. Everybody has an equal right to release CO_2 or 'pollute with greenhouse gases.' This right could be traded similar to the Kyoto agreement. Under a global C&C agreement, citizens of the US would have to buy or trade carbon credits from poorer countries where people use a hundred times less. Meyer suggests three steps: (1) Reach an international agreement on a cap on atmospheric CO_2 concentrations. Then, (2) estimate how to cut back to that goal, and (3) divide the budget among the worlds population on per capita basis. This approach would reward fast-increasing populations and would not be fair. To be fair, in terms of ecological and cultural carrying capacities, would take a different calculation.

A fair budget could be figured in this way. We could figure a world carbon budget, as an emergency budget using the total carbon production from 8000 YBP divided by the current population for 10-50 years in the future. Then, for a permanent budget, use the numbers from the period 1400 or 1800 for 10-50 years in the future. Then calculate planetary cultural carrying capacity. Sum all the capacities and assign it 100%. So, for instance, if China has 13% of cultural carrying capacity, regardless of the actual population, then it gets 13% of the carbon use at the 1800 level. This kind of budget would be tied to the actual productivity of regions, combined with any technological advantages. Of course, the budget should be reassessed regularly, every five or so years.

Budgets should be made for all critical elements and molecules, such as nitrogen and phosphorus. We think that the boundary for nitrogen in systems is 39 million tons per year (removal from the atmosphere). It is 133 now. Nitrogen losses can be reduced by planting winter crops. The CAFOS animal feed operations should recycle their own nitrogen. Biofuels need to be discontinued, especially from corn, but also from grasses and trees. A global budget for phosphorus would limit the rate of flow into the ocean, which has been a sink for millions of years, to under 10 million tons or less per year; we may exceeding some critical maximum limit already. The rate increased exponentially when humans started contributing to natural erosion and movement with agriculture, deforestation and conversion to cities and roads. Better agricultural techniques can reduce it significantly.

Ozone budgets are relatively well-known. The gases from industrial processes, HFCs and CFCs, are 10,000 times better at capturing heat energy and last for many centuries. The Montreal Protocol reduced CFC gases in the air. It was the first victory over a global pollution problem. Many companies benefited from the change and from redesign of processes. There was some reduction in ozone loss from substitutes, like hydrochloroflourocarbons (HCFCs), which still cause some depletion, and Hydroflourocarbons (HFCs) cause almost no depletion. The Kyoto Protocol could be as effective, if all nations would agree. Kyoto does not get ratified by the US or Australia due to prohibitive costs. The cost of compliance might be high, but we need to measure the costs of doing nothing. Well, hurricanes can cost 10 billion.

Emissions trading in sulfur dioxide was invented in 1995 to deal with pollution from burning coal. It is very successful.

6.8.2.2.4. Industrial Ecology Revisited

Despite a few paths of plastics recycling, aluminum or steel, most industry is a one-way path from energy and materials to waste energy and materials. Major changes are occurring, though. The scale of civilization now makes externalization unfeasible. The costs of pollution and waste are being internalized; other inputs, such as labor and capital, are becoming more expensive. Economies will have to internalize or be forced to internalize. With the internalization of costs (since the losses as well as benefits will accrues privately), the system will benefit from intrinsic responsibility.

Like agriculture, industry draws energy and resources from the earth and dumps its waste back. But, it draws too many resources too fast, and there is nothing that has coevolved to live on the waste. Unlike a pioneer stage of succession, industry is, in Evan Eisenberg's words, at a "fetal" stage. It relies on the maternal biosphere, or the biospheric matrix, to feed it and lick its wastes. Alas, this fetus is very large and could kill the mother soon, unless the fetus matures or the mother reacts faster.

Isolated attempts at industrial ecology have been less successful. Biosphere 2, for example had difficulties balancing gases. The underground part of Biosphere 2, in the desert in Arizona, is a larger technosphere that supports the operation of the biosphere, with 200 motors, 100 pumps, 60 fans, valves, computers, miles of wiring and ductwork. These machines circulate air faster and scrub algae better than the minimal natural processes in a closed environment. Kevin Kelly refers to it as a marriage of ecology and technology, a symbiosis. Dorian Sagan considers that man-made systems are ultimately natural, a phenomenon of metamorphosis. Perhaps the biosphere project is a crude form of the planetary biosphere reproduction.

6.8.2.2.5. Evaluating Technology

We need some global organization, perhaps like the State of California's Department of Toxic Substances Control (DTSC), to focus on evaluating new technologies, especially alternatives to treat, recycle, clean up, and eliminate or reduce hazardous waste at its source. DTSC uses demonstration projects, data analysis, and life cycle assessments to provide support to other DTSC programs and help developers bring their ideas to market.

Such an organization would deal with remediating chlorinated solvent groundwater plumes, with life cycle assessment of the impacts of a product, and with evaluating nanotechnology. It would have to decide when to accept or reject a technology that promises some advantage, perhaps starting with potential impacts on the planet, then on ecosystems, then on human cultures and human individuals.

6.8.2.2.6. Containing Technology

The intent of many corporations and governments is to transfer technologies rapidly to the marketplace. Many technologies, however should require longer testing periods and required modifications. A suitable global organization would also decide under what conditions the effects of technology could probably not be contained. Does technology always escape and produce its effects on the nonhuman environment as well as on other cultures? If so, then technology is always ecological, that is, it is always part of the environment. It always generates some change in the environment it is part of. It is not the same environment after the introduction of the extension of technology. Any addition (or subtraction) is a change, and any change has many effects on everything. The loss of wolves in Britain did not simply subtract one species; it affected all other species in varying degrees. The conditions of survival all changed.

Attempts at containment raise questions. When should we reject a technology that promises some advantage? How do we balance technology against human or nonhuman lives? Perhaps we should start with potential impacts on the planet, then on ecosystems, then on human cultures and human individuals.

6.8.2.2.6.1. Applying Precautionary Principles

Technology has to be held to standards according to the precautionary principle. For instance, we have to require a minimum testing sequence for new technologies, with a minimum waiting period. Moratorium? A moratorium is a legally authorized period of delay in the release or performance of a technology.

Some groups implement the precautionary principle as the basis for environmental policy, others for human health policy. The principle and the main components of its implementation (the 1998 Wingspread Statement on the Precautionary Principle, in Raffensperger et al.) are stated: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the precautionary principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action."

Several groups and government bodies in the United States, including the Board of Supervisors of the City and County of San Francisco, have made the precautionary principle the basis for environmental policy. The Precautionary Principle should be applied if there is the possibility of environmental or health damage, and if there is uncertainty as to whether an effect will occur (and its potential magnitude). Precaution is about anticipating and avoiding negative effects or damage. It requires more science, from different fields, to make the best possible decisions for preventing harm. The precautionary principle requires more, not less science than traditional decision-making methods. The managing body has to acknowledge the uncertainty and ambiguity involved in any decision.

The principle is especially important with gene technology. A substantial proportion of soybeans, corn, and cotton grown worldwide is genetically modified. To date, most genetically modified plants are grown in the US, followed by Argentina and Brazil. Many consumers are concerned about the use of gene technology in food production, although less concerned about its use to produce medications and vaccines.

6.8.2.2.6.2. Integrating Technologies & Lives with Design: Amish & Swiss Approaches

Technology needs to be integrated into society. It needs to be made appropriate to the goals and desires of a culture. The notion of appropriate technology, however, was developed in the twentieth century to describe situations where it was not desirable to use every new technology or those that required access to some centralized infrastructure or parts or skills imported from elsewhere. The ecovillage movement emerged in part due to this concern.

Technology needs to be integrated into the entire environment. Some technologies have negative environmental effects, such as pollution and lack of sustainability. Some technologies are designed specifically with the environment in mind, but most are designed first for economic or ergonomic effects. The effects of technology on the environment are both obvious and subtle. The more obvious effects include the depletion of nonrenewable natural resources, such as petroleum, coal, ores, and the added pollution of air, water, and land. The more subtle effects include debates over long-term changes, such as atmospheric heating, deforestation, natural habitat destruction, and costal wetland loss.

The underground part of Biosphere 2, in the desert in Arizona, is a larger technosphere that supports the operation of the biosphere, with 200 motors, 100 pumps, 60 fans, valves, computers, miles of wiring and ductwork. These machines circulate air faster and scrub algae better than the minimal natural processes in a closed environment. Kevin Kelly refers to it as a marriage of ecology and technology, a symbiosis. Dorian Sagan considers that man-made systems are ultimately natural, a phenomenon of metamorphosis. Perhaps biosphere is a form of the planetary biosphere reproduction.

Technology changes institutions and the relationships between them. As an institution adapts a technology, its view changes. A new technology threatens other institutions, which have competing technologies, so the whole mass has considerable momentum and investment. As the nature of institutions changes, the nature of communities, and cities and cultures, changes.

Technologies change the structure of things with new metaphors. As metaphors (like totems) are good things to think with, technologies become things to think with. The whole idea of technology, according to Evan Eisenberg, is not to eliminate work or to replace nature with synthetic artifacts, it is to restore the balance of work and leisure that hunters understood—it is to find the best way between the dirt and the mouth. Sometimes this can be done with simple tools. When complex tools, such as computers, are used, they have to be designed to be appropriate to the use and environment.

A nation could promote appropriate technology to manage resources for its region. Dangerous technologies would he reduced through wholesale substitution, if not of materials, than by labor-intensive solutions. Traditional housing, for instance would be preferred; its form and design are integrated into the culture, it is adapted to the local climate and is usually less expensive, due to use of local materials. Much traditional architecture is authentic and unselfconscious; its forms fit the context of place and develop in response to place. With arcologies, the urban ecologies designed by Paolo Soleri, the city can change its relationship with nature; an arcology is a good solution for an urban culture, as it solves the problems of waste, resource-use, scale, obsolescence, and segregation.

One way to balance technologies is to create a program for recovering old technologies that are useful under many circumstances and may be more appropriate than more complex solutions. Digging sticks, for instance have been useful for collecting or harvesting vegetables; they can be used just as effectively in rooftop gardens as in Amazonian rainforests or Australian deserts. Another way might be to base an approach on the Amish or Swiss.

6.8.2.2.6.2.1. *The Amish*. The Amish have developed an attitude toward technology based on their biblical cosmology and philosophy of life. The Amish are a contemporary, 'low-technology' farming culture living in the eastern and central United States, having fled several nations in Europe to find religious freedom. The Amish, although decentralized groups that vary in conservatism, in general, accept only technology that permits them to maintain their isolation from a secular, consumer society. So, for example, some use limited access to telephones, electricity and electrical appliances, and automobiles.

While the old order Amish are permitted to use batteries, generators, and many devices powered by those sources, they reject electricity from power grids, and the use of 110-volt electric appliances and computers. The prohibition of power-line electricity serves as a way to separate them from the outside world, so that their Bible-based standards will not be diluted or forgotten. The act of rejection of electricity also contributes to bonding in the community and is an acknowledgment of the need to submit to authority. There is no need to debate the possibility of every new worldly appliance to come along; it is removed from individual decision-making. The decision also effectively isolates the Amish from pervasive media like the internet that surely would have compromised Amish community. The rejection of electricity serves to delay social change that may erode fundamental beliefs.

Many Amish decisions about technology seem to be very flexible. For instance, people who are sick and need refrigerators are allowed to have them. Sometimes an Amish home will have a telephone to serve many families, usually for emergencies or communication with other Christian neighbors. When an Amish family purchases a secular home, some Amish churches allow a 'grace period' of 6-12 months during which the Amish family may continue to use electric power, until it can be adapted to Amish standards.

Many Amish use candles for light. Some still use windmills for power or pumping water. Amish typically make use of various batteries for devices such as flashlights, and recharge them using a diesel generator. Some Amish accept the use of solar panels to generate energy to charge batteries, heat water or power an electric fence. Solar energy is recognized to be part of 'God's grid.' All of these forms of power serve a practical purpose, but are limited in scope, thus restricting the type of technology that can be used.

The Amish stress simplicity and humility. They avoid any behavior or expression associated with self-exaltation, pride of position or enjoyment of power. They believe that God is pleased when people work in harmony with nature, to care for animals and plants. Amish always live in rural communities. Most Amish travel in horse-drawn buggies, although some modern conveyances and conveniences are used restrictively. Technology is not considered inherently evil—those technologies that are banned are those that might distract or damage the community.

However, the Amish are embedded in a technological society. They depend on the use of their neighbor's high technology, such as telephones and automobiles. They also depend on an industrial system for their 'low-tech' tools and materials. The Amish do not reject all modern technology, but choose pieces of it to use it in a controlled manner to live consistently with their values. They subordinate technology to the good of God, family, and community, and that subordination becomes a symbol of their separation the secular, which can hold evil. The Amish life might seem extreme in its simplicity and austerity, but Amish leaders are responding to extreme situations with extreme measures.

The Amish model may be impractical as a model for larger society. Some of the technologies the Amish reject are instrumental in the realization of human potential and improvement. It may be unwise to give them up entirely. Even if there was a general will in our society to adopt the Amish model, it is unlikely that the material needs of the current population could be met satisfactorily without some of the technologies the Amish reject. At least the transition to the Amish model would be extremely difficult. Third, human nature being what it is, even if we generally acknowledged the wisdom of the Amish model, few of us would be willing to give up the material comforts that the Amish reject. On the other hand, if civilization faces collapse soon, extreme measures may make the Amish model practical for many people.

6.8.2.2.6.2.2. *Swiss Technology*. Accelerated technological change has become a fact and involves the evaluation, development, implementation and substitution of technologies within innovation-driven enterprises. The Swiss embrace new technologies for improvements and trade advantages. But, they are reasonably cautious about adopting technologies. Strategic technology management needs to address these issues. Management control has experienced a fundamental change and in parallel, the question arises whether current management control systems can adequately cope with complex technology issues in technology-based enterprises. Previous technology management control approaches may be inadequate. Management needs to develop a Technology Management Control Systems in technology-based enterprises.

The Swiss Jura Arc is an illustration of the construction of a local system of production using new technologies (Maillat et al., 2000). Conventional production systems can be transformed into systems based on microtechnologies that result from a combination of conventional micro-engineering technologies and newer technologies, such as optics, new materials and microelectronics. A technology district formed as individuals made decisions to reconfigure the production process and management. The environment is the focus in innovating the production process. Dynamic complementarities and interdependencies, between production and local institutions, are emphasized. Theoretical linkages are identified between the industrial, technological and territorial dynamics.

The Swiss pay attention to the implications of technological change on their society and on the dependencies of environmental, public and private interests. They use a holistic approach to technology management, a systems approach, which analyzes and contrasts technology management on corporate and national levels. With different levels of observation of technology, multiple perspectives can be used to manage its new forms.

6.8.2.2.6.3. Certifying Technology

Like electronic appliances and forest management, technology could be certified in terms of its performance qualities and impacts. With certification, the entire history of a technology would be made visible and known. Certification traditionally has been driven by consumers facing negative impacts. Although existing rules and laws protect people from faulty products, there is currently no way to protect them from an inherently harmful technology. Certification inherently requires more attention to and knowledge of impacts and limits.

Most criteria are numbers on costs, impacts, and wastes, but they could reflect pollutants produced and the synergistic effects with other pollutants or technologies. An international certifying body, an independent, third-party group, could use a systems and practices approach to proscribe the use and reach of a technology. Although certification will be blamed for management failures and higher costs, it could reflect real, long-term costs and could keep high standards to improve the overall balance and health of the ecological and technological system. Certainly, certification will cause shifts in patterns of use and appreciation. It addresses issues of equity and justice as well, not only for human generations but ultrahuman beings, who also participate in the planetary system.

Certification will allow consumers to choose technologies that enhance common values, within the large-scale economic and political trends that shape human culture. Technology problems are part of a matrix of industrial social practices and policies, but there are now pressing economic and ecological reasons to revamp them. To be successful, certification has to address industry shortcuts and economic shortcomings. The goals of certification should include making technology benign and sustainable, as well as protecting ecological systems from harmful technologies.

6.8.2.2.6.4. Using Appropriate Technology

Appropriate technology is that technology designed with special considerations for the environmental, ethical, cultural, social, political, and economical aspects of the community it is intended for. Proponents of appropriateness claim those methods require fewer resources, are easier to maintain, and have less of an impact on the environment compared to techniques from mainstream technology, which is wasteful and environmentally polluting. This form of technology offers labor-intensive over capital-intensive approaches. Laborsaving devices are used when there are low capital or maintenance costs. In practice, appropriate technology is often something described as using the simplest level of technology that can effectively achieve the intended purpose in a particular location.

E.F. Schumacher, in his book, *Small is Beautiful*, popularized the movement used by Gandhi. Schumacher was very strongly influenced by Gandhi's philosophy. He took the village development idea further with 'intermediate technology' in early 1970s. Many others, such as R.B. Fuller, Victor Papanek, and Arne Naess, contributed to the appropriate technology movement.

6.8.2.2.6.5. Embracing a Technology Diet?

In the case of industrial nations, we have been embracing excess for many generations, so that we are crippled by stress and sickness. Perhaps all we need is a diet, an emergency diet. The essence of a diet is to restore oneself to health, by restricting unhealthy consumption.

As societies and cultures may also be guilty of this kind of behavior, so they need to put themselves on a diet. We know that people are unable to perform well on unbalanced diets or sometimes even behave in a human way, so the diet would have to be whole and healthy, just without excess or overindulgence. A diet for a small industrial planet could be presented as a series of actions based on technical, managerial and design ideas.

For example, we could start a carbon budget for planet, and cut carbon use drastically by decarbonizing the power grid with solar, wind, and other sources, then ban new coal-fired plants and regulate existing ones. We could extract CO_2 from the atmosphere, by planting trees and designing a permanent agriculture. We could regulate our population, by basing it on biological/cultural carrying capacities and by starting a Year of Consideration with no births.

We might freeze our energy use at 1950 or 1910 per capita levels. We could cut waste by using less and sharing, by designing more ecological technologies, and by creating entire industrial ecologies. We could cut transportation, by not traveling as much or as wastefully, and by using old-fashioned practices like walking or by using virtual technology like the internet. If we did travel, we could optimize transportation with hybrid or solar cars that get 4-200 40 mpg or better. Trains could be solar electric or maglev. Ships could return to sailing technologies. Airplanes could be grounded 3-4 days a week.

We could seriously cut the automatic or planned expansion of human/urban/agricultural areas, cut conversion of wild ecosystems, and preserve wild areas as wisely as possible using north-south ranges and north-south corridors, even through cities and fields.

6.8.2.3. Technology Design Related to Properties of Culture and Life

We can use the properties of ecosystems to consider design concerns with technology, although those concerns might be better linked with the properties of a culture: Conduct, wholeness, flexibility, adaptation, endurance, and vitality. Each of these properties should help us understand the limits and alternatives to design technology.

6.8.2.3.1. Conduct Related to Design Technology

Conduct is the course of cultural behaviors through a behavioral landscape. The concept of the epigenetic landscape can be used to explain why people become trapped in the use of a technology. The use-need path or chreod is deeper than the cognitive path that relates technology to history and need. So, we have to use the technology even though we may be aware of simpler solutions, such as bicycles or evaporative cooling. If the need chreod is too deep with investment or profit, we cannot explore the cognitive chreod. This may explains why necessity cannot be the mother of invention; the necessity path, eating to avoid starvation for instance, is too deep to allow exploration of a shallower path of daydreaming or design. The broader behavioral landscape of leisure is needed. Conduct can be described as the stable path of culture through a landscape of possibilities. Once the course has been set, it is most likely to channel most subsequent behaviors, unless some event or catastrophe triggers a deeper course.

6.8.2.3.2. Wholeness Related to Design Technology

Culture provides an identity for its members. It tells them who they are, where they came from, and why they are special. Identity is basic to human existence. People are identified by their roles. A person is an incarnation of his and her group—even in industrial culture, one is identified as an astronomer or farmer. Specific technologies are often part of an identity. Identity is that persistent quality that can be described apart from its performance in interactions, but not isolated. The relationship between identity and wholeness is a rhythm, with unique patterns. In fact, culture is concerned with all things and beings in a whole. If the rhythm is whole enough, it could incorporate appropriate technologies into it.

6.8.2.3.3. Flexibility Related to Design Technology
The rules of a culture lend order and stability to the whole, as well as flexibility. Flexibility means not being over connected, or not being too rigid or too efficient. Than means that culture is able to slough off older technologies for newer ones—or new ones for appropriate technologies that fit better into a sustainable pattern. That way culture is able to keep some options and unused connections open. Some of the flexibility comes from different ways of establishing connections in specific places. Culture is bounded by ideas and habits, but is open to flows of energy and materials. It is loose-fitting. It requires order, but not too much order. It is tolerant of discontinuities and contradictions, and this gives it flexibility. If the contradictions between technology and moral behavior become too great and maladaptive, however, the culture can collapse. Flexibility can allow the choice of technologies regardless of novelty or fad-value.

6.8.2.3.4. Adaptation Related to Design Technology
The patchiness of culture is parallel to the co-constrained construction of a species and its environment. Co-constrained construction enforces coevolution, the emergence of a highly ordered complexity to full structuration. Culture has to balance between embracing change and resisting change. People show a desire for new technologies, tools and products, but often fear and resist change. Resistance to change is a normal part of a cultural process. Groups like the pygmies have specialized to fit the requirements of the environment, successfully. This makes it difficult to adopt other cultural arrangements. A culture modifies and is modified by the environment, and both can adjust and survive. Technology is part of a culture and it aids survival in the wider environment. Each technology is a way of exceeding the limits of the environment. This changes the environment, which pushes new changes in human thought and technology. Technology itself, however, has not been used for improving ecological balance. It could and it needs to be used that way to aid survival.

6.8.2.3.5. Endurance Related to Design Technology
A cultural system is stable and persistent in time. It is a general property of some systems that acquired information is used to close the door to further inflow. A mature culture needs less information, since it works toward preservation, and closes itself off to information that does not fit the shape of the culture. The effect of maturity is to allow a maximum variability between systems with slight external differences, such as place or initial conditions. Cultural shapes need to be loose enough and diverse enough to change when new information is required. Cultural stability is the ability to maintain cultural identity under the flow of external forces and disturbances. A culture has to be able to resist disturbances that are too disruptive. Sometimes those disturbances result from an inappropriate technology that then needs to be modified or rescaled. If the technology cannot be modified, it has to be resisted.

Resistance is a positive act for a self-reliant culture. Culture also has to be resilient enough to recover from intermediate and small disturbances from the environment or technology.

6.8.2.3.6. Vitality Related to Design Technology

To be constant and stable, a culture has to be vital, that is, it has to be productive, to be able to convert energy and materials into foods and structures for survival. With order and integration come stability and security, without which no one can survive. Primordial security comes from a physical, knowledgeable relationship with nature. Stability can also be related to compartmentalization, communications, and the richness of interactions and connections. The system, with all of its technologies, is self-creating. It renews itself as its contents change, as disturbances change the parameters of the system. But, technology that does not fit the culture or its environment is a barrier to cultural renewal. If a culture is vital enough to be productive with less complex technologies, then it can judge and choose technologies according to its best longer-term interests and not be trapped in the depth of habit or investment. When human societies were small, the amount of control and security required was small. Although societies have grown to immense sizes, human security has not, despite incredible increases in the sophistication of technologies. Perhaps that is because vitality does not always require sophisticated technologies beyond a certain point to achieve goals of a good and stimulating existence.

6.8.2.4. Technology Design Related to the Properties of Life

We can use the properties of life to consider design concerns with technology. These properties are: Movement, cellular structure, irritability, growth and development, adaptation, and reproduction. Each of these properties should help us understand the limits and alternatives to design technology. Because of the emergence of technology from human creativity, many properties of technology seem similar to living.

6.8.2.5. Thoughts on Human Physical & Cultural Evolution

As humans continue creating extensions of their bodies through technology, as well as surgically or genetically enhancing those bodies, their patterns and behaviors change. Human cultural evolution has already resulted in more complex forms of culture, with technological modifications and enhancements. If humans finally become domesticated, then sexual selection will become controlled and perhaps artificial.

We already use computers for dazzling communications. We are starting to embed chips in our bodies and brains, to repair diseases or enhance memories. Perhaps smaller computers will be internalized, for better modeling and communication, perhaps for dealing with the complexity of global design.

Scientists have worked on reasoning holograms and on cloned sheep (although the first one did not live to a normal life span). Science might continue to clone humans. It might design specialty bodies for working in a vacuum or for eating cellulose or even converting solar energy directly into calories. More complex bodies could perceive other wavelengths. Would those bodies replace the evolved organic bodies we use to dream and make art?

Of course, it might be possible to create new bodies with new brains that have self-awareness and consciousness. Technology and design could take great leaps, but they would need to be enhanced to deal with the unanticipated consequences of such radical changes.

Extreme technology could remotely combine new bodies with faster than light signals (possibly through quantum entanglement or wormholes). Communication would literally take a quantum leap. External storage would be unnecessary, since it could be done at the atomic or molecular level inside the body, although permanent, as in the life of the universe, might be problematic. Nevertheless genes, memes, and wenes could be accessed and modified temporarily or for the long-term.

6.8.3. *Designing Hybrid Systems & Mixed Communities*

Given the limits of the Precautionary Principle, as well as other principles and standards, it seems possible to create living cells that could create machines. It seems possible to produce nanotools that could scrub or repair living cells. In fact, it might possible to create entire communities of machines and living beings on a very small scale that would have a vast number of interconnections to wild ecosystems. It is quite likely that these systems might be more fragile than natural systems, collapsing or dying out in months or years. And, it is quite possible that the remaining waste might not be completely biodegradable. Ecosystems already get mixed with plastics and pollutants. Given the possible dangers, however, these possible changes and applications need to be kept isolated for extensive testing. In fact, the proposals need to be critically reviewed by panels of ecologists, engineers, and other scientists and literate reviewers. This kind of explosively reproductive technology has to be planned and engineered through complex thought experiments, especially before it becomes part of the mix. Thought experiments let us describe interactions, such that if one thing and another interact and a third thing happens.

Mixing is part of the process of ecosystems, as animals and plants try to fit and excel at living and reproduction. Human and wild communities are already mixed. Humans use tools, so that means that technology and nature are also mixed; many other mammals have been observed to use tools. Humans have always collected food from mixed systems, without landscape conversion. A maturing agriculture might recapture some of this strategy. Mixed crops are easier to grow; we know that from experimentation.

We need to have mixed communities. This is what evolution and wildness do—provide the turbulence and chaos that every system needs to be mixed and renewed. Nature, the formal matrix for wildness and chaos, pursues a strategy of overproduction and waste. This is not the wise, motherly Nature of our dreams, this is a wild creator, profligate with energy and forms of information through low-efficiency and the waste of cells, seeds, and sperm, and with the escalating warfare of plants and animals. The sheer magnitude of energy and diversity allows tremendous margins of error. Error pushes the whole process, allowing possibilities and diversities. Flawless transmission would have stayed at bacterial level. Freeman Dyson suggests that the reign of genes, like that of the Hapsburgs is "despotism tempered by sloppiness." The harmony and stability of nature are perceived by human minds as they make them abstract.

We have metaphors to support the idea of mixed systems, including a process perspective, field concept, self-organization, and co-constrained construction. These metaphors form the basis of a new image for humanity, where we are an integral part of food webs and part of an organic cycle of birth and death. Human nature does not find meaning in an absurd world, but discovers its structure by interacting with the surrounding order.

We have learned from Charles Darwin and others that nature chooses the 'fit,' those who adapt to a specific environment. But, that nature seemed more stable and predictable than it does now. We are learning that the 'flexible,' those who can adapt to several or changing environments, may survive better under changing conditions. And, now that nature and culture are coevolving, it may be the 'creative,' who can change the conditions slightly and limit the changes wisely, who may survive even better! For instance, the North American species that were adapted to glacial-era forests died out 12,000 years ago. Flexible Generalists like humans did not.

Cultural development also changes through a process of hybridization. Industrial culture becomes a hybrid as it tries to satisfy the needs and wants of a growing population, especially for space and food. We have hybrid political systems, such as democratic socialism. We have to have goals and define new niches in mature hybrid ecosystems. We may not need as much technology. Symbiosis can be a model for cooperative designs.

Changes in growth and dominance have pushed us beyond our traditional cultural experiences. The dangers from this are immense: Slow catastrophes, such as extinctions and total conversions; sudden surprises, such as dead zones in the ocean or holes in the ozone layer as a result of overfertilizing, or overenergizing or overpoisoning; human ignorance of change and uncertainty; and slow, inadequate responses to very long-term changes.

The novelty and complexity of interactions of innovations can lead to thresholds that are tipping points, triggering punctuations in natural functions with consequences that may surprise humans. The current global environmental condition has no comparable analogs to any other previous time. One source of surprises seems to be the interaction of climate and environmental change combined with economic development and human and animal health. As tropical forests are converted to farmland people encounter diseases without having evolved resistance. We have to search for discontinuities and surprises that we may not be able to predict, although we can learn to be recognize early warning signs.

Our growth, pollution and terraforming has put us in a trap and only design and engineering, combined with severe conservation and changes in rich lifestyles, can get us out. Urbanization might help. So could technology. The new technologies promise help, but also will create larger problems. These are nuclear power, biotechnology, geoengineering, and information technology, which might be effectively multiplied by convergence, and either enhance or wreck human performance and a proper perspective for rethinking science.

We feel it necessary and important to embrace new technology. Environmentalists consider that sustainability is a sufficient basis for technological design. This may not be so. It may be necessary, but not sufficient. Perhaps some kinds of large-scale thought, such as Messianic thinking, have influenced our disposition to large-scale technological fixes, as well as the idea of redemption from the practice of irresponsibility.

As part of restoration on a large scale we have to consider whether it would be viable to green North Africa with technologies promote rain and build soil. Would it be viable to move icebergs to water the coasts of South America or Australia? What about micromachines and the use of nanotechnological devices in human bodies? We always think that technological problems are easier to solve than social problems. They are not, partly because they become social and environmental, and need fixing.

For climate change, one technological option might be large-scale planetary geoengineering, which requires equally large oversight. Energy use is so large that it requires a government. Extreme technologies are so large that they require a global government. The scale is large, as is speed and scope. Most meaningful actions have to be at the largest scale possible. But to be good at global, we have to think at the level of the solar system.

We need to creatively adapt to and interpenetrate the uncontrollable uncertainty of a new climate. If we make mistakes, they can be repaired if small enough. For restoration, we can experiment, improvise and innovate at a small-scale. We need appropriate technology, but we also have to behave appropriately with other forms and scales. That is, we need to keep an appropriate level of complexity. Our civilization and social structures may be too complex to support. Suspending technology all together might lead to disaster, unless we combined it with radical reductions and conservation, which may be considered in any mix of strategies. But, we can also assess our current technologies and combine them with other approaches to create a truly mixed design on regional and global levels.

6.8.5. *Conclusion: Adaptation or Relaxation*

Everyone agrees, to some extent, that we need science and technology to meet human needs, at our current levels of population and luxury. And, these systems have to be integrated systems of production, consumption, and distribution—postindustrial and ecological.

The most meaningful actions have to be at the largest scale possible—hence, global ecological design. But to be good at global design, we have to think in the solar system.

We tend to think of civilizations or nations as metaphors for behavior. Primasck and Abrams suggest that identity with 'generations' might be more meaningful than civilizations. But, generations are shaped by cultures and now by global influences and trends.

Advanced communities have to adapt biologically sound processes. Pollution is only a symptom of imbalance and improper resource utilization. The wars on pollution and on poverty are as ineffective as the wars on people. A serious problem is our lack of understanding of the extensive, long-term effects of pollution on the atmosphere. Once it is determined that materials and wastes, especially nuclear or chemical are dangerous and long-lived, they should be minimized. There are ways to reduce generation of wastes by acting on the flow: Reduce number of products; reduce the quantity of waste in each product; increase the durability of each product; and make sure that the cycle is a spiral. The best results might come from a mix of these strategies.

The greatest threats facing ecosystems and biomes, and the organisms and species adapted with them, are not just disease organisms or pollution, but the synergistic effects of fragmentation, pollution, and climate change. And these are best addressed all at once.

We need to relax, paradoxically, to have more time. A problem with the degradation theory is that time and leisure are needed for technological innovations. People starving rarely invent their salvations. We need to have faith in our strength and resolve so that we can act wisely with technology and design. The computer offers computing speed and storage of information, but despite our faith in it, it is not enough to solve any problems. Paradoxically, we need to be less adaptive. As Rene Dubos pointed out, we may be able to adapt to pollution and habitat destruction, simply because, like rats and bacteria, we can adapt to radical changes, even if other plants and animals that we value cannot adapt and perish. Therefore, we need to implement thoughtful plans and designs so that we will adapt to more healthy and stimulating conditions.

6.9. *Practicing Ecosystem & Planetary Medicine: Gain Ecohygiology*

Medicine has made great progress in the past hundred years, especially with the invention of machines that allow noninvasive examination of virtually every part of the body and the discovery of drugs that can control moods or modify diseases. It is possible to transplant malfunctioning organs or sets of organs. Some diseases seem to have been extinguished; others have been controlled. The understanding of diseases has been extended to psychological dimensions and to social contexts. Some medical practitioners and researchers even talk about removing death—as if it were a disease—or cloning healthy replacement body parts or whole bodies. Medicine, in combination with advances in hygiene and food technology, extended the average life span.

But, medicine is not perfect. Some diseases are making a comeback, and new diseases are starting to appear regularly. Some of the new diseases transfer from wild animals to humans, and a few from humanity to the planet, such as greenhouse fever or ozone loss. Some cures, such as chemotherapy, seem to cause more damage in the long run than no cure at all. Some medicines, or at least their effects, including packaging, chemicals, and testing cycles, are degrading human and wild environments; medical toxins, such as mercury, are killing plants and animals. Some treatments drain individuals and entire insurance companies with their costs—and some of the extreme costs are passed on to all individuals, healthy or sick. Some procedures, especially many kinds of elective plastic surgery, have no medical purpose at all. The distribution some medical procedures is centered on those rich enough to pay the recognized costs. Modern medicine has seemed to reach some invisible limit.

Alternative kinds of health care are attempting to address these problems and limitations, but they also seem to be limited to the exclusively human dimension. Public health emphasizes prevention for individual and communities. Other crisis environmental sciences, such as conservation biology and ecoforestry, try to address the unwanted effects of the medicine, but are unable to influence the causes.

A new field of inquiry is needed to focus on the health of the entire system, and to reconcile the care and health of ecosystems, populations, communities, and individuals. Using the term first used by D. J. Rapport, this field can be designated Ecosystem Medicine. This field is contrasted with traditional medicine.

6.9.1. *Medicine and Its Brief History*

The Greek physician Hippocrates theorized that illness was a natural biological event and that the body could heal itself naturally, in time. The Hippocratic corpus focused on prognosis rather than diagnosis, but, it insisted on observation and reason as the basis for any actions.

Hippocrates suggested that there was a relationship between the occurrence of disease and the physical environment. Hippocrates' insight was that health can be produced and maintained by natural elements, such as hygiene, diet, mental balance, physical conditioning, and a supportive home. Health depended on being in harmony with these things (this section has been abridged to emphasize global medicine; the full text is in *Redesigning the Planet: Local Systems*).

Over the thousands of years since then, medicine has changed and developed. The entire history of medicine can be compressed into six stages. Traditional medicine is common-sense and faith-based. Rational medicine, especially for the Egyptians and Romans, was the result of observation. Scientific medicine (from the 1860s) regarded the body as a machine that could be fixed with surgery, amputation, pressure release, medication, or radiation. Psychological medicine recognized that some diseases were related to the functioning of the brain within the body. Social medicine recognized that the body can be harmed or helped by the thoughts of other people. Finally, ecological medicine addressed the context in which health is embedded.

Despite the history of medical thought, many forms of medicine still exist together and still work simultaneously within a culture, although they address different aspects of sickness and health.

In medicine, a disease is identified through a syndrome of patterns. Medicine has a long history of trial and error in identifying patterns, but it has built a foundation of science (hierarchical knowledge), now, with advances in cellular and molecular biology. Medicine, as what doctors do, has been called a science, humanely practiced. It has also been called an art. Yet, it is neither an art nor science, but an intermediate discipline that combines theory and practice; the theoretical knowledge of science and symbols, as well as the practice of individual experience, is combined with an altruistic commitment to the patient.

6.9.2. *Strengths and Problems of Medicine*

Medicine is making dramatic successes. Modern medicine excels at managing medical emergencies, especially where the patient is unconscious, as well as traumas, complex surgical techniques, and the treatment of many kinds of bacterial infections.

As a discipline, however, medicine is faced with many unexpected problems, for example, ignorance or lack of information. Scientific information in diagnostics has been called “scanty;” there is even less information in therapeutics. Therapeutic experiments are difficult to design, control, carry out, and interpret. Even prognostics (and therapeutics) lacks long-term observation of selected patients that could be used to predict the course of disease in a specific patient.

Another problem is human error, especially in diagnosis or surgery. The arrogance of doctors, their false certainty, and their contempt for patients, contributes to error. Yet, doctors know that their skills and knowledge are incomplete; they cannot keep up with everything, and medical practice cannot eliminate the large degree of uncertainty.

There is the creation of new problems, iatrogenic problems (doctor-generated), from hospital sicknesses to wrong drug dosages. Iatrogenesis can be direct, as when medical care results directly in pain or death, or indirect, as when medical policies reinforce an organization that allows or promotes illness. The sheer press of medical prescriptions, for instance, undermines people’s confidence in their own ability to choose healthy paths.

Misunderstanding contributes to some problems. Medicine addresses many things that are part of life and health, such as death. But, modern medicine fights against death, in spite of the fact that death is an essential part of life, not just for the individual, but for the species and ecological system. This is not to say that death should not be resisted by individuals, but that science should not try to deny death a place in the process of living. Not having death would cause terrible problems with sustainability.

Furthermore, there is an environmental dimension to most problems. Medicine focuses more on individuals, and less on populations, the chemistry of toxic agents, government regulations, or environmental effects (or backgrounds). Environmentally-related diseases are hard to recognize. There is no classification scheme or surveillance mechanisms for them. The impacts of environmental illnesses are not much calculated. Instead, medical science is focusing on molecular biology to work out genetic factors in diseases. Although important, it is not likely that genetics will ever offer a complete explanation of why certain people get certain diseases. Environmental factors are the necessary complement for understanding diseases.

Many of these problems could be avoided with changes in procedures and oversight. Some problems simply express the limits of life and complex systems, and thus are limits and not problems at all. But, some are problems with the way we look at society and at medicine, that is, the problems are cultural and have to be solved on that level. They might be addressed using different models of thought.

6.9.2.1. Bad Medical Images and Metaphors

Conventional medical inquiry into health and disease is limited by its assumptions and metaphors. We have been living under the burden of weak images and false metaphors. We have assumed that we are individuals, separate not only from the environment but also from each other, but we are embedded in shared psychological dimensions, in societies, and in environments.

For purposes of argument, a model is interchangeable with metaphor. In a sense every image or metaphor, e.g., "the body is a machine," is a model. A model is a tool to integrate data, logic, and thought. The genius of the reductive, analytical scientific method is that it breaks down the complexity of nature into simple, focused, managed, short-term experiments that can be tested and confirmed. Of course the method is ruthless, shortsighted and incomplete. And of course, simplifying a social human being ignores the multidimensional intensity and richness of life; furthermore, there is an immense loss of information in addressing only a few one-dimensional parameters. It is, as Feldman and Lewonton say, "rather like trying to infer the structure of a clock by listening to it tick and watching the hands."

Another mildly productive but dangerous metaphor is war: War on cancer, cell-killing radiation, and magic bullets to eliminate the enemy, such as cancer cells, viruses, bacteria, and disfigured genes. The organization for war leads to separate departments and separate strategies, organ by organ, disease vector by vector. Health is then defined as the absence of an enemy. The business metaphor leads to links with pharmaceutical companies and billing companies. Modern medicine, like a computer, becomes a commodity, a contract for services between individuals, with no special moral status, although minimal courtesy and consideration are required.

6.9.2.2. Scale of Medicine

Medicine started at a small scale, the individual. It has become very successful with even smaller scales, the cellular and molecular. It is these scales that get the most attention and the most funding. But the lessons we learn from these small scales are sometimes small and narrow lessons. As medicine has expanded its scope to include the environment as a cause of illness and social images as clues to illness, the lessons become larger and bring into play those uncomfortable things such as means and ends, good and evil, and prejudice and inequality.

Medicine has been effective at a small scale, but when it is applied at a larger scale for small-scale predetermined (or individual) interests, then tragedy can result. Medicine has been increasing its scale, with the effect now that our predeterminations come into question. Human needs and goods get mixed up with needs and goods of other beings. The mixture rapidly becomes complex.

Changes in disease and treatments have caused a crisis. Crisis is defined for the moment as that point when doctors (or bankers or lawyers) take over to solve a large medical problem. The word crisis is from the Greek word meaning choice or turning point. The idea of the original meaning is that treatment is not a race but a turning point. Money, people, and better management are assumed to be good enough to treat the crisis. So, they accelerate the team whose very speed may have caused the crisis.

A decline in health is seen as happening at all scales, from global to local systems, from populations to individuals. In the recent past only the rich spoke of a need for medical care. Now elaborate care is seen as a new need for everyone. In the past, the sick were a minority; now, over half of people in the US and Europe are monitored by health professionals. Society has become organized for the new majority of people requiring constant medical care.

Medicine becomes a scarce resource. If most people are sick, and they seem to be by modern medical standards, then health becomes scarce. Modern health care concentrates on eliminating pain and prolonging the lives of the very ill. Beyond a certain level of intensity, professional health care smothers health as a basic freedom, that is, health as personal and social harmony with the wild environment. Because of the scarcity of the resource and its expense, there are breakdowns in health care (related to an ability to pay).

Medicine has become a disabling profession in Ivan Illich's words. Beyond a certain intensity, medicine engenders disease and helplessness. Healthy homes are replaced by sterile, limited-activity apartments (where no dying is allowed). Patients become prisoners of the disabling specialists. Medical institutions, corporations for instance, have acquired the power to subvert the purposes for which they were originally founded. They disable citizens with specialists. Medicine focuses its concern on therapeutic engineering, intervention into the lives of sick or potentially sick people. The mathematical medicine of biomedicine predicts future health as a kind of preventive medicine.

6.9.3. *Extensions to Medicine*

By 1997 almost half of adult Americans had visited practitioners of alternative medicine at least once, if not regularly. This social trend is occurring because alternative practitioners are willing to acknowledge the necessity of treating illness within a larger context, one of meaning and spirituality, and not just the symptoms.

Alternative medicines seem to be better at managing disease prevention. C. Everett Koop, in the 1988 *Report on Nutrition and Health* concludes that dietary imbalances, which are preventable, are the leading contributors to premature death in the US. The Center for Disease Control calculates that 54 percent of heart disease, 49% of atherosclerosis, 37% of cancer, and 50% of cerebrovascular disease could be eliminated by lifestyle modification.

Alternative medicine recognizes an intuitive dimension for healing systems and people. Everyone, who is good in their field, works sometimes by intuition, which is the integration of knowledge at a subconscious level, involving more than just senses and technical expertise.

6.9.3.1. Extensions of Medicine to the Community

Medicine already has to consider the whole spectrum. In disease, the harmony of the body is disrupted by some event through the environment. The disruption causes a symptom, of some kind, which becomes objectified as it, the disease. But, the disease is a conceptualization of the disharmony of the patient's world, that is the self-image and human image, and that image is partially defined by the human community and the larger environmental community, that includes movements of animals, plants, and microorganisms. Medicine has to consider multiple etiologies of disease, from environmental causes, to human social, genetic, somatic, and psychological aspects.

Modern medicine already considers epidemiology (or population medicine) "the study of the distribution and determinants of disease and injuries." The goal of epidemiology is to limit disease through early intervention, controls and treatments. These actions are performed through a community—a group of people with a shared location. Community health is the private and public efforts of individuals, groups, and organizations to preserve the health of those in the community.

Community health education emphasizes the importance of preventative health care at the community level. Their basic function is to give people facts about health, causes of disease, and methods of prevention, so that they can act for their own well being (and for that of their families). There are established strategies for community health: Establish a board of health, collect statistics, perform research, implement sanitary measures, then preventive services, health protection, and health promotion.

There are shifts in roles and continuity. Physicians offer advice for individual patients in an office. Community medical doctors are advocates for individual patients by communicating with employers, public health agencies or other agencies; they may advise and educate citizens and leaders about environmental health.

6.9.3.2. Extension to Environment: Environmental & Conservation Medicine

Environmental medicine usually refers to—for instance, in the 1988 Institute of Medicine report—the diagnosing of and caring for people exposed to chemical and physical hazards in their homes and workplaces through media such as contaminated soil, water and air. This definition emphasizes nonlife-style environmental factors, but does not omit traditional lifestyle factors such as diet, smoking and drinking alcohol. Environmental medicine has been considered as dealing with the impacts of air, water, or food contamination on the well being of people and not much more (see Table 6934-1).

Emerging infectious diseases cause novel complex problems, especially if diverse organisms are perceived as threats to humans. Emerging diseases are either infections newly expanding their territories or new creations. Viruses can exist as latent or persistent sources of infection in a population. To some extent human disease has always been the result of the reaction to environmental stress, certainly from microbes and other things, but also from the failures of agriculture, sanitation in cities, deforestation, and the use of exotic chemicals.

Population size and structure are also critical factors in infection susceptibility.

Medicine is more sophisticated and accomplished, but environmental degradation and the decrease in biological diversity—and the stresses from them—are increasing rapidly, resulting in new diseases and new problems for individuals and populations.

There are already in place city, county, state, and federal laws regarding sanitary standards (also for the disposal of hazardous materials). These laws are responsible for five human resources: air, water, food, shelter, and waste. Human sanitarians are responsible for controlling, preserving or improving environmental conditions so that human health, safety and well being are maintained.

Environmental medicine is an anthropocentric medicine to help people overcome problems from environment. It is biased for human welfare without regard for cost to others.

Table 6932-1. Possible hazards to the system

Site	Earthquake, flood, wind, drought
Physical	Radiation, vibration, forces, abrasion, humidity
Chemical	Toxins, poisons, allergens, irritants
Biological	Microbiological, vegetative, insect, animal
Psychological	Stress, discomfort, depression
Sociological	Overcrowding, isolation

There are examples of relationships of environmental conditions to human health (and the discovery or classification of diseases that probably existed previously but were misdiagnosed). Health has started to take account of the health patterns that result from ecosystem changes. New infectious diseases and cancers occur. For example:

1. Lyme disease. The white-tailed deer and white-footed mouse thrive in an impoverished landscape where large predators no longer select out sick animals. The disease gets magnified when the vectors, ticks, hitch up the spirochete to humans.

2. West Nile Virus (WNV). WNV is a virus that is maintained in nature through biological transmission between susceptible vertebrate hosts by blood-feeding arthropods, such as mosquitoes or ticks. The virus is maintained in a complex life cycles involving a nonhuman primary vertebrate host and a primary arthropod vector. These cycles typically remain unknown to humans until humans interact with the natural focus or the virus chooses human hosts as the result of some ecological change.

WNV was first isolated in the West Nile District of Uganda in 1937. The ecology was characterized in Egypt in the 1950s; it was first noted in Egypt and France in the early 1960s, and it first appeared in North America in 1999. Humans and domestic animals can develop clinical illness. The most serious manifestation of WNV infection is fatal encephalitis (inflammation of the spinal cord and brain) or severe meningitis in humans and horses, as well as mortality in some domestic and wild birds. WNV has been a significant cause of human illness in the United States in 2002 and 2003.

3. HIV/AIDS. Human Immunodeficiency Virus (HIV infection) causes an Acquired Immune Deficiency Syndrome (AIDS) in monkeys and human beings. The virus appeared to be resident in wild African monkeys. Possibly after decades of forest cutting, the virus was able to use humans as hosts. The first attested date for AIDS was 1959. In order to trick the human immune system, HIV can evolve new molecular pieces of the microbe, called

antigens, within an individual patient.

4. Hantavirus. Several people died during the Hantavirus pulmonary syndrome outbreak in 1993 in the southwestern United States. The summer of 1992 was rainy, leading to an increase in the crop of pinon nuts, which lead to an increase in the rodent population. Various species of rodents have carried (presumably for a long time) this strain of Hantavirus; cases may have occurred previously but been unrecognized medically. The larger reservoir population of rodents led to closer contact with human populations and the emergence of the Hantavirus in 1993 in the Southwest.

Subtle environmental changes, after a delay, affect the spread of disease in humans. This spread may be accelerated not only by exploration and destruction of tropical rainforests (where HIV may have emerged), but also by the increase in the amount and speed of travel and commerce (which aided the Asian tiger mosquito, a recurrence of cholera, and others). Also, large human populations allow a disease to shift to another area and avoid dying out.

Culture is intimately intertwined with health. Culture provides the mode for pain and suffering. It provides rules for sickness and death, as well as compassion for others suffering. African customs of polygamy and extended families provide a larger pool for HIV and hastens its spread.

The health of ecosystems is also intertwined with human health. Since 1996 a group of Canadian and Peruvian researchers has been developing an adaptive ecosystem approach to human health. They used two phases: A conceptual framework that combined ecosystems as complex systems with secondary data and fieldwork, and an application to understanding and improving a problematic situation in the Peruvian Amazon. The goal, however, seems focused on human health. They included natural resource use.

The term "conservation medicine" was introduced by Koch to describe the broad context of human health. Tabor says that conservation medicine "studies the multiple two-way interactions between pathogens and disease on the one hand, and between species and ecosystems on the other." He says it combines human health, animal health, and ecosystem health (shown as 3 intersecting circles equally). But, the application seems to narrow to human health. Michael Soule says "conservation medicine is the right medicine." It has more expertise, more knowledge, more research, and more cures—and possibly more understanding and prevention.

6.9.4. *Ecosystem & Global Ecosystem Medicine*

Medicine has gradually extended its attention to wider domains, from the personal health of individuals to the health of human communities and the health of those communities in an ecological matrix. It will be concerned eventually with the health of the environment.

The next step is to integrate ecosystem medicine with environmental medicine and ecosystem science. This means starting by creating a body of cases, then, evaluating the responses to the cases, and finally using that body of experience as a predictive for future treatments. A short discussion of ecosystems is necessary first.

6.9.4.1. Ecosystem Health

An ecosystem is a set of communities of species, using the flux of energy and matter in the same place and time, that is the smallest unit capable of recycling the elements of its membership. An ecosystem is also a topographic unit, a volume of land, occupied by organic beings, extended over an area and through an extended time, with connections to larger mineral, chemical, water and air cycles.

The new paradigm in ecology is the "flux of nature," which replaced the balance of nature, a homeostatic balance, with a homeorhetic balance, the flux. The ecosystems, in general are: open to external forces, do not maintain stable point equilibrium, have directional change as a result of stochastic forces and partial intention by itself, are influenced by both history and current composition, are adapted to natural disturbances, and have adjusted to small scale human influences for thousands of years.

Concepts of health applied to organisms can also be extended to communities and ecosystems. Both are complex whole systems with parts and functions. Of course, ecosystems are more complex than humans, which is also why we have trouble measuring social or cultural health (there is no standard society or standard ecosystem as there is a "standard human"). That complexity means we that should be measuring a large number of variables, starting with soil depth (richness, compaction), then annual nitrogen uptake (often related to leaf litter), trophic flows, species counts, and patterns of activity.

Norms for humans and animals are more definable due to the large numbers and the long history of observation. Ecosystems often have only one sample, if they are very unique. This means that there is no population and no possibility for replication. The use as analogy for individual systems may not be very productive.

Environmental health is a set of characteristics of the environment that affect the well-being of humans. Life energy, according to the physicist David Bohm, belongs to the implicate order, the unseen totality that underlies our reality. Health is the harmonious interaction of everything, or every pattern/flow that is part of the implicate order.

The flowing movement of the implicate order is harmony. But, since flow and order (in the holomovement) are imperfect and uncertain, perfect harmony or perfect health is not possible. Breaks in harmony are disease. Blockages of flow or stagnant flow result in disease. C. S. Holling considers that local pockets of chaos keep ecosystems stable by forcing the evolution of new forms to create new niches. Ecosystems reach their fitness near the edge of chaos. So crashes and explosions occur. In human medicine, that chaos seems to be a feature of ill health. That is, health is a form of harmony, not a characteristic of some things.

Health is not a final state, as modern medicine often regards it. Furthermore, the flow has channel or limits. The harmony of motion is more than just parts. Health is a description of the kind of harmony, not the opposite of disease.

The health of any wildlife species in a system is tied to the entire system, as well as to changes at the boundaries. This is especially true of preserved places. Gray wolves in parks have been shown to carry antibodies to canine distemper, canine parvovirus, and infectious canine hepatitis. It is likely that coyotes and fox in the same range also have been exposed to these diseases.

Ecosystem health must become a scientific discipline, addressing losses of biodiversity, habitat degradation, and disease explosions. With an understanding of ecosystem health, patterns of mortality in species may be more be able to be predicted and interdicted.

It is possible to examine ecological health from various perspectives: The emergence and resurgence of infectious diseases of humans and others; the effects of hazardous substances; the health effects of unwise actions, such as fragmentation or other alterations of systems; and, the interdependence of species and the connection of health, also. There was a link between natural history (descriptive ecology) and medicine in Thales and others. Ecosystem medicine reexplores the connections, which never disappeared anyway.

Aldo Leopold started to describe a science of land health: “Health is the capacity of the land for self-renewal. ... A science of land health needs, first of all, a base datum of normality, a picture of how healthy land maintains itself as an organism.” Notice that Leopold anchored this concept in a theory of organism rather than an ecological theory of community. Ecosystem medicine uses the broader concept of community to explore ecosystem health.

6.9.4.2. Global & Local Threats to Ecosystem Health

Threats to ecosystem health are well known. They can be summarized briefly as global or local problems. The local problems include: Removal of key elements, species, resources, and productivity; the disruption of natural cycles; the introduction of novel elements, as the result of inappropriate technologies; human take-over of habitats for human purposes, often the result of simple population pressures, but also of greed and sloppiness; and, extinction spasms in general, but specifically, for example, the decline of amphibians worldwide, due to habitat loss, pollution, and fungal infections (exacerbated by global climatic chaos). The global problems include: atmospheric heating; ozone depletion (chemical causes); the disruption of global cycles; and, contaminations (nitrates, mercury).

These threats can cause ecosystem collapse. Ecosystem breakdown happens as a result of stresses, singly or grouped, that relate to interference patterns in the system, most of which are caused by the human species now, although the potential for asteroids or volcanic eruptions remains.

As with people, health is related primarily to lifestyle (or life habits) and not to intervention by a doctor. Alas, the lifestyle of an ecosystem is often determined by its keystone species, and in most cases now humans are that species. There are specific issues in ecosystem health: Biomagnification of pollutants; diseases crossing species boundaries (and boundaries in general); the relationship between biodiversity and ecosystem health; between habitat destruction and health; and, plants or animals that cross boundaries (requiring us to track health in several ecosystems). There are also specific pathways for infection of ecosystems: Any kind of simplification, from monoculture to habitat degradation or simplification can allow disease to spread faster and farther; the decline in predators; a lack of competitors (to which pathogens are not as adjusted); and, dominance by generalists or specialists, which allows higher pathogen levels. This is not a comprehensive list of threats to ecosystems. But, it might be adequate to use to develop the concept of ecosystem medicine.

6.9.4.4. What is Ecosystem Medicine?

Traditional medicine has developed traditional medical specialties, including: Anesthesiology; Immunology (allergy, reaction to foreign substances); Dermatology; Family; Gynecology/ Obstetrics; Internal medicine (further divided into specialties: cardiovascular, metabolism/ endocrinology, gastroenterology, hematology, infectious disease, nephrology, pulmonary, rheumatology); Neurology; Pathology (chemical, neurological, derma); Pediatrics; Physical/ Rehabilitation; Preventive (Public Health, occupational health, and aerospace health); Psychiatry; Radiology; and Surgery (which deals with diseases that require

operative procedures to restore or preserve function or to cure the disease).
There are rough parallels with ecosystem care. For instance, ecosystem medicine might include: Examination by infrared or other parts of the spectrum (the equivalent to radiology); the study of boundaries, or ecotones (similar to dermatology); immunology (reaction to exotic species or foreign substances); pathology (chemical, virology); internal functioning (metabolism, element cycles, infection); surgery (such as the removal of exotics from invaded ecosystems); rehabilitation (restoration of structure or function); and preventive efforts (ecosystem health).

Ecosystem medicine covers the spectrum from human organs to the complete ecosystems of the planet and maybe the planet itself. Everything is nested ecosystems, from a body to the planet. Ecosystem medicine is not exactly humanitarian or ecocentric. Although it addresses ethical concerns and the focus is on ecosystems, it is more ecoperipheral; it approaches its subject sideways, cautiously and slightly out of focus, and aware of the frame.

Ecosystem medicine asks a much larger question that is integrative and contextually sensitive: Is the physiology of the base system healthy enough for self-renewal? Focus is shifted from the symptoms of a disease to the entire functioning process of existence within ecological limits. Health is embedded in the context of the system, with all of its constraints, limits, and opportunities for development. Our knowledge of the world is returning again to a unified image, so it seems every field is converging. Alas, every field is also diverging and looks fragmented—perhaps because we are using the wrong lens.

6.9.4.4.1. Organic Metaphor

What we have learned from physics and psychology is that the body is a pattern in dynamic relationship with its surroundings. Health is an extension into the relationships of bodies. The breakdown occurs in the larger pattern, the body in context with other bodies. Health and disease, harmony and motion, are all connected, so none of them is negative or positive as local events in context. In most cases the causes of disease, bacteria and viruses, are only competing in the life base. A metaphor needs to reflect the reality. Machine metaphors or war metaphors are not adequate.

Lovelock used the human body as an analogy for the self-regulating planet. After all, the planet has recovered from several major traumas, such as oxygen wastes and strikes by planetesimals (up to 10 miles in diameter). Each time, although the time may have been a million years, life bounced back. The biota of the planet appear to regulate the surface temperature, atmospheric composition, and ocean chemistry, for a start (perhaps like the human body regulates its temperature, blood chemistry, and other vital signs).

But, the organism is only a metaphor. With scientific study, the earth appears more regulated. Organisms, however, seem less regulated, considering symbiosis and neural competition and selection. Nevertheless, organisms are more a functional whole than the planet, which is whole more because of limits. Most organisms are limited by their original designs, that is, the body cannot replace the heart and liver with one purifying pump. The planet is not limited to one set of designs for its composition (biologically anyway).

The central metaphor of the Gaia hypothesis is that the earth is an organism. But, we consider that it is more loosely organized and less integrated than organisms. But, then we find that organisms are less integrated than we thought. Organisms seem like the ultimate bricoleurs, which gather up patterns, only some of which are then selected in living.

Organisms are functional wholes, with genetic programs for growth and development.

The organism might not be adequate as a metaphor. As a metaphor, the web offers connection. Perhaps a nested set of boxes would be more fruitful. As the nested series of embedded centers, it is the largest center, the environment, that is the most crucial. Without a healthy environment, community and individual health with only be a temporary situation. Healthy ecosystems are the foundation of healthy communities, which are the foundation for healthy individuals.

6.9.4.4.2. Ecological Perspective

A germ tries to live well and to reproduce. If it is quick, and spreads to more than one new victim, then it does not matter if the first host (often human) dies. Human beings and germs all evolve tricks and counter-tricks to stay alive. Medicine is one of our tricks.

The many breakdowns happening—in government, in education, in health care, in the family, and in business—may be negative or positive forms of rearrangement. In the larger, evolutionary context in which these social changes are taking place, the disintegration of our social structures may be a positive phenomenon. Without understanding the larger context, it is easy to mistake these breakdowns as pathologies. From an ecological perspective, most change is neutral.

Our planet is friendly, because it was a humaning world (or composed of "peopling rocks" as Gary Snyder puts it). We have been afraid of the planet and depressed by it, and we have responded by degrading it. Human impact in the form of overuse and inappropriate technologies is rapidly degrading the environment. This syndrome creates new patterns of human and ecosystem disease and instability. But, we can be rejuvenated by understanding, and we can rejuvenate systems we live in.

An ecological perspective recognizes humanity's deep connection with our supporting ecosystems. Individuals cannot live healthy lives in unhealthy ecosystems. Due to the large human population, healthy communities and biological systems depend on human restraint and responsibility in technologies, population, production, and consumption.

This ecological perspective is a way of examining the whole context of medicine, to see how it might be redirected to examine its context within community and ecosystem health. The ecosystem approach requires a knowledge of actual and potential pathogens in the system. Consciousness is an important emergent property of physical health.

This means transforming our global and local economic and social structures, not totally, but within limits of the cultures that furnish with our identities and rules. Both can work. Current economic structures are locked into exploiting the maximum for the minimum, or for controlling scarce resources for a favored few. Profit with emotional and spiritual impoverishment is not healthy, but support with emotional commitment is. We need to develop a sense of enoughness within the real natural abundance, within the ecological limits. Security is found in working within the limits, in a healthy environment.

6.9.4.4.3. Ecosystem Medicine and Ecological Principles

In medicine a false positive diagnosis is an inconvenience; a false negative diagnosis can be catastrophic. This is true in ecology and conservation biology, as well. Making a diagnosis is a form of gambling, so it should be done on the side of caution.

The practical ecology of a scientist needs to be grounded in a theoretical formulation.

The science of ecology provides principles that can guide actions. These include:

- The importance of scale cannot be ignored; things that work at a small scale do not always work at a large one; large scale rules cannot be predicted from small ones.
- Patterns of interdependence (connection and embeddedness) are as real as bodies, and have to be considered.
- Resilience, the ability to recover from disruption, is a characteristic of a healthy ecosystem.
- Appropriate measure, the Greek ideal emphasizing minimal intervention, is a proper approach to less healthy systems.
- Diversity is crucial for stability and interest. Approaches must be matched to the type of ecosystem and culture.
- Cooperation is necessary. For patients, partnership. For communities, the interaction of patients and professionals. A cooperative framework for healing within the depths of communities and ecosystems.
- Reconciliation (equality of opportunity for treatment) is necessary.
- Conviviality, basically living together in harmony, according to Ivan Illich, is a necessary strategy.

These ecological principles, and many more not presented here, can guide our actions to make good, healthy places.

6.9.4.4.4. Actions and Treatments

Medicine can be destructive to individuals, land use can be destructive to landscapes, and ecology can be destructive to animals and ecosystems. The concept of ecosystem health, by bringing the pieces together into a conversation, could avoid much of the destructive behavior of semi-autonomous departments that are not questioned or contained as part of a larger picture.

There are limitations for our treatment of ecosystems. We do not have a list of diseases for ecosystems. It is difficult to see the effects of ecosystem change or disease from the air or from a distance. Ecosystem illness is similar to chronic illness in humans. The appearance of symptoms indicate that the disease began long before the symptoms became apparent. So, the exact date of onset cannot be pinpointed. If so, then prevention becomes more important. And it is related to genetics, lifestyles (of forest entities, for instance), stress, and environmental effects. Furthermore, prevention is not a short-term, one step solution.

Some patterns of resource use need to be understood on the landscape level (and now on the global level). Others need to be examined over a year, decade or life of the system (especially in the Amazonian forest). There has to be a landscape level mechanism (and also a global one now) for regulating common resources. Local diverse patterns are good, but they must be coordinated at the landscape or higher level. It is the normal range of variability that has to be defined. Models need to be created for a wide range of habitat ecosystems.

There must be an institutional framework, with legal and social mechanisms, for monitoring and managing common resources. This is necessary for the health of the system, as well as the long-term health of humans. That means all interest have to be represented, even global corporations trying to profit from disease or rareness (brought about by overuse).

Public health specialists and population biologists look at disease in populations, whereas, doctors and veterinarians consider disease in individuals. The latter intervene while the former observe. The ecosystem doctor has to intervene in ecosystems. Ecosystem doctors care for the basic systems and communities.

Surveys need to be made of every kind of ecosystem. We need to have an inventory of kinds of systems and kinds of changes. How is conserving terrestrial animals part of conserving ecosystem health? We do not know whether animal declines were caused by disease or some other factor (competition or predation). We need to find that out.

Monitoring is the key to understanding changes. Disease needs to be monitored as an important indicator of integrity. Other indicators are surveys of key species, habitat mapping and human impacts monitoring. Complex interactions have to be monitored, using a range of indicators at levels from behavioral to ecological. There may be limitations of the bioindicators of ecosystem health. Perhaps we need to find common and endangered indigenous species and monitor them, hoping that would reflect the health of the system.

Many systems that have been overused to collapse need to be restored. Especially in forests, many small changes have a cumulative effect. Climate change can lead to loss of forest biomass. Change of rainfall patterns lead to water stress in adapted species. Deforestation results in other patterns of change, especially in vectors. Reforestation is associated with rapid changes in vectors, which can adapt to nonindigenous species of vegetation. Restoration is a necessary part of reforestation. Maintenance of remnant populations may not be enough to prevent loss of key species on a landscape level.

6.9.4.4.5. New Goals for Human Medicine as Part of Ecosystem Medicine

Medicine can continue to advance and confer benefits to societies, but it has to have a larger perspective. The physician had traditional obligations to the patient, to herself, and to her society, but now there are obligations to the environment. All these are partial because all of them are inescapable and unavoidable.

Medicine needs to monitor disease and health, as well as the human use of the environment and its consequences. Medicine needs to improve research for the prevention and treatment of new diseases related to ecosystem changes or degradation.

The standard for our efforts should be health—of communities, ecosystems, and corporations—not profits, technological sophistication (although that is sometimes a good thing in use), or fame. The common goal is a healthy environment as a basic human right.

Medical advertising needs to change. Rather than promote the unquestioned use of drugs, advertising needs to promote awareness of paths to human and ecosystem health.

6.9.4.4.6. The Possibility of Global Medicine

Is the planet really in peril from human activities? Or can it work with new changes? The planet has a concept of health, or rather we have the concept, and we can describe it by contrast with an organism, but we have too little experience to try to make the health of the planet a real issue.

James Lovelock launched a medical model of Gaia (in his book *Healing the Planet*). The earth can be considered a patient that humans can address with some medical training. A few planetary diseases are evident now, such as greenhouse fever, ozone loss, or acid rain 'indigestion.' And there may be potentially fatal diseases at early stages, such as nuclear winter or extinction spasms. As a patient, Gaia is less threatening than a ruthless pagan goddess. Lovelock suggests a practical medicine for the planet, which grows from guesses and empiricism to practical solutions and good hygiene. Of course, this is what ecosystem medicine is—the application to the special cells and organs of Gaia.

Medicine is the identification of problems, such as stress; and, we are aware that humans put stress on global systems. We need to monitor the health of the system, checking temperature and pressure, breathing, biochemical tests and biopsies from ecosystems. We need to increase our understanding of decay and healing. Medicine has shifted responsibility from individual, to be healthy, to doctors and medicines, after decades of dramatic success with some medicines and treatments. This way shifts the burden to the intervener. The way out is avoidance, or awareness of long-term restructuring. Gaian medicine returns the responsibility with the planet, not with an incomplete flawed human management.

This form of global thinking is a critical correction for the machine world view, which traps us in a narrow atomic, context-free extreme individualism. Some forms of biological thought, such as Neo-Darwinism, have converted Darwin's organic view to a noisy market of manipulative machinery. The metaphor of the machine justifies our indifference to environmental disasters, since nature is considered a lifeless aggregate of atoms.

We can figure out if the planet is healthy—it is relatively stable. But, we are not sure what the planet requires to stay healthy. Does it require asteroid collisions? Does it require the increase in solar radiation? Does it require the ellipse of the planet orbit, with refreshing distances? Lovelock suggested that the galaxy was a giant warehouse containing spare parts needed for life. He also wondered if humans could be the stewards, as representatives of the varieties of life, for the planet—not managers, with full responsibility, or masters that make it provide for us. As stewards, we would address species in communities and ecosystems. Gaia as a living planet is a self-regulating system that can correct itself, under most circumstances, and without too much interference.

6.9.5. *Summary: A New Category of Medicine*

Less than 30 years ago, the environment was of little concern to most people. Now it is the primary issue for most people. Calvin Coolidge once said that the "business of America of business." The biggest single business in most of the world, now, is the environment. All farming, most pharmacology, most tourism, and many other "industries" have their basis in the health and beauty of the environment. The environment contributes to the largest share of most gross national products directly or indirectly.

Historically, we have used ecosystems without regard to their continuity or to their health. Partial knowledge and technology has allowed us to exploit our environment beyond what is desirable for us or for other species. While moderate exploitation is necessary to live, too much exploitation is unwise. A wise use of resources would not make the world less habitable. We are part of the system and must protect its health as a whole.

A new category of medical professional is needed: People who address the health of ecosystem themselves. Human physicians may need to be able to identify critical environmental conditions that affect human health, but others are needed to identify the health of those systems themselves. Human physicians need to know the basic principles of diseases related to environmental change or chemical exposure; others need to know the principles of ecosystem health and how that is related to human health.

Conventional medicine has great strengths, as do alternative medicine or traditional cultural medicines. Ecosystem medicine must develop such strengths. Ecosystem medicine incorporates all other kinds of medicine as special cases. It can use the best and most appropriate of any procedures. No single approach works best for every instance.

Using a model of ecosystem medicine offers a comprehensive framework for investigating the problems of health, from individuals to ecosystems, especially the interactions between individuals, social groups, place, and environmental change.

Ecosystem medicine is a medical discipline, aimed at restoring ecosystems to health. As with any medicine, the patient actually does most of the work to become healthy, although the doctor gets the credit and the payment. This leads to respect for the practitioners, but also to more responsibility and more rules. The first rule, which we might take to be basic, is identical to the first vow of the Hippocratic oath, "Do no harm." Noninterference is a basic ecological principle—do not interfere with the health and stability of the ecosystem—the health, diversity, and stability of the ecosystem are a first consideration.

Ecosystem medicine bases itself in a community context and limits the use of the ecosystem to that which the ecosystem can afford to provide and remain healthy over indefinite time. Ecosystem Medicine undertakes the responsibility to preserve the healthy functioning of the ecosystems under its domain. It also has a responsibility for the ecological production of goods from an ecosystem.

This is the local application of ideas for specific ecosystems, which may have a direct link to human health. The systems still have to be self-sustaining and self-renewing, Of course, the planet can also be linked directly to human health. In traditional medicine the organs are more integrated than in ecosystems, which are looser and more complex. James Lovelock has emphasized the health of the planet as a single system.

The health of ecosystems and human institutions should be measured with a holistic index. We have not developed qualitative indicators of ecological health or quantitative measures of social health, much less an ecocentric view that would value preserves of nature for themselves.

To address the health of ecosystems, ecosystem medicine would be a temporary medicine, not a constant intervention or even a continuous diet. We have already tried to gain complete control over ecosystems through scientific methods and technological applications. We have not been able to control them successfully. We regard modern medicine as a foolproof system that tried to eliminate weakness, disease, and mistakes. It has not. Ecosystem medicine must limit its goals.

One goal is the pursuit of the health of ecosystems and their inhabitants. That goal is good health. Individual health is in the context of community health, which is in the context of ecosystem health. Another goal is security. Symptoms of insecurity are poor human health, migrations, and conflicts (territorial or religious). Environmental security is more than the abundance of natural resources and having a stable social and economic situation. It is the health of the whole system.

Rather than telling the ecosystems what to do, rather than controlling their growth, we need to watch ecosystems to see what they do (this used to be the function of natural history), and we need to let them do it (this requires patience and temperance), with a minimum of interference. Abraham Maslow regards this attitude as taoistic, and the way to ecosystem health is letting the ecosystem do most of the choosing and working.

Our response to the ecosystem, being concerned with its health (as ecosystem doctors or nurses perhaps), is not benign neglect or complete anticipatory stewardship, it is participation in the process of the ecosystem as a harmonious system, with mutually restrained conflicts and constrained influences.

The goodness of our lives reflects an imperfect balance of love and selfishness, reason and passion, sensuous materiality and spirituality. We have the responsibility to be healthy, to contribute to the health of our community, and to contribute to the health of natural ecosystems. Good intentions have to be combined with ecological knowledge and ethical behavior for the discipline to be meaningful. Aristotelian ethics emphasized justice and fairness; Epicurean ethics, gentleness and kindness; Stoics, duty; and the later Stoa, love, compassion, and mercy. Our rules for living together have to be a compassionate participation in the whole planetary process.

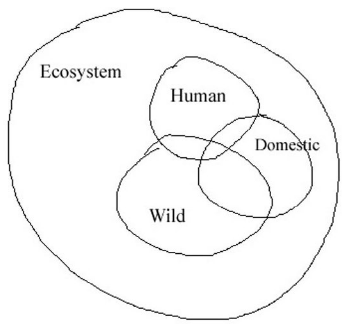

Figure 695-1. A Simple Diagram of Ecosystem Medicine

7.0. Managing Design Levels

Even after heroic designs have been composed and applied, they have to be maintained and managed. Management is a continuous requirement. Management is necessary to keep the designs from being abandoned or subverted. Human settlements can be managed in small-scale ecovillages and communities. Large human settlements, or urban areas need to be managed in watersheds and regions.

The history of human use has resulted in numerous problems, which could overwhelm any attempts at frameworks or designed landscapes. For instance, the continual growth of industrial societies, not just populations but the entire infrastructures, could overwhelm any design. The historical inequities between cultures, and even within most cultures, unless it is addressed, could tear apart the society before it could improve circumstances with designs. Thus, design has to include such things as poverty and unfairness, bad distributions and human greed. Corporations are examples of situations where legal changes and scale have released an entity from any normal ethical or legal restraints. Corporations have to be limited before designs can be effective.

Many design factors have to be considered, from economics and city shapes to religion and the power of religion to bind people into voluntary limited arrangements. These factors could distort a design, so design must account for them, also.

7.1. *Global Design Factors: Cities & Urbanization*

Over thousands of years, people created good communities in good places, often by accident, sometimes by intent. These places developed on a smaller scale, such that people learned to fit their activities to the place. Often, their cultures expressed unconscious ways of ecological adaptation. Myths and taboos limited the taking of rare or overly-desired species. Human technology and tools increased productivity without interfering with ecosystem processes, although there were some social and environmental changes.

We can use such societies as examples for some of our modern communities, with the understanding that the scale has changed, our technology is far more effective, and our cosmology has become more mechanical. For a modern community to prosper into the distant future, the community has to adapt a conscious ecological plan. It has to learn to mimic a mature ecosystem in terms of diversity, balance, flow and waste. Not only do houses and buildings have to fit the greater environment, from geology to climate, but economic efforts have to minimize exotic elements and waste, then work to fit with other efforts in the equivalent of a food chain.

7.1.1. *Ecovillages*

To some extent since the 1950s, intentional communities have allowed people to consciously address the creation of good places with concern for scale and fitness. Somewhat later, the ecovillage movement addressed these concerns of community, ecology, and spirituality by trying to create intentional, small-scale villages, within an urban or rural setting, within the matrix of other communities and places, which would be more sustainable. Many such villages are intentionally created as models of sustainability in action, for the purpose of working against the degradation of the overall cultural and ecological environments.

Principles can be distilled from these efforts. There are Ecological Principles: (1) The scale of the village and its impacts must fit the ecological context, (2) human interactions should be integrated into ecosystemic interactions, (3) the health of the system is important as social and individual health, (4) maintain the natural level of diversity, (5) ecosystem exploitation and modification has to be limited to known flexibility or limits, (6) Protect heritage areas.

Then, there are Social Principles: (21) The village should foster a sense of ownership through participation in design, building and maintenance, (22) the village should be self-sufficient and self-reliant as a settlement, depending on local resources, food and capital as much as possible, (23) the village must maintain the infrastructure of all its facilities, (24) the village must allow order to be visible with known rules, shared values, moral order and authority figures, from older people to police, (25) the village has to allow initiative to come from anyone, from the bottom up, (26) allow a range of people to live there, (27) governance has to have some form of consensus decision-making, and (28) the health of all is as important as individual.

Finally, there are Design Principles: (31) Define spaces clearly through design, signage, and landscaping, (32) design for appropriate levels of privacy, (33) design for integration of all aspects of society from hospitals and prisons to schools and factories, (34) design for access, warmth and beauty—and not just visual beauty, but for the music of sounds and the harmony of smells and tastes.

Of course these principles do not exhaust the number that can be used, and many of them have been expressed as principles of ecological design. And, many of them could be enhanced by the use of specific strategies for action, such as ecoforestry, permaculture, natural farming, and industrial ecology.

These principles can be related to the properties of ecological systems and can be expanded into standards that facilitate opportunities to everyone. These standards would have to do with energy conservation, renewable energy, the use of local resources and materials, the importance of scale for walking, the incorporation of native species and habitats into the structure, the creation of new kinds of domestic ecosystems, the protection of wild areas, providing a safe stable environment, providing a variety of building and living choices within a good range of affordability, and offering a mix of economic opportunities.

7.1.2. *Ecocities* (Personal correspondences with Paolo Soleri, 1982-2012)

Doubtless, many of these ideas and principles can be applied at larger scales. Paolo Soleri started to create designs for ecological cities intentionally on a larger scale. Ecological cities would be designed to minimize environmental impacts. Partly, this would happen through density and intensification. Such a city would also try to be self-sufficient in the production of energy and food, using many areas and rooftops for agricultural production as well as for turbines and collectors. Green plant canopies on rooftops could reduce the heat island effect of large urbanizations. Air conditioning, for instance, could be accomplished through design with the chimney effect, which Soleri has integrated into most of his designs. The arcology could collect the water from evaporation and rain. It would minimize pollution. It would recycle wastes with interconnecting links in an industrial ecology. Transport would be improved through proximity and internal design. In addition the unfinished Arcosanti, there are other examples of ecocities in the making, including Curitiba Brazil, Alvstaden Sweden, and Kalundborg Denmark.

7.1.2.1. Goals & Enantiodromia

The goal is not only to create good places, and be connected with other good places, but to express meaningful ways to live. Unfortunately, goals are shifting patterns that are different for different images in different times, and also become responses to the fitness of past goals (see Tables 7121-1 and 7121-2).

Table 7121-1. Goals of Modern Individuals (or the Small Picture)

In	*Neighborhood*	*Housing*	*Transportation*	*Jobs*	*Leisure*
Goal	Separation	Size	Personal	Money	Fun/rest
What's Missing?	Community	Comfort	Usefulness	Meaning/ pleasure	Fun/rest
What's Result?	Isolation	Waste	Spread	Dissatisfaction	Fatigue
What's Response?	Violence	Unhappiness	Pavement	Sabotage	Ennui
What replaces that?	Ecovillages	Small homes	Light rail	Self-employment	Hobbies
And, what Replaces it?	Villages in arcologies	Self-built	Walking	Satisfaction	Watching

For instance, in neighborhoods, the goal of separation resulted from older traditional urban neighborhoods with some crowding. The separation as it was achieved, however, lost the feel of community, as people had their own quarter-acres and personal cars to reach the local malls and supermarket complexes. They felt more isolated and more vulnerable to fear and violence (especially the middle classes). Many of these people decided to intentionally bring back the sense of community as well as reduce waste and vulnerability to violence by creating intentional communities, such as ecovillages. But, even these did not always have the density that inspired creativity and invention. An arcology could provide a better context.

Table 7121-2. Goals of Modern Institutions (or the Big Picture)

In	*Science*	*Technology*	*Management*	*Corporations*	*Religion*
Goal	Data	Technique	Efficiency	Money	Truth attendance
What's Missing?	Knowledge	Appropriateness	Humaneness	Real cost	Meaning
What's the Result?	Irrelevance	Mass produced	Bureaucracy	Conversion	Rock & roll in services
What's the Response?	Personal search	Simplicity	Law suits	Activism	Personal religion
What replaces that?	Astrology	Wood shop	Computers	LLC	Scientology
And, what replaces it?	Ecology	Personal	Work effort	Nonprofits	Loose associations

Goals are obviously imperfect. There is always some element missing that results in a suboptimal condition. And, the resulting dissonance prompts a response, which may result in an improvement or a less satisfactory element. Perhaps with continued experiments on ways of living, combined with an ecological perspective and forms of ecological design, communities can optimize human happiness or at least satisfy it minimally. What do we design for? Maximum numbers? Maximum luxuries? Maximum happiness? Based on our knowledge of systems and maxima, it is dangerous to design for maxima of any kind, or even for optima—perhaps it is best to aim for a satisficing level. New local village and city patterns have suggested that we can design for safety, design for peace, and design for health.

7.1.2.2. Designing Communities at Any Level

In designing local communities, with properties, principles and standards, three approaches (and possibly more) can be used. Design can address safety, peace and health.

7.1.2.2.1. Designing for Safety

Public health officials started requiring design changes in buildings to prevent injury and disease. Buildings had better lighting and guardrails. They had closed trash rooms and regular pickups of trash. Later, automobile accidents prompted officials to require higher-impact bumpers and seatbelts; these technological changes reduced injuries and deaths. Through an ecological design model, Ian McHarg started tracking broad social factors, such as poverty and exposure to violence, related to the urban environment and its history and inequalities.

At about the same time, sociologists noticed that some environmental characteristics were associated with crime and suggested that the physical design of urban spaces could influence behavior. C. R. Jeffrey suggested that the proper design of the built environment could reduce crime and the fear of crime, by minimizing opportunity and promoting positive behavior. His idea of 'Crime Prevention Through Environmental Design' (CPTED) was guided by five principles: Natural Surveillance, Access Management, Territoriality, Physical Maintenance, and Order Maintenance. Surveillance maximizes visibility through the use of design features, such as windows; access management directs people through signs and markings, but can also use landscape features to guide people to entrances and exits as well as limit access to some areas; Territoriality is confirmed by delineating spaces—although there is an emotional element that can allow people to feel warmth, belong or pride, instead of disgust or anger; Physical maintenance requires regular repair and upkeep of facilities; Order maintenance requires attention to disruptive or damaging behaviors, as well as rules stating what those behaviors are.

Much later, sociologists noticed that the isolation and design of prisons and jails may have contributed to a worsening of crime. Architecture has begun to promote better conditions and better placement for some jails and prisons. Jails especially are being integrated into the community, to reflect their function as short time, locally controlled holding facilities. For instance, the Brooklyn House of Detention is expected to reopen in 2012, with an improved façade and street-level stores, at its current location close to the courthouse and police station. Ken Ricci notes that jails are a legitimate buildings in an urban environment, part of the whole civic landscape. Ricci, of Ricci Greene Associates, has designed inmate quarters with larger views of a recreation yard under an open sky.

Jail housing is changing from a linear cell model to units facing a central day room. Jails are like ecological buffer zones that allow transition between systems with protection for both systems. Some prisons are being designed to fit into their local environment in the countryside. Of course, design cannot be isolated from inequity or violence, much less laws and the justice system itself, which might also benefit from social design. For example, the War on Drugs and Three-strikes legislation exhibit the flaws in the system. We need to find alternatives to lockups. Jails and prisons need to be an appropriate sizes for communities.

Now, we are noticing that with rapid changes in societies and immigration, more holistic approaches are needed for design. The entire environment needs to be addressed in design. A participatory ecological forestry could not only restore the biological wealth of a community; it could involve more people and perhaps reduce some forms of violence (and this has been the explicit goal of ecoforestry movement in several nations). Neighborhoods could become more aware of their environment; their efforts may increase native tree cover and reduce the damage from invasive species. The Urban Community Greening (UCG) effort in Cape Town South Africa reports that it has been successful in using community agriculture, horticulture and forestry to reduce violence in informal settlements of Black Africans and refugees near the metropolitan area. Community greening efforts may reduce the risk of violence, even from new patterns of violence. After Apartheid, according to Harris (2003), new forms of prejudice and conflict emerged, including xenophobic hostility to foreigners, vigilante acts, and economic struggles around land and service issues. These new patterns merge with the old ones to complicate political change. Many other places are facing a 'culture' of violence' that may result in 'feral' cities or failed nations. The collapse of civil order threatens all residents and many larger levels of security, including global security.

The social production of criminals through prison culture could be transformed with different opportunities and involving designs. Glass walls on a street showing prison work in glass or art? David Orr has written that with only minor modifications, university buildings could be converted for use as factories or prisons or vice versa.

Urban planning considers buildings, groups of buildings, parks, streets, walkways, transit areas, business areas such as automatic tellers, industrial structures—in fact any structure that is not operating on 24-hour cycles—and all shared places. All community buildings, such as schools, might be used for other purposes at other times of the day. Especially auditoriums and gyms. They could be round the clock community centers, as some are in Sao Paolo Brazil. Urban planning addresses the safety and security of all those places. Given the large number of old structures, these can be retrofitted and redesigned to new standards along with new structures made to those standards.

7.1.2.2.2. Designing for Peace

Given that there will always be violence, it can be reduced, diminished, and localized. It can be more integrated into a community, or rather allowed at certain levels. Some kinds of violence might be reduced through participation and understanding. Community greening might work to redesign the community environment through participation and cooperation. Reducing violence results in more peaceful activities. These peaceful activities can restore environmental damage, as well as instill greater trust and create cooperative links. It can promote changes in perception and beliefs; for instance, ecological understanding increases the time-horizon of our influences and our decision-making, and it allows us to broaden our identities and cultural norms.

In general, ecological understanding and peaceful activities can reduce the risk from violence, as well as from larger ecological catastrophes. Groups and societies can develop resistance to violence and resilience after catastrophes. Both resistance and resilience, remember, are aspects of the ecological stability of ecosystems. Developing a community, like developing a muscle, gives it more strength, which allows it to address inequities and conflicts—and catastrophes—without falling apart.

Starting in Mesopotamia, and the storage of food and luxury items, cities built walls to protect their people and resources. Farmers and the poor were protected within the walls or just outside. This design feature continued for thousands of years until technology finally rendered walls impractical. Without walls, cities had to resort to different methods to deal with attacks and crime. Improved armies and weapons reduced attacks. Public welfare institutions were developed to reduce crime and poverty. Later the 'City Beautiful" movement rationalized that in a more pleasant environment, people would be less likely to commit criminal acts. Beauty seemed to be ineffective on some levels, however. Urban planning still often uses walls and beauty to address crime. It was recently thought that he medium of television, by showing so much violence, increased violence in the community. Then, it was thought that by showing absurd levels of luxury, television instigated violence from people who had no such luxury but desired it. Disenfranchised individuals, or individuals from disenfranchised groups, may be more likely to use violence to attain success, at least success defined by money and luxuries. Much violence results from the perceived need to use violence as a path for economic improvement; more violence results from the easy access to modern weapons.

Perhaps architecture itself can be related to violence. Hard, large, cold, threatening—biologically and mentally—buildings reflect our cosmology of the machine and that depresses our spirit. But, as the British and Japanese, to some extent, have learned, it is important to rebuild in the same form, with the original materials, wood or stone, to make sure that our buildings shape us in ways we want.

Tom Vanderbilt rewords Clausewitz to consider war as an extension of architecture by other means. Perhaps, but before that, architecture was an extension of war by other means. Vanderbilt points out that architecture is defensive structure and target. That aerial warfare and urban planning even share language and tactics. Architecture can also be used as a weapon, Eyal Weizman suggests, as when Israeli settlements in the West Bank tower over Palestinian villages or a superhighway soars over Palestinian farmland.

Decay is a problem related to violence. Some cities, such as Detroit, are shrinking cities. Other cities, such as Beijing or Beirut, are fragmenting or hollowing out. A few cities, such as New Orleans are breaking down. Others, such as Leipzig Germany or Ivanovo Russia are disintegrating. Unless cities can maintain their infrastructures and be perceived as desirable locations, residents leave or fight.

Our landscapes have become as artificial as our cities as they are converted to farmland or grazing lands. Can ecological design, community greening and urban planning make communities, cities and nations more peaceful? Maybe design can reduce the desires (or motives) and the opportunities for crime (it may not ever reduce abilities, as they evolve with the improvements)?

7.1.2.2.3. Designing for Health

The purpose of housing is to provide shelter from the elements, which is basically the atmosphere. The purpose of business or industrial buildings is the same, although it may be extended to separating business actions or dangerous processes. But, buildings also have to provide safety from disease; they should be hygienic, providing clean water and air, channeling dirty water and polluted air. They need to provide areas for food consumption and waste. They need to encourage social and mental well-being—that is, they cannot be too ugly or noisy.

The design of many buildings contributes to isolation. The sprawl of cities, lack of public transportation on the streets, deserted streets, and tall buildings all imply or demonstrate lack of access. The urban environment includes the effluents from buildings, the waste water, pollution from products or generation of electricity, dangerous chemicals, noise, vehicle activity—roads are a problem to safety.

One design solution is density, as envisioned by Soleri and others, that is, moving things closer together. The entire city needs to be considered as a design project, vertical and horizontal, below ground and above, self-sufficient or highly connected with trade.

Feedback is also an important component of behavior. Buildings that have daily readouts or visible monitors might influence people to turn down heat or turn off lights to save energy or reduce waste. The design includes participation with feedback loops.

Human feedback is critical, also. Design needs to be used centered. It needs to achieve ease of use as well as 'ensoulment,' in the words of Naoto Fukasawa. It needs to be nonneutral as well as persuasive with its values. It needs to be participatory for the residents and designers, with everyone performing some active role. The goals of design have to include the social transformation of consciousness and positive behaviors as well as more efficient and beautiful shapes. Community engagement with designers and designs can be encouraged through cognitive dissonance. And that can be created with notices, posters, events, and prizes. Participation encourages enthusiasm for the project. Performance design creates more empathy for other participants, where the affects of actions are anticipated and the emotions of others are experienced. Community and online networks allow observation of various kinds of consequences under different conditions. This is what thought experiments are!

Specific buildings need to mimic local landforms or vegetation. They need to perform natural functions, such as damping the wind, holding water, and preventing erosion. The native vegetation surrounding needs to be restored so it can function as wind barriers or shades. Rainwater collection systems, permeable paving, and appropriate structures have to be considered. Design needs to address ways to move people outdoors more often. It can do this with in-outdoor transition zones and areas for outdoor activities.

All of this basically has to do with health. Health is the harmony of conflicting elements, such as disease, joy, selfishness, and altruism. Ecosystem health envelops the health of species and individuals, human and other. It is not enough simply to reduce disease and violence. Health has to do with the environment. It has to do with aesthetics, and that includes all the senses—humans need music as much as beautiful forms; they need stimulating smells and tastes, as well as clean water and clean air. Sounds and smells, for instance, can complement and enhance any building or area, whether the sounds are symphonies or leaves rustling.

True sustainability requires integration with regional and global cycles. It may require tradeoffs of wilderness and waste sites.

Intentional communities, such as ecovillages and ecocities, find a basis for sustainability in appropriate properties and standards, as related to ecological, social and design principles. The basic concern has to be with ecosystem health, with the operation of global cycles. This will not happen without an expansion of consciousness that is required for ecological understanding at larger spatial and temporal scales.

Even arcologies need to be designed for exposure and lack of isolation, that is, they need to consider how the interior barriers, walls and open areas are situated. Both ecovillages and ecocities need to be aware of their influences on the larger scales of patterns of exploitation and interference. Unless the local patterns are integrated with regional and global ones, local improvements may not withstand stresses and collapses elsewhere.

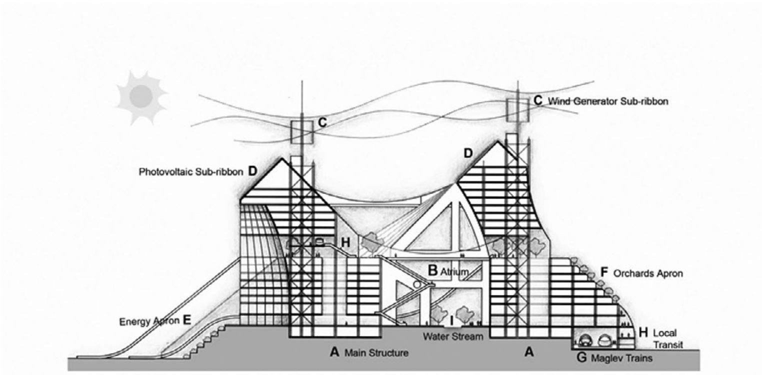

Figure 712-1. Cutaway of Soleri's Lean Linear Arcology
(in *Redesigning the Planet: Local Systems* and in book of the same name).

7.1.3. *Ecological Cities*

By Paolo Soleri (Being edited 2013)

7.1.4. *Ecological Cities as Expressions of Urban Life*

What is a city? Since the dawn of settled agriculture, humans have been altering the landscape to secure food, create settlements, and pursue commerce and industry. Croplands, pastures, urban and suburban areas, industrial zones, and the area taken up by roads, reservoirs, and other major infrastructure, all represent conversion of natural ecosystems. These transformations of the landscape yield most of the food, energy, water, and wealth humans need. Of the planet, humans have converted approximately 29 percent of the land area (about 3.8 billion hectares) to agriculture, roads, and urban or built-up areas. Agricultural conversion to croplands and managed pastures, alone, has affected approximately 26 percent of the land area (about 3.3 billion ha). Agriculture has displaced a third of temperate and tropical forests and a quarter of natural grasslands. Agricultural conversion is still an important pressure on natural ecosystems in many developing nations; however, in some developed nations agricultural lands themselves are being converted to urban and industrial uses.

Urban and built-up areas now occupy more than 471 million hectares (about 4 percent of land area). Well over half the world's population live in cities. Urban populations increase by almost 200,000 people daily, adding pressure to expand urban boundaries (UNEP 1999:47). Suburban sprawl magnifies the effect of urban population growth, particularly in North America and Europe. In the United States, the percentage of people living in urban areas increased 10 percent, from 65 percent of the population in 1950 to 75 percent in 1990, but the area covered by cities roughly doubled in size during that period.

These patterns are the result of historical processes relating to the availability of land, technology, and dominance. They do not need to be preserved. New patterns are possible that respect limits, that keep populations and impacts in balance with the rest of the planet. Arcologies may be the best design.

7.1.4.1. *Arcologies*

Cities miniaturized nature. They miniaturized wildness and displayed it in parks, zoos, and even buildings. Cities, the largest of human structures, have resisted conversion to arcologies. The size and investments required for arcologies discouraged investors and builders from creating them. Is it that ecology as a science is too daunting?

How is a city like an ecosystem? Does it have borders, flows and cycles? Early cities had a balance and relation with wildness and country. Now, the change in scale to empires as well as just growth of populations and cities has unbalanced this. Cities still have to follow the laws of physics, as well as the laws of chemistry, biology and ecology. Before the change in scale to cities as homes to millions, cities could waste and pollute, and the waste would be thinned out by the tides or winds. Essentially wilderness did the housekeeping and provided the sink. No longer. Cities have to embrace an industrial ecology that cycles things within.

The edge of the city, more than a wall, is like a membrane that allows cycles, water, resources, and people to move in and out. But, the edge can keep out exotic, dangerous animals and people, and it can keep the concentrated and complex organizations inside.

We should not be overwhelmed by having to meet limits. What is a limit? A crushing wall? Is a limit not like a grid or a poetic form? Something that has to be met yet forces or inspires creativity? Surrounding ecosystems provide constraints to the size and kind of city.

We should not be overly concerned with the material size of a city. How much of nature is organic? One percent? How much is material and elements? Biomass is 1 ten billionth of the earth mass. Most of the materials that make up a city can be neutral.

What are the trade-offs of living in an arcology? People would be required to give up many of their habits and addictions, but these would be replaced with new patterns of moving and dwelling that might be much more enjoyable, much more open to a civilized conversation with others.

What should cities look like? A collection of buildings? One large complete building? The mushroom of an underground network? (See drawings of two of Paolo Soleri's arcologies on pages 240 and 554).

7.1.4.1.1. Reshaping Buildings

Instead, architects generally remained at the building-size projects. Some architects have suggested altering the design of buildings and combining uses. For example, an apartment building block typically encompasses one square hectare of land. At best, in most cases, the block is 50 percent structure, and 50 percent surrounding yard, lawn, patio, or sidewalks. This footprint has 0.5 hectare enclosed space, and 0.5 hectare open-sky space. Rooftops as designed, however, are rarely usable for additional "live loads" of constant use activity nor dead loads of landscaping and outdoor furniture. By moving to a "stepped pyramid" form, it is possible to have a footprint of 1.0 hectare of enclosed space plus nearly one hectare of open-sky space.

The stepped pyramid form, or modern ziggurat, casts minimal shadows on its own tiered plazas, and does not influence the solar access of neighboring buildings. A structure with twelve floors casts a smaller shadow profile than a six-story block building. The street-level of a pyramid would have one hectare of shops, offices or workshop businesses. The second level would have offices. The higher levels could have apartments with garden areas.

Buildings designed as boxes with "square-shoulders," reduce the open-sky area of the maximum possible solar penetration. This reduces the solar gain for patio gardens as well as reduces the possible locations for solar-power panel positions. In worst cases, blocky buildings cast shadows which not only darken the adjacent streets, but also shade lower portions of buildings at nearby distances. Skyscrapers and high-rise buildings can put large zones in shaded darkness, especially at higher latitude locations in winter, which ensure that buildings have to use more utilities, raising heating and lighting expenses for lower levels.

Manhattan Island has a night-time residency density of 1.5 million people. The area of the island is 67.34 square kilometers. A reasonable building density would be 45 buildings per square kilometer, assuming that 20 percent of the area would be reserved for industry and public access. Replacing blocks with pyramids, the potential population of Manhattan would be about 2.23 million people without any building being taller than six levels and no building shading any other. There would be 2,800 hectares of commercial space on the street level, ample for transportation, services, shopping markets, and workshop businesses.

7.1.4.1.2. Reducing Footprints of Cities

City and artificial areas should be restricted to the remaining small percentages, of the least productivity. In cases where the city area exceeded that maximum percentage, an equal area of rooftops or pavement areas would have to be dedicated to agricultural activities. Thus, there would be no limit to house density, only coverage area, and that would be directly related to natural primary productive areas.

7.1.4.1.3. Retrofitting to Arcologies

Arcologies are based on an optimum size, related to productivities, limits and values. Arcologies are planned so that the management of elements and order of patterns form a balanced system. Arcologies integrate farming and wilderness into the city and the city into the environment.

Individual buildings could be retrofitted to be part of a single arcology. Perhaps a Buckminster Fuller geodesic dome could be erected over the parts of the city to be converted. The remainder of the city would be taken apart and recycled.

7.1.4.1.4. Design for Miniaturization & Intensity

The success of life depends on miniaturization, where a prodigious number of overlapping mechanisms are packed into a small space. These mechanisms persist through built-in regulation circuits, but the systems are open enough for novelty. As an emergent form of life, cities have packed patterns and increased their intensity. Arcological cities have the potential to increase it still more, while decreasing their impacts on the environment.

John and Nancy Jack Todd claim that living machines could miniaturize the production of human services, thereby letting nature develop wild systems that would provide global services. They say the designer could set the tasks for the machine and let it develop its own biotic complexity. Living machines would not need to be isolated from natural systems. However, it seems that whenever these living machines interface with living systems, there would be a potential for domination, collapse or hybridization. Such machines would fit well in the urban environment, which is already miniaturizing our relationships with nature.

The world has already been miniaturized in our imaginations, as well as by some technologies and in some urban environments. The effect of some of these technologies, such as television and movies, is that many who once accepted their lots of hunger and disease have seen western affluence and desire to share in it. Not to share equally with them now would be inhumane. Miniaturization seems to promise the intensity of ethical decisions and behaviors as well.

7.1.4.1.5. Design for Integration

Integration is one of the basic properties of a field. The processes of differentiation and integration, where the processes interpenetrate, run simultaneously from top and bottom, and shape a hierarchy from both sides, allow complexity to emerge. As we have seen, a city is a design that has emerged from the properties of a culture in a place, both of which are embedded in ecosystems and its enveloping field.

Many of the problems of modern urban societies, such as alienation, insecurity, and homelessness, do not occur in archaic societies. If we could recover the security and integration of these societies, with their unity of work and life and of economy and morality, we could extend economics beyond capitalism.

Global exchange, however, occurs at a different scale and a faster tempo, so that cultural elements often sit beside one another without any kind of meaningful integration. In these cases, the scale of exchange may overwhelm a holistic culture with an assortment of materials personally chosen. Some items, such as blue jeans, give a superficial uniformity to all cultures. Global exchange seems to create a tight integration of economics and cultures.

However, the integration may not be coherent. Ecologists call the excessive integration of a system hypercoherence. According to Holling, a system that is too-highly connected is an accident going to happen. Rigidity increases vulnerability to change. The number and strength of all the connections is a problem if disruptions occur regularly, and they do in modern cities.

Arcological cities might be able to reduce or strengthen connections in a more flexible pattern. Of course perception is a large part of patterns. And, we perceive the direction as being towards more complexity and more integration until we have megacities in a global society, coordinated on several levels, within a more complex biosphere. An arcological pattern would allow local cities to maintain their diversity be optimally integrated into new global forms. Self-sufficient cities would allow residents to start thinking locally and acting locally, within the ecological designs of the cities and within global constraints.

Ecological design, described by Fritjof Capra, is a systems-based approach to economics integrating human activity and natural processes. Capra states that it reflects the basic principles of organization of nature that have evolved to sustain life. Ecological design has an important role in sustaining, developing, and integrating residents into broader ecological and cultural environments, shaping these environments and being shaped by them in reciprocal actions. Bricolage is a way of synthesis and a technique to integrate historical and cultural knowledge into an urban form that is an optimal fit into its place.

7.1.4.1.6. Advantages of an Arcology

With an arcology, the city can change its relationship with nature; an arcology is a good solution for an urban culture, as it solves the problems of waste, resource-use, scale, obsolescence, and segregation. An arcology is a monumental design, which appeals to human desires for creating monuments.

The size of an arcology would allow great diversity in retail stores and job opportunities, especially those related to running the arcology. The shape will allow optimum use of sunlight. Common areas will be designed in.

The siting of an arcology, with its ability for self-sufficiency, leaves large contiguous areas of wilderness nearby; this would allow people to access wild areas, which would meet their needs for being in nature. The arcology would have a very small footprint compared to traditional cities. Although generally self-contained, an arcology could be open through local gardens and fields, which would be part of the design.

7.1.4.1.7. Disadvantages of an Arcology

Being optimized for size within a place, an arcology would not be expandable, although that may not be a disadvantage. The outer or inner shape of the city might not be flexible. Like any building that relies on complex technologies, regular breakdowns are expected. How would the arcology allow people to fend for themselves in terms of warm, energy and food? If the arcology does not have enough internal or nearby external agricultural areas, then food may have to be imported.

Reliance on traditional technologies, such as concrete manufacture or energy generation from fossil fuels, might contribute to environmental problems, such as carbon dioxide release. The shape of the arcology, along with interactions, may not solve the problem of the disparities of wealth. Although the design may encourage interaction and sharing, people will always be able to choose separation. Although the design may reduce crime and violence, people will be able to choose those actions also.

Some people may suffer psychological problems from intense living in a planned environment, but perhaps no more so than in any other city. Arcologies may not be able to solve the problem of increased movements of people, who may commute regularly between other cities and nations.

7.1.5. *An Arcology is a Wild City*

What should cities look like? Can we place them around mountains? This would solve the problem of interior space and lighting; everyone could have a view. Arcologies complete the idea of the city and make it ecological, sustainable, frugal and exciting to live in. The pattern of an arcology is integrated into natural processes and cycles.

How big are arcological cities? How big should they be? How big is too big? How small can they be? Is there an optimum size?

Is it determined by wilderness? Is the city dependent on wilderness? What does it need? What does it take? If it is dependent, how should it show that? Should wilderness dominate the city and force every design? What is wilderness? Thing, Idea, process, life? Is wilderness the center of life? Is the city? Should we withdraw our presence from wilderness?

Do cities answer as deep needs as wildness? Can we ever go back from cities or fields to wilderness and rural communities? Are cities traps? Is the city an evolutionary dead-end or horrible mistake? Created with the principles of ecology, cities could be the ultimate human creation.

The city now provides a place of danger, for hunting and excitement. But it still depends on wilderness and fields, so it is artificial excitement. Cities allowed us to be more abstract and to abstract the culture from nature to make a second nature. Our imagination took over with cities, and with technology, which changed cities and increased luxuries and artificial habitats. A second kind of diversity was created, of habitats and niches (for mice and rats and weeds and pigeons as well).

Arcologies have progressed from a thought experiment to experiments with specialties and specializations. An arcology creates a separate ecosystem like an episystem that participates in the cycles of nature but spins new fabrics and elements, as well as new ideas and adventures.

The whole premise of arcological design is that it has to be balanced with wild ecosystems, That is, nature has to be woven in with the city or vice versa. The scales have to match. They have to be balanced. That does not mean that every part of the city has to have wild tendrils in it. We can still have solid concrete and glass. Perhaps some of the parks can be truly wild. But, evening out the whole and spreading it uniformly might make it unworkable. Wild systems usually have minimum sizes.

7.1.5.1. Recreation & Agriculture in Cities

An arcology designed to have gardens, parks and agricultural areas built in to it could offer many forms of recreation, from walking, hiking, bicycling, skating, and running to watching and meditating. Small agricultural areas could offer planting and weeding, as well as picking and harvesting—and this would provide the bulk of food or a healthy supplement for many residents.

7.1.5.2. Streams, Forests & Wildness in Cities

An arcology that was placed very near to surrounding agricultural areas and especially close to wild forests and grasslands could continue the matrix of species, so that the arcology would contain or be visited by species. Thus, bees and flies, as well as voles and raptors would live within the extension of the arcology. Having predators nearby would keep ‘pests’ in balance. Trees could provide significant air-conditioning for the arcology through shade, as well as aesthetic and recreational opportunities.

Streams would be incorporated into an arcology, either from uphill landscapes or as a result of channeling precipitation. Running water, with fish and plants, would provide additional aesthetic and recreational opportunities for residents. Water could be recycled for numerous uses in complex paths before being released to natural treatment wetlands; this would save many millions of liters of water. Immediate access to wild waters and systems would provide incalculable benefits to urban residents.

7.1.6. *Antarctica World Pyramid Arcology*

Paolo Soleri notes that, as a human product, architecture has to be redefined and reconceptualized, to be antimaterialistic as the environment itself, created with a scientific and religious collaboration. With Soleri, the city becomes a global term on a planetary scale. An arcology is a proposal for a habitat for living in uncertain times and conditions. An arcology is also a construction process for the ecological city as well as a process for internalizing and transfiguring the world. A city's vitality as an aesthetic phenomenon depends on abstract and concrete elements: Miniaturization, equity, harmony, centralization, chance, complexity, compactness, frugality, the sacred, integration. In fact, these properties are similar to those detailed for ecological design (See earlier sections in this book).

An arcology is a large dramatic structure that promotes a rational way of life. The concept of a one-structure system is not incidental to the organization of the city, but is central to it, according to Paolo Soleri. Such an urban structure hosts life, work, education, and culture in a dense, compact system that is interleaved with domestic and wild landscapes. The compactness of an Arcology leaves 90 percent more land for farming and conservation.

Antarctica is a medium-sized continent. It is situated over the South Pole almost entirely south of the Antarctic Circle. It is a very rough circular shape with the long arm of the Antarctic Peninsula stretching towards South America. There are two large indentations, the Ross and Weddell seas and their ice shelves. The total surface area is about 5.5 million square miles (14.2 million sq km) in summer, approximately twice the size of the Australian continent. In the winter Antarctica doubles in size due to the sea ice that forms around the coasts. The true boundary of Antarctica is not the coastline of the continent itself or the outlying islands, but the Antarctic Convergence.

The acute angle of sunlight spreads heat and light over a larger area. The remoteness and extreme weather of Antarctica has attracted explorers and scientists. Permanent research stations have been established by several nations, who have divided the continent into territories. Several people and groups have proposed larger settlements on the continent.

The United Nations has worked to protect the continent from development for its resources. A world arcology is proposed for Antarctica as a new headquarters for the United Nations. Housed in a single large pyramid in a neutral territory, the structure would become an iconic symbol of a new world order, where humanity could dwell in an artificial, sustainable, zero-carbon, low-waste ecology within a wild environment. From a distance, as a whole, this city would be a monument with symbolic value.

7.1.6.1. General description of Arcology For 250,000-300,000 Residents

With 98 percent of its surface covered with snow and ice, Antarctica generates more snow and ice every year. The average thickness of ice on the Polar Plateau is 7000 feet, and ice depth can reach 15,000 feet. Ice is an important resource for the planet, and it accounts for 70 percent of the fresh water on the planet. The arcology, however, would be located in one of the rare snow-free areas, close to the ocean for relatively easy access by ship.

The pyramid shape of the city has a long history. Beginning at least 5000 years ago, Mesopotamian, Egyptian, and American pyramids have been built, mostly as religious structures. A ziggurat was a temple tower of ancient Mesopotamia, having the form of a terraced pyramid of successively receding stories or levels. Some modern buildings with a step pyramid shape have also been termed ziggurats. The largest arcology project under consideration is Masdar City near Abu Dhabi, in the United Arab Emirates. It is projected to house between 45,000 and 50,000 inhabitants on 6 square kilometers, and to have a sustainable, zero-carbon, and zero waste ecology. Another giant pyramid is designed to cover 2.3 square kilometers of land and will be capable of housing up to one million people.

Japan's Shimizu Cooperation has designed a 'mega city pyramid.' The Shimizu Pyramid squeezes two dozen 80-story skyscrapers into a 3-dimensional frame. Its footprint would cover an area the size of 275 city blocks. The Shimizu Pyramid is proportionally similar to the Great Pyramid of Egypt, an assembly of 55 smaller pyramids, each about of the size of the Giza Pyramid. It would host 750,000 people. Megatrusses are the bones of the circulatory system of the city and contain the critical transportation, a network linked by a 140 kilometers of horizontal and diagonal area tunnels meeting at 65 transfer points called 'nodes.' It is not much smaller than an average city transit system, but it serves an area about 1/50th of the size. Yet, it would be the largest structure on earth.

The Antarctica World Pyramid Arcology would be one of the largest pyramids built, holding up to 300,000 residents in its volume.

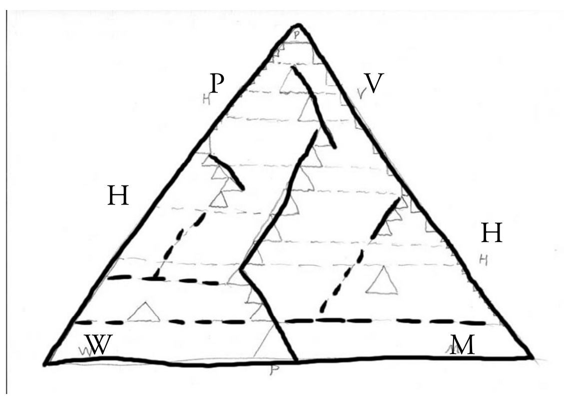

Figure 7161-1. Crude cutaway of the Antarctica World Pyramid Arcology (P = public areas, V = vertical agriculture, H = housing, M = manufacturing/commercial, W = wild areas)

7.1.6.1.1. Site

Despite its slow accumulation of ice and snow, Antarctica is a true desert continent, having about 2 inches of precipitation annually. It is also characterized by atmospheric high pressures, low humidity, and low evaporation rates. The natural (not anthropogenic) desert is not caused by Hadley cell circulation patterns, nor is it a rain shadow desert; the circumpolar winds do not bring much water inland.

The interior of Antarctica receives the most indirect rays from the sun, which means that it receives minimal heat. For long periods in the winter it receives little or no sunlight. The interior is relatively high altitude, which further reduces temperatures. Because the interior land mass is distant from the ocean, it gets no warming effect from the water. The interior is characterized by extreme cold and light snowfall. Previously deposited snow is often moved by winds and blizzards. In the southern hemisphere summer, by contrast, there is almost continuous daylight.

On the polar plateau, temperature is controlled by solar input, latitude and altitude. The annual average temperature is minus 58°F (-50°C), and much lower in winter; summer temperatures can reach minus 22°F (-30°C), partly due to the increase in solar radiation, but also because the surface of the ice is a little darker and less reflective.

The unique Antarctic desert in the McMurdo Dry Valleys is characterized by almost no snow or ice and by slightly higher temperatures. The 15,000 square kilometer region closest to New Zealand is barren. This has intrigued scientists for over a century.

The area has been granted status for protection by the United Nations. According to Antarctica New Zealand, the area is designated an Antarctic Specially Managed Area (ASMA), at the Antarctic Treaty Consultative Meeting in Cape Town, South Africa. Although several small research or conservation areas have been protected, this was the first sizeable area to be given protection under the 1998 Madrid Protocol, connected to the Antarctic Treaty.

Researchers or visitors to the Dry Valleys will need to abide by strict rules. Areas unaffected by wind or snowfall, or by freeze-thaw cycles, can hold impressions for decades. For example, some footprints made in the 1950s were still clearly visible.

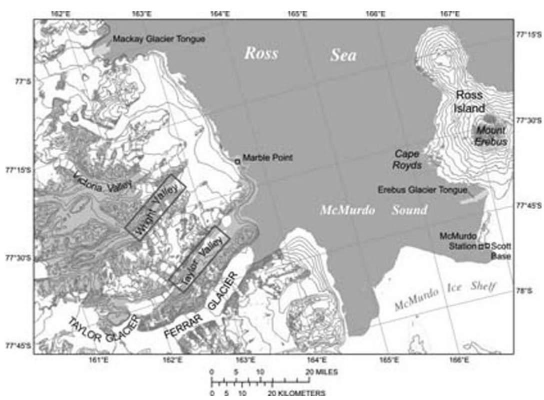

Figure 71611-1. Site of the Antarctica Pyramid Arcology

7.1.6.1.2. Populations

The city is designed for a large human population that would be surrounded by wild plants and animals within the building, as well as by domesticated annuals and plants. The outer environment would not be available for agriculture or gardens, although it could offer limited cold weather recreation. The numerous research stations could be better supported from the arcology, which would reduce separate efforts to stock the sites from home nations.

7.1.6.1.2.1. Human Population

The arcology is designed for 250,000 human residents. Perhaps as many as 40 percent would be transient during the summer.

Soleri notes that the intensity of life in an arcology could be overwhelming with the sheer human magnitude, but that this possibility is diminished by the design of neighborhoods and the positive nature of the Urban Effect. Semi-self-sufficient, three dimensional and overlapping, these areas include housing with amenities and necessities. Schools, parks, retail stores, cafes, offices, and other complex components of the city would distribute and absorb the daily flow of people.

About one-third of the population would participate in public work or service activities during daylight hours. With another third of the inhabitants at home, involved in home life or home work and thus out of the flow, and another third traveling to other areas for agriculture or research, human movement would display a rhythmic pulse.

7.1.6.1.2.2. Animal & Plant Populations

Lichens (symbiotic combinations of algae and fungi) grow in Antarctica because of their high tolerance of drought and cold. But also because of little competition from flowering plants. Lichens have been discovered growing on mountains within 295 miles of the South Pole. Some bare rocks are colonized by vibrant red, orange and yellow growths of lichens. Where rock is uncovered by ice for large parts of the summer, green lichens can grow to a few centimeters high and resemble a field of dark grass from a distance. Some other hardy plants like pearlwort (a flowering plant, one of 3 species found there), algae and mosses are found along the coast and on the Antarctic Peninsula, the warmest part of the continent. Antarctica has no trees or bushes.

The largest Antarctic land animals are invertebrates less than an a quarter inch in size. Mites, ticks and nematode worms tolerate the low temperatures in the winter by becoming frozen in ice under rocks and stones. There are no land-based vertebrate animals. All other, larger vertebrates there are dependent on the sea for feeding or are migratory and leave the continent in winter. Penguins live on pack ice and in the oceans around Antarctica, breeding on land or ice surfaces along the coast and on islands. The seas along the coast support a wide range of birds, fish and other sea life. The seas support large ecosystems. After a bloom of phytoplankton in the water, animals that consume this abundant food supply, especially krill, can multiply to high levels, perhaps higher by weight than the global human population. The krill, rich in protein and fat, are food for large numbers of animals at the top of the food chain, including penguins, seals, and whales.

In the arcology itself, decorative plants could be grown in private or public areas. Larger numbers of plant crops could be grown horizontally or vertically. Companion animals in limited numbers would live mostly in private areas. Small numbers of domestic animals, such as small pigs or sheep, might also be kept in private areas. A number of larger animals, such as cows or camels, could be kept in special areas with grasses and vegetation. Animals would be limited due to the costs of feeding and keeping them.

7.1.6.1.3. Spaces

The arcology would have a relatively small footprint at 25 million square feet (575 acres), with 40 stories, 3 of which would be underground in the gravel and bedrock. The arcology would share design motifs with other pyramids. The base square is 5000 by 5000 feet. The maximum height of the building would be in the range of 1000 feet, divided into 100 stories. The average floor area is 8,000,000 square feet, with a bottom floor area of 25,000,000 sq ft and a total floor area of 832,500,000 sq ft (and volume of 8.3 trillion ft^3). Density would be 435-521 people per acre (the denser parts of Hong Kong are 1000 and Mumbai are 791; efficient urban density is estimated at 100-500 households per acre or up to 1200 people per acre). Density is reduced with generous wild and agricultural spaces.

Table 71613-1. Space Distribution in Pyramid Arcology

Spaces	*Area*	*Percentage*
Living space	250,000,000 sq ft	30%
Public/commercial space	150,000,000	18%
Civic functions		
Commercial		
Public circulation services	132,500,000	16%
Utility		
Paths/rails		
Food-growing space	150,000,000	18%
Parks/wild	150,000,000	18%
Total Area	832,500,000	100%

Over 30 percent of interior space is designed for housing, forming neighborhoods within floors. An additional 18% is commercial space including retail stores, offices, restaurants, grocery stores, and production facilities. Additional office space may be developed in the center as part of the housing area. About 5% is reserved for administrative or civic use, distribution centers and convention facilities. And, another 5% houses utilities and construction yards at eight levels. Green space for food growing and parks covers 36% of the total area, divided equally, mostly on the lower levels. These areas include various environmental uses and provide open, public streets and parks. Another 16% serves as public circulation services and cultural zones comprised by schools, medical facilities, day care centers, theaters and art facilities. And, 10% of the area allocated for cultural zones is underground and specifically designated as a Virtual Reality recreational park (similar to what Soleri proposed for his Hyper Building).

The percentage set aside for parks is higher than for most cities (good cities usually set aside 10-15% of their area). Deciding how much area for food-growing is difficult, as most cities trade and import their food, much of which, like wheat, corn, melons, or tomatoes, require large areas. However, for greenhouse, hydroponic, or small truck gardens, eighteen percent should be enough.

The figure for circulation is a hybrid figure, since many utilities can be underground. Using alternative technologies, perhaps 1-5% of the area is needed for electricity generation, much of which would be the surfaces of other structures.

In a modern city such as Los Angeles, 59 percent of the ground area is dedicated to streets and parking (other cities such as Detroit, Chicago or Dallas use 48-41 percent). By comparison, traditional walking cities were always more compact; the arcology simply eliminates cars, trucks, buses, and trains. However, walking paths, sidewalks, as well as light rail and escalators are expected to take up 5-7% of the total area.

Areas set aside for civic and commercial functions are relatively generous. Most of the entire population of the arcology, as well as external workers or visitors would be 'housed' in these areas for 8-11 hours per day. Assuming that each business had 3-9 employees, perhaps as little as 3-5% of the area would be reserved for commercial enterprise.

Civic functions would also be relatively dense and so require less space over shorter times. This would be for public meetings, city meetings, or celebrations—but it would also be for heroic meetings or presentations, so the spaces would need to be larger and more dramatic, perhaps 4-10% of the area.

7.1.6.2. External Structure

The structure would be a pyramid with equal bases. It would be oriented with one edge facing north. The external surface would be a curtain wall of glass and stone.

7.1.6.2.1. Building process

The structure would be constructed as a skyscraper, using construction cranes to add stories from the bottom. The frame of the building would be steel, which would be clad in 6 inches of fire retardant, fiber composite insulation panels.

A phased construction sequence would allow limited operation of completed sections as construction continued. Phase One, the ground level, would extend from 40 feet below grade to 160 feet high. It would include the structural base of the pyramid. Phase Two would continue to 500 feet high. Phase Three to 1,000 feet high.

Because of the size, bulk, and complexity of this project, an automated robotic building technology, which would continue to evolve as technology develops, would be used. Construction would move up the building on a 'sliding' construction platform, operating much as slip form construction does (similar to the Luxor Hotel in Las Vegas).

Foundations and floors would be made of concrete. Concrete is a versatile and stable building material and the second most widely used resource in the world (after water). Concrete, however, can produce a lot of carbon during its manufacture. One of the most important factors is that cement, the main energy-intensive binding component of concrete, is made from crushed Limestone, one of the most common minerals found. Limestone is generally be harvested and processed locally, which reduces transportation costs. Alternatively, to reduce 'carbon waste,' cement could be made wholly or partially from waste products from other production processes such as fly ash (waste from electricity generation), silica or slag (waste from steel manufacture), which could reduce its carbon footprint by 80 percent. Low-Carbon Concrete (LCC) is already being used in Britain and Ireland.

Despite its carbon costs, concrete has advantages over wood or plastics. For instance, it is durable—sustainable design and green building emphasize long-term solutions and products over cheap, short-term products that generate waste. The negative impacts of human development are minimized by 'reduction, reuse and recycling.' Concrete can last for many times longer than conventional building materials, such as wood or drywall. It is resistant to insect activity, rot, rust, and fire. Concrete also forms airtight seals, which minimize drafts and reduce air-conditioning costs. Although concrete is naturally light-colored and can reflect light and heat, it will also take colors so its dark surfaces would absorb heat. Concrete acts as a natural insulator and retains heat, which is useful in cold climates. It can absorb warmth from the sun and keep the heat inside.

On a global scale, concrete is the most commonly used material for building infrastructure. The manufacture of 1.5 billion tons of cement generates approximately 5% of global carbon emissions. LCC could save over a billion tons of CO_2 emissions, billions of tons of quarrying, and thousands of years of electricity use. Like normal concrete, LCC offers fire resistance, sound and noise insulation, thermal mass, ease of construction, and availability. LCC, however, is stronger, more durable, and lighter in color than normal concrete. LCC can last twice as long in aggressive environments, such as those found on farms, in marine environments or under harsh climates. LCC shows greatly improved strength after fire, which can reduce the strength. Acids such as those found in farms and wastewater treatment plants cause deterioration of concrete. Previously developed sites may contain contaminants in the soil and ground water, which attack concrete, causing expansion and cracking that lead to accelerated deterioration. LCC improves the chemistry and reduces the porosity of the concrete, protecting it from sulfates. Salts on roads and in marine environments penetrate concrete, attacking the steel reinforcement and causing it to expand. This causes the surrounding concrete to crack. Cracking and voids lead to significant damage in concrete. LCC has less cracking because of its chemistry, and has a much reduced void ratio than normal concrete.

The use of heavyweight construction materials with high thermal mass can reduce total heating and cooling requirements. Dense, cast concrete has the highest conductivity and heat capacity after water, higher than granite, block or clay, and much higher than plaster, timber, carpet, or fiberglass. The heat that the city generates is used for more heating or energy generation.

7.1.6.2.2. Surface Sheeting

The façade would be dark-colored glass and stone. The surface would be chameleon-like in its ability to absorb the same amount of heat as the surrounding rock and soils. Or it could reflect more heat. Glass of course is a fluid mosaic, with molecules of other materials embedded. The membrane would create electrical potential, that is, there would be differences in charges between inside and outside and between bottom and top, which might be used to generate electricity.

The very large windows would be—not standard glass, which would drain the building of heat—but new 'Superglass Quad' windows, which would reduce the energy costs. The super-insulated windows would consist of two standard glass panels, separated by two tough plastic sheets known as 'heat mirrors.' These four layers would create three spaces that were filled with krypton gas, which would prevent the formation of condensation on the glass and heat loss to the outside. Altogether, the windows would have a thermal insulation rating equivalent to a wall insulated with fiberglass bats (with an R-value of about 2.6).

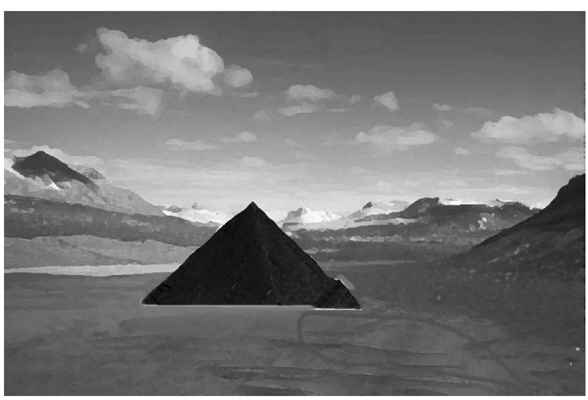

Figure 7162-1. Ice-free Setting of Antarctica World Pyramid Arcology

7.1.6.2.3. Membrane Qualities and Insulation

Membranes give shape to a structure. As a membrane, the glass and stone façade would be relatively impermeable, due to the climate to limit physical particles or air. There would be a minimum of plants and animals that would penetrate the membrane. And, there would be a minimum of egress points, such as doors or balconies. Essentially, the structure would be a closed system, and all forms of agricultural or wild spaces would be enclosed. As Soleri refers to arcologies in space, the only form of architecture is interior deign. This alters principles of construction. The city no longer has a membrane but a wall.

One important way to reduce heat loss is to build extremely well insulated structures. The use of commercially available insulting materials like the Thermalkool radiant barrier (which is paper thin and is rated R52) and other materials like mylar would help greatly. Using these materials in alternating layers with air pockets between them may let the walls be rated at over R300 at less than one foot thick. By comparison, a typical American home uses fiberglass insulation that's usually rated R30.

Another way to further reduce heat loss would be to seal the buildings air tight. Preventing air and with it heat from escaping the structure would reduce the energy demands needed to heat it. This would, however, contribute to the problem of maintaining a constant fresh air supply. An air exchanger system, combined with a thermal energy recovery system through the use of Stirling engines, or another thermal energy conversion technology, could be used.

One system would be to have the cold fresh air intake shaft and the warm air exhaust shaft run parallel to each other with a number of Stirling engines located between them, as Soleri suggests for the Hyper Building. The temperature difference between the cold outside air and the warm air from inside the buildings could be converted back into electrical power. Also, a small amount of the waste heat would be transferred though the plates on the Stirling engines, providing a small warming effect for the incoming air. This method could be used with large chambers to effect a single large air mass at one time rather than a shaft system. A chambered system could also allow for multiple stages of thermal energy recovery and air intake heating to occur, further increasing the energy efficiency of the system.

If the underground structure was well insulated, it would enable the surrounding ground to remain frozen. This would increase the stability of the structures and tunnels with less bracing and support.

Individual homes could include a heat exchanger that would transfer the heat from stale air to fresh air being pumped in. The heat exchanger and a heating coil could warm incoming air and pump it to other areas.

7.1.6.3. Internal Structure

An arcology is a natural place to experiment with a new generation of products, for instance, tools that promote greater autonomy and decentralization, as well as better and smaller communication devices, which is already a trend in technology. Alternative energy sources could be used to power longer-lasting, higher-quality appliances and motors, built with benign manufacturing systems in an industrial ecology. The arcology itself would be a multiple-use building, which would be assembled from mass-produced, modular housing and automated paths, rails and roads, using recycled or biodegradable materials.

The structure would have a central light well, although much light would be allowed by the triple-glazed cladding. Utility shafts would be placed through the vertical solid interior support walls.

7.1.6.3.1. Support Structure

Although the structure would have 100 floors, each floor would have an atrium that would be at least 4 stories high, projecting into other floors. Internal pyramidal volumes would be modules for public spaces as well as neighborhoods of homes.

The steel sides of the pyramid would support many rooms, although the internal vertical elements would allow heavier floor loads. Carbon tubes could be used for support elements and for building walls. In a building that size, a lot of carbon could be recycled and sequestered.

7.1.6.3.2. Modular units

Many home units would be manufactured as plug-in modules, either shaped as cubes or as a favored polyhedron. These could be built in other nations and shipped there. Pyramidal frames for space volumes as well as subunits for research facilities or manufacturing areas, would be modular.

7.1.6.4. Areas

In most proposed arcologies, the areas are zoned according to use, and this is reflected by room-size, utility density and other design features. Special areas for energy generation would not be necessary, since the use of micro-generators and collectors would fit in or on the internal and external walls.

7.1.6.4.1. Neighborhood Homes

Home size is expected to be on the European or Chinese model in terms of space, although the spaces would be very efficient. We know from studies of prisoners and animals, that crowding produces stress. To avoid the reactions of crowding, we need to design for varieties of well-designed spaces. Good designs can change behavior. Open neighborhood or public areas would meet the need for large open spaces.

One kind of neighborhood could have a central tower 11 units tall for apartments (each unit 38 ft in diameter), and each unit would be trilevel. Another kind of neighborhood could be completely horizontal, with units surrounding central services and a public area with parks and trails.

Individual homes could display several kinds of wall and floor coverings. For example, lichens are one of the few plants to survive in Antarctica. Paint is traditionally used on walls, but lichen could be applied, and it would grow and change colors with time and season (Victor Papanek lists 118 colors from Lichens). This would save on cost, labor and depreciation, and it could be sprayed on with a nutrient solution; it may be patchy at first, as well as shaggy (up to 1.5 inches).

7.1.6.4.2. Neighborhood Public Areas

Public areas would be sized according to the floor population, such that there would be a public area for every 250 people.

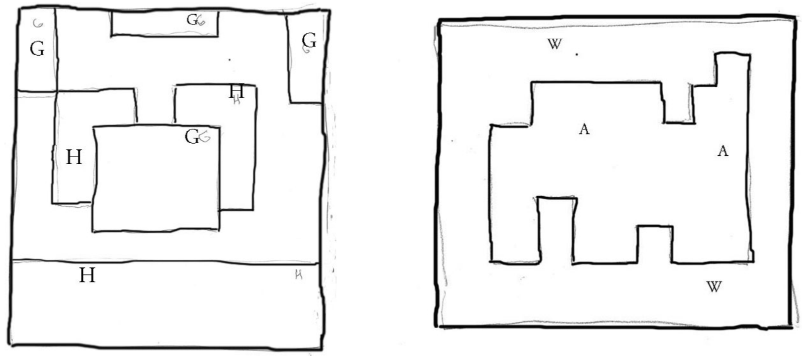

Figure 71641-1. Floor/Agricultural plan of Antarctica World Pyramid Arcology (G = greenhouse, H = housing, W = wild plants, A = domestic plants).

7.1.6.4.3. Neighborhood Stores
In the beginning, the arcology would provide small stores for every neighborhood for basic clothing, tools and foods. Stores would be allowed to fail or increase with the demands of a neighborhood.

7.1.6.4.4. City Public Areas
The top of the pyramid would be reserved for special occasions. There would be permanent areas there for religious purposes.

The arcology would require more participation. Furthermore, the design of public areas should contribute to a more democratic style. It would be a governable size, with clearly defined boundaries. The arcology would specifically work to maintain a framework to represent the people, as well as the other beings in the ecological system, by reemphasizing the goals. Efficiency would be less important than participation in good judgments.

The arcology would be a limited size from a calculated optimum, dedicated to protecting desired ways of life, while leveling extremes of wealth and paying the total ecological and economic costs (See section 6.8.3.2. in *Redesigning the Planet: Regions*).

7.1.6.4.5. City Large Stores & Factories
There would be large stores for every three floors. Because of its nature as a UN center, it is not likely that factories or industries would develop for trade. However, given human invention and play, a number of 'cottage' industries might develop, for instance, for making jewelry, furniture or scientific instruments.

7.1.6.4.6. Food growing
Due to the limits of the climate and site, very few exposed fields, if any, would be planted in the areas surrounding the arcology. That environment is rough wilderness, with relatively few animal and plant species.

Therefore, it is likely that food will be grown inside, in greenhouses, either in media or hydroponically. Some areas may have tree or root crops. Individual homes may also plant herb or limited gardens.

A vertical farm would create 'closed loop agricultural' ecosystems, where nearly every aspect of the farming process is recycled and re-used, especially water and nutrients. This and some horizontal farm areas would solve the problem of inadequate expanses of fertile farmland. A 'Pyramid Farm' might offer a solution in the form of a complete self-sufficient ecosystem that covers everything from food production to waste management.

7.1.6.4.7. Recycling and Waste

Sewage would be treated with the living machines as envisioned by John and Nancy Todd, and based on many of their suggested principles. The foundation of such a machine is microbial communities. But, the machine would also be a photosynthetic community, and a linked ecosystem with a variety of pulsed exchanges and nutrient reservoirs. They note that the system should have steep gradients for higher efficiencies of operation (for example large differences in pHs).

7.1.6.5. Infrastructures

The operation of the arcology would initially be managed by a special department, perhaps formed from the volunteer military branch of the UN.

In a similar way, all services would be provided by pre-organized groups. This would be for food and materials, as well as medical and educational services.

Water would be valued and recycled. The arcology tries to maintain the natural flow of water by making as many surfaces porous and collecting the water from other surfaces. Grey water could be used for flushing and irrigating. Water might have to be rationed at times, depending on the efficiency and speed of recycling.

Emergency services would be provided by specialists, given the conditions and isolation of the arcology. The arcology would have a hospital to handle routine needs.

Transportation is an important part of any city. The scales of transportation systems favor different kinds of vehicles. For instance, distances from 500 to 5000 miles can be served by ships, dirigibles or airplanes. Trains might be favored for distances from 50 to 1500 miles. Buses from 50 to 500. Light rail, monorail, maglev and trains might be most efficient from 5 to 100 miles. For 1 to 25 miles, buses, taxis, scooters, bicycles, and roller-skates. And for under a mile, walking, elevators, escalators, and moving sidewalks.

Due to its unique setting, no private automobiles would be allowed in the arcology. Golf-cart-sized vehicles could use pedestrian or separate trails for hauling all materials.

The main terminal on the southwest side of the structure would connect the arcology to the local port. Mag-lev lines would take travelers from the port and from the main station to local stations within the building. Inside the building, travelers, residents, employees, and visitors would shift from mass transit to local elevators. These would primarily operate within public spaces throughout the interior. Within vertical neighborhoods, vertical circulation would be enhanced by extensive use of escalators or elevators. Pedestrian movement is aided by escalators, diagonal or spiral escalators, moving sidewalks, elevators, electric conveyances, and bicycles. Because moving sidewalks expend relatively much energy, they would be limited to short stretches.

Service transportation is provided between floors and in construction yards, warehouses and distribution depots. Freight elevators would handle construction materials and large goods, furniture and appliances.

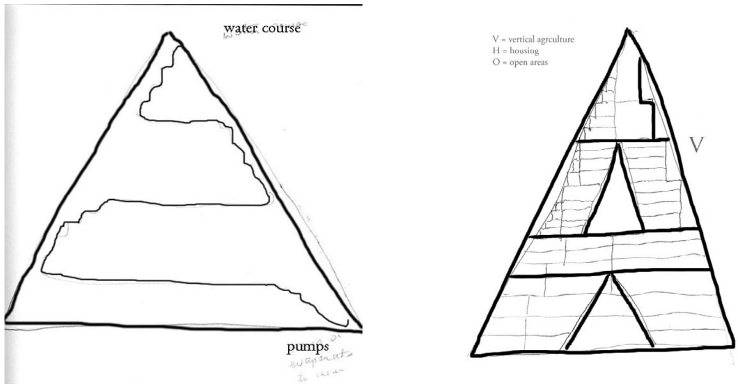

Table 7165-1. Waterflow & Transportation in Antarctica World Pyramid Arcology

7.1.6.5.1. Horizontal Travel (Walkways and Tunnels)
Paths of various lengths and widths would connect all the areas of each neighborhood. A limited number of moving sidewalks would provide transportation for the elderly or handicapped.

7.1.6.5.2. Diagonal Travel
Diagonal travel, on angled elevators and escalators, would connect the areas near the surface of the pyramid.

7.1.6.5.3. Vertical Travel
Vertical movement would connect upper and lower floors. Five elevators per floor would be located in the vertical structures. Stairways would be located in three areas near the perimeter.

7.1.6.5.4. Utility cores & Air/Water Systems
Utility cores would be bunched for efficiency. Airflow and controlled temperature would be handled by interior ventilation systems using the Chimney effect (hot air rises).

7.1.6.5.5. Energy generation
The goal for the structure is to generate its own energy. The requirement for the arcology is crudely estimated at 50,000 Megawatts. Initially, the structure would depend on energy from fossil fuel. Solar collectors are not going to be efficient in the local light regime. Wind generators could be large and external, or small and internal, but may not be able to provide enough energy for air-conditioning.

Some built-in features of the building itself, from generators from falling water and excess heat (body and thermal), would supplement grid energy. In general, the thermal mass and airflow design of the structure would allow significant conservation of energy, lowering the requirements from fossil fuels.

The design of the structure puts an emphasis on the pedestrian, saving the fossil fuels that would normally power personal automobiles. The three-dimensional, multiuse design puts the pedestrian within walking distance of most functions, allowing residents to live, work and learn in densely-packed, lively spaces. Close access to wild nature gives residents limited recreational opportunities without personal vehicles. Food production in the greenhouses save fuel by eliminating much trucking of food to the city.

Alternative sources of energy production for the reduced needs of the residents include solar panels with photovoltaic cells on the external glass, which could occupy 500,000 square feet and produce 10 megawatts of low voltage electricity per hour for use in low voltage lighting throughout the building.

Windmills also located to the east of the arcology could produce 10 megawatts of electricity every hour of the operation. A field of solar power generators, 3000 Genset hydrogen conversion units near the south face could take advantage of even low light to produce 100 megawatts of electricity per hour, the bulk of the household electrical needs in the arcology.

The structures ventilation system takes full advantage of both rising warm air and sinking cool air, the chimney effect.

Small-scale, pre-sealed nuclear generators, perhaps four for the entire structure, could provide the basic power for heavy or industrial use. Each would provide approximately 285 MWe (MegaWatts energy). This technology is considered 'well-developed.' Russia has been using similar small units in Siberia with success since 1976; India, China and South Africa are experimenting with alternative designs, and in the USA, General Atomics is developing a gas turbine modular helium reactor, to directly drive a gas turbine, operating at high temperatures with helium as the coolant.

The sealed 'cartridge' design from Hyperion Power generation generates 25 MWe and would run for five years (and could be returned for refueling); possibly some could run for 30 years. It is small ('hot tub' size) and self-contained. If coolant fails, the reactor is designed to shut itself down. With a passive cooling system, it would work without power. Each unit could serve as a burial chamber for its small wastes. These units would reduce capital costs (30-50 percent of large-scale nuclear). Costs could still be $100 million or more. It would be difficult to steal one without heavy equipment.

7.1.6.5.6. External grid

There is no energy grid on the continent. Small-scale, pre-sealed nuclear devices, perhaps five for the entire structure, could provide the basic power for heavy or industrial use. Once installed in the ground, no maintenance would be required, and the shell would hold the waste products.

7.1.6.6. Context

The context for the arcology is a fundamentally wild continent, with no real history of cultural use. Transportation and communications are limited. There would be no external trains, cars or buses. Some snow-track vehicles might be needed and maintained for external travel to the shore, interior or research sites.

7.1.6.6.1. Cultural

Although there is a form of scientific culture, as a result of exploration and research, there have been no native cultures on the continent. A separate form of culture may be developed in the arcology, given that all inhabitants would be cultured individuals from other nations or cultures. Most likely residents will follow their traditional behaviors.

7.1.6.6.2. Transportation regional

Most transportation into the continent is by ship or air. There are no formal permanent highways or rail. With the establishment of an arcology, several short snow roads may connect several national bases. The arcology should be connected to an oceanic port by a permanent road (that would limit traffic over sensitive areas).

7.1.6.6.4. Wilderness location

The continent is a wilderness and would be established as such by the UN. Continued scientific research would be allowed, but the number of workers and tourists would be limited to the impact on dry, delicate systems.

7.1.6.6.5. Communications

Inside the arcology, communications would be supported by wired or wireless networks. External communications would depend on satellite coverage and connections.

7.1.6.6.6. Resources

Oil and natural gas fields have been identified in the Ross Sea. Coal and iron ore exist in the mountains. These are not permitted for mining until 2048. Platinum, copper, chromium, nickel, gold and other minerals have been found, although not in large enough quantities to be exploited.

Fishing in the ocean waters surrounding the continent is limited by various treaties, especially the Convention on the Conservation of Antarctic Marine Living Resources (1982).

The most common rocks in West Antarctica are volcanic (similar to the Andes). East Antarctica has a platform of metamorphic and igneous rock, laid over with sandstones, limestones and shales.

7.1.6.7. Discussion

The pyramid has a relatively large surface area, compared to a sphere, for its enclosed volume. In this location, the larger surface area is necessary to capture solar energy. The shape may also be kinder for presenting openings to light and air. Although there are seasonal variations, especially regarding light, the overall climate is polar.

Investigating forms, Victor Papanek suggested that only one shape can make a stable, fully three-dimensional integrated space grid possible, a tetrakaidecahedron, a 14-sided polyhedron with 8 hexagonal sides and 6 square faces. It is rounder than a cube and squarer than a sphere. It resists pressure between the two. A cluster of 30 could make a suboceanic station, a space station, or a cluster within floors of the pyramid.

The modular polyhedra could have curved ceilings inside. Curved spaces may have psychosomatic effects on the residents, which will benefit their health.

Greater attention is given to the human scale in an Arcology. Pedestrian distances are measured by walks and in minutes. Other wheeled vehicles, such as bicycles or battery-powered carts, could be available for delivery or recreation.

Greater attention is also given to the role of technology. Technology can be used to expand or contract resources. Technologies have the capability to minimize the use of resources, but they also have negative effects. Breeding, fertilizer, pesticides, and modern equipment have certainly increased agricultural production, but the negative impacts of genetic loss, soil degradation, erosion, and pollution decrease actual and potential productivity. When all factors are combined, and total energy cost is compared with energy production, the result is disappointing and does not compare well with traditional methods, using draft animals and human labor (Wittbecker, 1976). In this environment, however, technology is more important for survival.

The arcology should have a proper mix of handicraft labor, intermediate technology, and heavy industry. The root problem is how to live with technology in a mature manner. We need an ecological awareness at all levels, a humane, existential ecology, where humans are part of the system and aware of it. But that may not be enough; we may have to legislate limits or induce adherence with economic incentives, if awareness and reasoning are not more evident.

The goal of planning is community success and personal happiness, based on self-reliance in food and shelter, self-sufficiency in agriculture, and self-limitation in size and desires. If human patterns were based on mature ecosystems, civilization would be far more complex; human values would allow for the welfare of humans, animals, plants, and land. We have to be wise enough to be disciplined, to leave wilderness for other beings, and yet to make good places for ourselves.

7.1.6.8. Conclusion: Antarctica World Pyramid Arcology

The city has been the most active and dynamic outlet of human life. Soleri refers to the city of the future as an arcology to remind us that a well-built city is always ecological architecture. But, for him it is also the fundamental instrument in the transformation of matter into spirit. The arcology would create a synergy between habitat and nature, body and spirit, and work and leisure. It would generate the urban effect more intensely, which would energize the inhabitants.

The Antarctic arcology would be a self-contained habitat of reduced size, with access to the surrounding wilderness. As a single structure, it would integrate the fundamental components of life—dwelling, eating, learning, working—into a frugal form, while accepting a certain amount of ambiguity and disorder. It would be a laboratory for doing and learning, tested through experience, and tempered by the opportunity to fail in part or on a small scale.

The principles of an arcology, from using marginal land and imploding spread to habitat density to internalizing and miniaturizing the urban effect and linking the habitat, energy and environment, serve as a model for a stable, exciting construct. The creation of a world arcology as the living headquarters of the United Nations on a separate continent is an important first step to converting the spread of urban growth into intense, rational settlements.

7.1.7. *Greenland Dome World Arcology*

In an arcology, architecture and ecology are fused in a city according to Paolo Soleri. The flat extended modern city is imploded into one building, a dense, intense, complex system that interpenetrates with wild systems. With Soleri, the city becomes a global strategy on a planetary scale for reclaiming wildness as well as for experiencing the human excitement for cities. The concept of a one-structure system is not incidental to the organization of the city, but is central to it, according to Soleri. An arcology is a proposal for a habitat for living in uncertain times and conditions. An arcology is also a construction process for the ecological city as well as a process for internalizing and transfiguring the world.

A city's vitality as an aesthetic phenomenon depends on abstract and concrete elements: Miniaturization, equity, harmony, centralization, chance, complexity, compactness, frugality, the sacred, and integration. In fact, these properties are similar to those detailed for ecological design (See earlier sections in this book). An arcology is a large dramatic structure that promotes a rational way of life. Such an urban structure hosts life, work, education, and culture in a dense, compact system that is interleaved with domestic and wild landscapes. The compactness of an Arcology leaves 90 percent more land for farming and conservation. The Greenland Dome Arcology would allow limited exploitation of a challenging site.

7.1.7.1. General description of Arcology For 60,000 Residents

The Greenland Dome World Arcology is located in northeastern Greenland in a rare snow-free area, close to the Greenland Sea for relatively easy access by ship (in summer months). Its size and shape are similar to Soleri's large dome arcology for cold climates. The interior of the central and northern Greenland Ice Sheet is the driest part of the Arctic. Annual totals of moisture and precipitation here range from 4 to 8 inches. The arctic climate is characterized by long, cold winters and short, cool summers. Northern Greenland experiences the extremes of solar radiation in summer and winter. This region is continuously below freezing, so precipitation falls as snow, with more in summer than in winter.

Through the process of continental drift, the enormous island of Greenland has moved through the tropics to its polar position. The island has a land area of over 772 thousand square miles (2 million km^2). The Inland central ice cap covers 81 percent of the land (and holds 10 percent of the planet's freshwater reserves). Most of the ice-free marginal zone is a mountainous landscape with scoured outcrops and steep fjord walls. Geologically, the central basement shield has gneiss complexes and belts of metamorphosed sedimentary and volcanic rocks from mountain-building episodes over 1.6 billion years earlier. Thick sedimentary deposits accumulated around the margins of the shield. Younger mountain chains formed in the north and northeast after 430 million years ago. The Ice Age that began 2 million years ago created the Inland Ice, as well as glacial deposits and erosion features.

Native Inuit peoples from Canada settled western coastal portions of the island around 2500 BC and established a hunting/fishing culture. Native cultures collapsed and were reestablished over thousands of years. The island may have been uninhabited when Vikings settled a small part during the 10^{th} century, during a warm period. The cut trees (probably birch and some willow bushes) for buildings and grazed livestock on the naïve grasses. The eastern settlement had as many as 500 farms. Greenland provided many unique things for trade: Walrus, walrus ivory, seal skin rope, falcons, polar bear pelts (and even the occasional live polar bear cub), eider down, narwhale ivory, falcons - as well as products like ox and sheep hides, wool, and homespun wadmal fabric. The weather changed; the climate started cooling in the Fourteenth century. They cut turf for walls; this also changed and degraded the vegetation. Summers became cooler and shorter. There may have been conflict with the Inuit. Norse settlers were not able to adapt to changes. The grazing collapsed. Trade collapsed, and the settlements collapsed.

The arctic was considered undesirable for settlement by most Europeans, although it was explored enthusiastically. It was a risky place to live. Settlements gradually expanded and modern nations have integrated the arctic region into their network of strategic decisions, military bases and new resource-based settlements. Mikhail Gorbachev proposed in 1987 that the arctic be a nuclear-free 'zone of peace.' The Arctic is changing faster than temperate or tropical areas.

Recently, Danish people resettled the area and reintroduced livestock. The green areas, only 1 percent of the land area, may become overused again. Trade however is still strong. The melting of the ice is increasing available land. But, conservation is still needed to avoid collapse. Greenland dominates the North Atlantic Ocean between North America and Europe. Many air and shipping lanes approach the island.

For a dense, frugal arcology, Arid zones have the minimum of sustainable natural resources needed. The high number of sunshine hours in summer in this areas provide vast energy production opportunities (and all-year long in other arid zones). As more people occupy arid zones, arcologies are essential for living efficiently and effectively on marginal land, and conserving resources and energy (although foragers and adapted agriculturalists have also lived sustainably historically).

7.1.7.1.1. Site

The site for the Greenland World Arcology is in the eastern part of Johannes V. Jensen Land, north of the Nord Station, a military and scientific base that is the northernmost permanent settlement in Greenland (and not accessible by ship). The site is in the Northeast Greenland National Park. The arcology could become the gateway to inaccessible northern Greenland.

Permafrost is a problem for buildings and roads. Geologically, permafrost, cryotic soil or permafrost soil is soil at or below the freezing point of water (32 °F) for two or more years. Ice is not always present, but it frequently occurs and it may be in amounts exceeding the potential hydraulic saturation of the ground material. Most permafrost is located in high latitudes close to the North Pole, and extends down to 45 feet or more; at this depth the temperature does not change with the seasons, remaining at about 23 °F, although in another 100 feet it rises to 50 degrees.

Formation of permafrost has significant consequences for ecological systems, primarily due to constraints imposed upon rooting zones, but also due to limitations on subsurface homes for local fauna. Of course, there are secondary effects from species dependent on plants and animals whose habitat is constrained by the permafrost. For instance, Black Spruce is dominant in extensive permafrost areas, since it can tolerate rooting pattern constrained to the near surface.

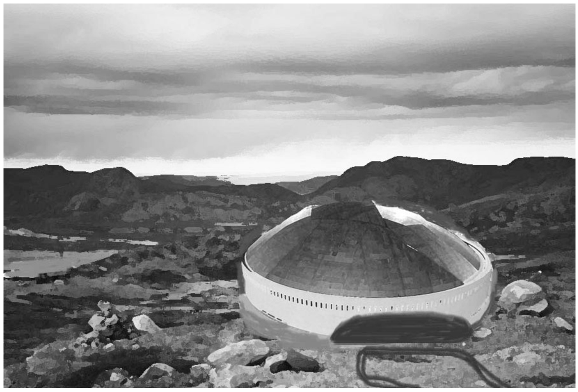

Figure 72411-1. Setting of Greenland World Dome Arcology
(With single road to port)

7.1.7.1.2. Populations

The city is designed for a large human population that would be surrounded by wild plants and animals within the building, as well as by domesticated annuals and plants. The outer environment would not be available for agriculture or gardens, although it could offer limited cold weather recreation. The few research stations could be better supported from the arcology, which would reduce separate efforts to stock the sites from Denmark.

Due to its limitations for arable land, Greenland has a small human population of 56,000 residents, predominantly Inuit (with the remaining 12 percent of Danish or European descent). It is one of the least densely populated nations (or territories).

7.1.7.1.2.1. Human Population

The arcology is designed for 100,000 human residents. Perhaps as many as 40 percent would be transient during the summer.

Soleri notes that the intensity of life in an arcology could be overwhelming with the sheer human magnitude, but that this possibility is diminished by the design of neighborhoods and the positive nature of the Urban Effect. Semi-self-sufficient, three dimensional and overlapping, these areas include housing with amenities and necessities.

Schools, parks, retail stores, cafes, offices, and other complex components of the city would distribute and absorb the daily flow of people. About one-third of the population would participate in public work or service activities during daylight hours. With another third of the inhabitants at home, involved in home life or home work and thus out of the flow, and another third traveling to other areas for agriculture or research, human movement display a rhythmic pulse.

7.1.7.1.2.2. Animal & Plant Populations

Hundreds of thousands of years ago, southern Greenland had forests similar to present-day northern Canadian forests. In the light of data from the Greenland ice sheet concerning the ice-age climate, and paleoecological studies of interglacial and Early Holocene deposits, a large proportion of Greenland's plants and animals may not have survived the ice ages. While ice-free areas (refugias) were present, only a few hardy, cold-adapted species may have survived, explaining why few endemic species are present in Greenland. Most of the present biota seems to be postglacial immigrants, which arrived by passive, long-distance, chance dispersal, carried by wind, sea currents and birds. Some species may have arrived there by walking or flying.

Both plants and animals are finely adjusted to their extreme living conditions. Several of the land-living species rely on a stable layer of snow during winter to protect them against the cold, while other species are dependent on the snow blowing away altogether or disappearing early. Snow is just as important as temperature for many of Greenland's plant and animal species.

Greenland has some plant species found nowhere else, including the East Greenland Saxifrage (*Saxifraga nathorstii*), Greenland Fescue (*Festuca groenlandica*), Greenland Alkali Grass (*Puccinellia groenlandica*), Greenland Blue-eyed Grass (*Sisyrinchium groenlandicum*), Alpine Fleabane (*Erigeron alpiniformis*), and Greenland Pondweed (*Potamogeton groenlandicus*). There are endemic microspecies of hawkweed, as well as Arctic willow, arctic daisy, kelp, and green seaweeds.

Wolves were present after the early mid-Holocene and have been documented recently from 5600 BC to AD 1420. Fox, hare, caribou, lemming, muskox, Dall sheep, polar bear, walrus, and wolverine can be seen today. Birds include tern, crow, raven, Iceland gulls, and snowy owl. Endemic invertebrates include a twirler moth (*Gnorimoschema vibei*), braconid wasp (*Aphidius tarsalis*), rove beetle (*Atheta groenlandica*), and comb-footed spider (*Ohlertidion lundbecki).*

In the sea, conditions are greatly influenced by the sea ice, which covers the sea for several months of the year. When the ice melts in spring, the sunlight penetrates into the sea and initiates production. Small crustaceans and polar cod are captured by mammals and birds. Ringed seal, hooded seal and Greenland seal breed on the ice. Seals are the primary prey for polar bears. Marine invertebrates are represented by the flatworm (*Proporoplana jenseni* Turbellaria), comb jelly (*Tjalfiella tristoma*), water flea (*Holopedium groenlandicum*), marine rotifer (*Notholca ikaitophila*), and a sponge (*Leucascus lobatus).*

With changes in precipitation and temperatures, a large part of the high Arctic area will change and gradually resemble the low Arctic area. Some of the species specialized for life in dry and cold high Arctic areas will be endangered or vanish with the disappearance of their special habitats. For some species, a milder climate will be an advantage. Other species, adapted to life in the high Arctic area, will face greater challenges. Musk ox in North and North-East Greenland will be endangered with more snow and periods of thaw in winter, which would produce an ice crust on the ground making it difficult for them to reach their food. Some of the wading birds breeding in North-East Greenland might disappear altogether with the change in their breeding areas. Animals in the low Arctic area will probably thrive due to the enhanced availability of food. Furthermore, a warmer and wetter climate may lead to an increase in diseases and insect infections.

In the arcology, decorative plants could be grown throughout the structure, in private or public areas. Larger numbers of plant crops could be grown horizontally or vertically. Companion animals in limited numbers would live mostly in private areas. Small numbers of domestic animals, such as small pigs or sheep, might also be kept in private areas. A number of larger animals, such as cows or camels, could be kept in special areas with grasses and vegetation. Animals would be limited due to the costs of feeding and keeping.

7.1.7.1.3. Spaces

The arcology would require an internal floor area of 173.3 million square feet and a volume of over 1.68 trillion cubic feet. The footprint would be relatively small at 4 million square feet (92 acres), with 80 stories, 10 of which would be underground in the gravel and bedrock. The arcology would share design motifs with other domes.

The maximum height of the dome would be 600 feet; the base would be 100 feet below ground and 100 feet above ground. Base square is 2000 x 2000 feet. The height would be divided into 100 stories. The base floor area is 4,000,000 sq ft; the total floor area is 173,300,000 sq ft (the volume is 1,680,000,000 ft^3). Density would be 652 people per acre (the denser parts of Hong Kong are 1000 and Mumbai are 791; efficient urban density is estimated at 100-500 households per acre or up to 1200 people per acre).

Table 72413-1. Space Distribution in Greenland Dome

Spaces	*Area*	*Percentage*
Living space	60,550,000 sq ft	35%
Public/commercial space	34,660,000	20%
Civic functions		
Commercial		
Public circulation services	17,330,000	10%
Utility		
Paths/rails		
Food-growing space	34,660,000	20%
Parks/wild	25,950,000	15%
Total Area	173,300,000	100%

Over 35 percent of interior space is housing, forming neighborhoods within floors. An additional 20% is public and commercial space including retail stores, offices, restaurants, grocery stores, and production facilities. Additional office space may be developed in the center as part of the housing area. About 5% is reserved for administrative or civic use, distribution centers and convention facilities. And, another 5% houses utilities and construction yards at five levels. Green space for food growing and parks covers 35% of the total area, divided equally, mostly on the lower levels. These areas include various environmental uses and provide open, public streets and parks. Another 10% serves as public circulation services and cultural zones comprised by schools, medical facilities, day care centers, theaters and art facilities. And, 3% of the area allocated for cultural zones is underground and specifically designated as a Virtual Reality recreational park, similar to what Soleri proposed for his Hyper Building.

The percentage set aside for parks is higher than for most cities (good cities usually set aside 10-15% of their area). Deciding how much area for food-growing is difficult, as most cities trade and import their food, much of which, like wheat, corn, melons, or tomatoes, require large areas; however, for greenhouse, hydroponic, or small truck gardens, twenty percent should be enough.

The figure for circulation is a hybrid figure, since many utilities can be underground. Using alternative technologies, perhaps 1-5% of the area is needed for electricity generation, much of which would be the surfaces of other structures.

In many modern cities, from 41 to 59 percent of the ground area is dedicated to streets and parking. By comparison, traditional walking cities in Africa, Asia and Europe were always more compact; the arcology simply eliminates cars, trucks, buses, and trains. However, walking paths, sidewalks, as well as light rail and escalators are expected to take up 5-7% of the total area.

Areas set aside for civic and commercial functions are relatively generous. Most of the entire population of the arcology, as well as external workers or visitors would be 'housed' in these areas for a third or half a day. Assuming that each business had 3-9 employees, perhaps as little as 5% of the area would be reserved for commercial enterprise.

Civic functions would also be relatively dense and so require less space over shorter times. This would be for public meetings, city meetings, celebrations—but it would also be for heroic meetings or presentations, so the spaces would need to be larger and more dramatic, perhaps up to 10% of the area.

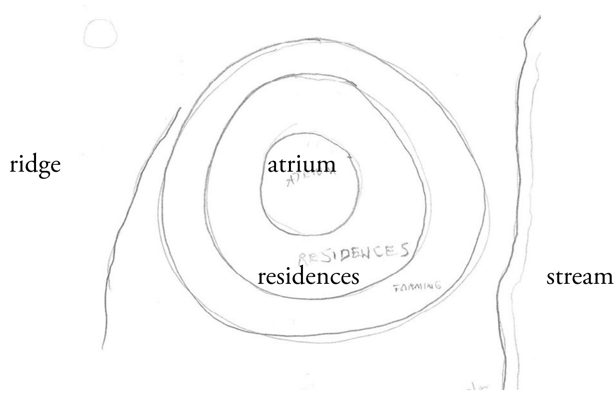

Figure 7241-1. Floor Distribution of Greenland World Dome Arcology

7.1.7.2. External Structure

The structure would be a large dome on a rectangular base. It would be oriented with one side facing north. The external surface would be a curtain wall of plastic and stone.

7.2.3.2.1. Building process

The structure would be constructed as a skyscraper, using construction cranes to add stories from the bottom. The frame of the building would be narrow steel struts. The steel frame of the building would be clad in 6 inches of fire retardant, fiber composite insulation panels.

The shape would be planned for minimum temperature and maximum wind velocity: Temperatures of -100 F. and winds up to 200 mph. A phased construction sequence would allow limited operation of completed sections as construction continued. Phase One, the ground level, would extend from 100 feet below grade to 100 feet high. It would include the structural base of the dome. Phase Two would build the floors to 600 feet. Phase Three would build the dome to 700 feet high.

The building at ground level would have double floors with cold air circulating between the two floors. Most of the building would be well above ground. This would prevent the permafrost from thawing out, turning to gravel and water, and drastically shifting from the building heat. As long as the 1600 feet (480 m) thick permafrost stayed frozen, the building would be on solid ground.

Because of the size, bulk, and complexity of this project, an automated robotic building technology, which continues to evolve as technology develops, would be used.

Foundations and floors would be made of concrete. Concrete is a versatile and stable building material and the second most widely used resource in the world (after water). Concrete can produce a lot of carbon during its manufacture. One of the most important factors is that cement, the main energy-intensive binding component of concrete, is made from crushed Limestone, one of the most common minerals found. Limestone is generally harvested and processed locally, which reduces transportation costs. Alternatively, cement could be made wholly or partially from waste products from other production processes such as fly ash (waste from electricity generation), silica or slag (waste from steel manufacture), which could reduce its carbon footprint by 80 percent.

Despite its carbon costs, concrete has many advantages over wood or plastics. For instance, it is durable, and sustainable design and green building emphasize long-term solutions and products over cheap, short-term products that generate waste. Concrete can last for many times longer than conventional building materials, such as wood or drywall. It is resistant to insect activity, rot, rust, and fire. Concrete also forms airtight seals, which minimize drafts and reduce air-conditioning costs. Although concrete is naturally light-colored and can reflect light and heat, it will also take colors so its dark surfaces would absorb heat. Concrete acts as a natural insulator and retains heat, which is useful in cold climates. It can absorb warmth from the sun and keep the heat inside.

Low-carbon concrete (LCC) could save over a billion tons of CO_2 emissions, billions of tons of quarrying, and thousands of years of electricity use. Like normal concrete, LCC offers fire resistance, sound and noise insulation, thermal mass, ease of construction, and availability. LCC, however, is stronger, more durable, and lighter in color than normal concrete. LCC can last twice as long in aggressive environments, such as those found on farms, in marine environments or under harsh climates. LCC shows greatly improved strength after fire, which can reduce the strength. Acids such as those found in farms and wastewater treatment plants cause deterioration of concrete. Previously developed sites may contain contaminants in the soil and ground water which attack concrete, causing expansion and cracking that lead to accelerated deterioration. LCC improves the chemistry and reduces the porosity of the concrete, protecting it from sulfates. LCC has less cracking because of its chemistry, and has a much reduced void ratio than normal concrete. The use of heavyweight construction materials with high thermal mass can reduce total heating and cooling requirements. Dense, cast concrete has the highest conductivity and heat capacity after water, higher than granite, block or clay, and much higher than plaster, timber, carpet, or fiberglass.

7.1.7.2.2. Surface sheeting

The dome would be made of triple thick, lightweight plastic (ETFE or ethylene tetraflouroethylene). The base would be glass and stone colored black. Glass of course is a fluid mosaic, with molecules of other materials embedded. The membrane would have potential, that is, there would be differences in charges between inside and outside and between bottom and top, which might be used to generate electricity.

The very large windows would be 'Superglass Quad' windows, which would reduce the energy costs. The super-insulated windows would consist of two standard glass panels, separated by two tough plastic sheets known as 'heat mirrors.' These four layers would create three spaces that were filled with krypton gas, which would prevent the formation of condensation on the glass and heat loss to the outside. Altogether, the windows would have a thermal insulation rating equivalent to a wall insulated with fiberglass bats (with an R-value of about 2.6).

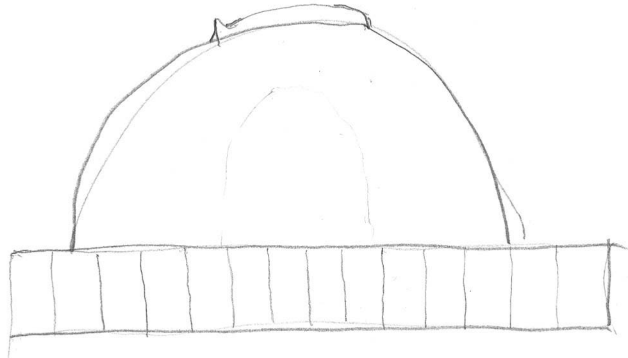

Figure 71721-1. Rough sketch of side elevation of Greenland World Dome Arcology.

7.1.7.2.3. Membrane qualities and Insulation

Membranes give shape to a structure. As a membrane, the plastic, as well as the glass and stone façade, would be relatively impermeable, due to the climate to limit physical particles or air. There would also be a minimum of plants and animals that would penetrate the membrane. And, there would be a minimum of egress points, such as doors or balconies. Essentially, the structure would be a closed system, and all forms of agricultural or wild spaces would be enclosed. As Soleri refers to arcologies in space, the only form of architecture is interior deign. This alters principles of construction. The city no longer has a membrane but a wall.

One important way to reduce heat loss is to build extremely well insulated structures. The use of commercially available insulting materials like the Thermalkool radiant barrier (which is paper thin and is rated R52) and other materials like mylar would help greatly. Using these materials in alternating layers with air pockets between them may let the walls be rated at over R300 at less than one foot thick. By comparison, a typical American home uses fiberglass insulation that's usually rated R30.

Another way to further reduce heat loss would be to seal the buildings air tight. Preventing air and with it heat from escaping the structure would reduce the energy demands needed to heat it. This would, however, contribute to the problem of maintaining a constant fresh air supply. An air exchanger system, combined with a thermal energy recovery system through the use of Stirling engines, or another thermal energy conversion technology, could be used.

One system might have the cold fresh air intake shaft and the warm air exhaust shaft run parallel to each other with a number of Stirling engines sandwiched between them. The temperature difference between the cold outside air and the warm air from inside the buildings could be converted back into electrical power. Also, a small amount of the waste heat would be transferred though the plates on the Stirling engines, providing a small warming effect for the incoming air. This method could be used with large chambers to effect a single large air mass at one time rather than a shaft system. A chambered system could also allow for multiple stages of thermal energy recovery and air intake heating to occur further increasing the energy efficiency of the system.

The sides of the arcology, especially near the frozen surface, would need a heat barrier. If the underground structures was well insulated, it would enable the surrounding ground to remain frozen. This would increase the stability of the structures and tunnels with less bracing and support.

Individual homes could include a heat exchanger that would transfer the heat from stale air to fresh air being pumped in. The heat exchanger and a heating coil could warm incoming air and pump it to other areas.

7.1.7.3. Internal Structure

An arcology could use tools that promote greater autonomy and decentralization, as well as better and smaller communication devices, which is already a trend in technology. Alternative energy sources could be used to power longer-lasting, higher-quality appliances and motors, built with benign manufacturing systems in an industrial ecology. The arcology itself would be a multiple-use building, which would be assembled from mass-produced, modular housing and automated paths, rails and roads, using recycled or biodegradable materials.

The structure would have a central light well, with 50 side wells, although much light would be allowed by the triple-glazed cladding. Utility shafts would be placed through the vertical solid interior support walls.

7.1.7.3.1. Support Structure

Although the structure would have 80 floors, each floor would have an atrium that would be at least 2-4 stories high, projecting into other floors.

Internal volumes, either spaces or enclosed spaces, would be modules for public spaces as well as neighborhoods of homes.

The dome structure would support only the dome materials. The internal vertical elements would allow heavier floor loads.

In recycling elements, carbon tubes could be used for building. In a building that size, a lot of carbon would be sequestered.

7.1.7.3.2. Modular units

Many home units would be manufactured as plug-in modules, either shaped as cubes or as a one or two polyhedrons. These could be built in other nations and shipped.

Frames for space volumes, as well as subunits for research facilities or manufacturing areas, would be modular.

7.1.7.4. Areas

In most proposed arcologies, the areas are zoned according to use, and this is reflected by room-size, utility density and other design features. Special areas for energy generation would not be necessary, since the use of micro-generators and collectors would fit on the internal and external walls.

7.1.7.4.1. Neighborhood Homes
Home size is expected to be on the European or Chinese model in terms of space, although the spaces would be very efficient. To avoid stresses and the reactions of crowding, we need to design for varieties of spaces. Good designs can change behavior. Open neighborhood or public areas would meet the need for large open spaces.

Individual homes could display several kinds of wall and floor coverings. For example, lichens are plentiful in Greenland. Paint is traditionally used on walls, but lichen could be applied, and it would grow and change colors with time and season (Papanek lists 118 colors from Lichens). It would save on cost, labor and depreciation. It could be sprayed on with a nutrient solution; it may be patchy at first, as well as shaggy (up to 1.5 inches), but would provide texture.

7.1.7.4.2. Neighborhood public areas
Public areas would be sized according to the floor population, such that there would be a public area for every 250 people. These areas would be spaced symmetrically and designed to be as multipurpose as possible.

7.1.7.4.3. Neighborhood stores
In the beginning, the arcology would provide small stores for every neighborhood for basic clothing, tools and foods. Such stores could be replaced or augmented according to neighborhood needs.

7.1.7.4.4. City public
The top of the dome would be reserved for special occasions. There would be permanent areas there for religious or social purposes.

Because an arcology might require more participation, the design of public areas would contribute to a more democratic style. It would be a governable size, with clearly defined boundaries. The arcology would specifically work to maintain a framework to represent the people, as well as the other beings in the ecological system, by reemphasizing the goals. Efficiency is less important than participation in good judgments.

The arcology would be a limited size from a calculate optimum, dedicated to protecting desired ways of life, while leveling extremes of wealth and paying all ecological and economic costs (See section 6.8.3.2. in *Redesigning the Planet: Regions*).

7.1.7.4.5. City Large stores, factories
There would be large stores for every two to three floors. Because of its nature as a political and research center, it is not likely that factories or industries would develop for trade. However, given human invention and play, a number of ‘cottage’ industries might develop, for instance, for making jewelry, furniture or scientific instruments.

7.1.7.4.6. Food growing
Due to the limits of the climate and site, very few exposed fields, if any, would be planted in the areas surrounding the arcology. The area is rough wilderness, with relatively few animal and plant species.

Therefore, it is likely that food will be grown inside, in greenhouses, either in media or hydroponically. Some areas may have tree or root crops. Individual homes may also plant herb or limited gardens.

A vertical farm would create 'closed loop agricultural' ecosystems, where nearly every aspect of the farming process is recycled and re-used, especially water and nutrients. This and some horizontal farm areas would solve the problem of inadequate expanses of fertile farmland. The Dome Farm offers a solution in the form of a complete self-sufficient ecosystem that covers everything from food production to waste management

7.1.7.4.7. Recycling and Waste

Sewage would be treated with the living machines as envisioned by John and Nancy Todd, and based on many of their suggested principles. The foundation of such a machine is microbial communities. But, the machine would also be a photosynthetic community, and a linked ecosystem with a variety of pulsed exchanges and nutrient reservoirs. They note that the system should have steep gradients for higher efficiencies of operation (for example large differences in pHs).

7.1.7.5. Infrastructures

The operation of the arcology would initially be managed by a special department, perhaps formed from the volunteer military branch of the UN or special hires. In a similar way, all initial services would be provided by pre-organized groups. This would be for food and materials, as well as for medical and educational services.

Water collection might be a problem. A limited volume of water would be available from the treatment process. Grey water could be used for flushing and irrigating. Water might have to be rationed at times, depending on the efficiency and speed of recycling.

Emergency services would be provided by specialists, given the conditions and isolation of the arcology. A small hospital would be necessary to treat the normal medical requests, from wellness exams and help from child birth to psychological problems and diseases, of a population of 60,000.

Transportation is a critical part of the structure of the arcology. The main terminal on the southwest side of the structure would connect the arcology to the local port. Mag-lev lines would take travelers from the port and from the main station to local stations within the building. Inside the building, travelers, residents, employees, and visitors would shift from mass transit to local walkways. These would primarily operate within public spaces throughout the interior. Within vertical neighborhoods, vertical circulation would be enhanced by extensive use of escalators.

Walking is encouraged; it is facilitated by trails, paths, and walkways. Pedestrian movement is aided by escalators, moving sidewalks and elevators. A limited number of personal conveyances, including bicycles, wheelchairs and 'golf' carts, would be allowed. Some, such as electric wheelchairs, Segways, and bicycles, would be powered. No automobiles, helicopters, or power boats would be needed.

Service transportation is provided between floors and in construction yards, warehouses and distribution depots. Deliveries would be made with somewhat larger carts. Freight elevators handle construction materials and large goods, furniture and appliances.

7.1.7.5.1. Horizontal Movement (Walkways and Tunnels)
Paths of various lengths and widths would connect all the areas of each neighborhood. A limited number of moving sidewalks would transportation for the elderly or handicapped.

7.1.7.5.2. Diagonal Movement
Diagonal travel, on angled elevators and escalators, would connect the areas near the surface of the dome.

7.1.7.5.3. Vertical Movement
Vertical movement would connect upper and lower floors. Ten elevators per floor would be located in the vertical structures. Stairways would be located in four areas near the perimeter.

7.1.7.5.4. Utility cores & Air/Water Systems
Utility cores would be bunched for efficiency. Airflow and controlled temperature are handled by interior ventilation systems using the Chimney effect (hot air rises).

7.1.7.5.5. Energy generation
The goal for the structure is to generate its own energy. Initially, the structure would depend on energy from fossil fuel. The requirement for the arcology is roughly estimated at 20,000 Megawatts.

The plastic dome shell could be 'painted' with collectors to route solar energy to batteries or flywheels (the surface of the dome may be large enough at 6.7 million square feet). Solar collectors may not be efficient in the local light regime. Wind generators can be large and external, but may not be able to provide enough energy for air-conditioning. A small 'wind farm' could produce 10 megawatts of electricity per hour.

Some built-in features of the building itself, from generators from falling water and excess heat (body and thermal), would supplement grid energy. In general, the thermal mass and airflow design of the structure would allow significant conservation of energy, lowering the requirements from fossil fuels.

The design of the structure puts an emphasis on the pedestrian, saving the fossil fuels that would normally power automobiles. The three-dimensional, multiuse design puts the pedestrian within walking distance of most functions, allowing residents to live, work and learn in a densely-packed, lively space. Close access to wild nature gives residents limited recreational opportunities without personal vehicles. Food production in the greenhouses save fuel by eliminating much trucking of imported food to the city.

Alternative sources of energy production for the reduced needs of the residents include solar panels with photovoltaic cells inside the dome on unit walls, which could occupy 200,000 square feet and produce 6 megawatts of low voltage electricity per hour for use in low voltage lighting throughout the building.

A field of solar power generators, 1000 Genset hydrogen conversion units near the south face, could take advantage of even low light to produce over 30 megawatts of electricity per hour, the bulk of the household electrical needs in the arcology.

The structure's ventilation system takes full advantage of both rising warm air and sinking cool air, the chimney effect.

Small-scale, pre-sealed nuclear generators, perhaps four for the entire structure, could provide the basic power for heavy or industrial use. Each would provide approximately 285 MWe (MegaWatts energy). This technology is considered 'well-developed.' Russia has been using similar small units in Siberia with success since 1976; India, China and South Africa are experimenting with alternative designs, and in the USA, General Atomics is developing a gas turbine modular helium reactor, to directly drive a gas turbine, operating at high temperatures with helium as the coolant.

The sealed 'cartridge' design from Hyperion Power generation generates 25 MWe and would run for five years (and could be returned for refueling); possibly some could run for 30 years. It is small ('hot tub' size) and self-contained. If coolant fails, the reactor is designed to shut itself down. With a passive cooling system, it would work without power. Each unit could serve as a burial chamber for its small wastes. These units would reduce capital costs (30-50 percent of large-scale nuclear). Costs could still be $100 million or more. It would be difficult to steal one without heavy equipment.

7.1.7.5.6. External grid

There is no energy grid on the north part of the continent. None would be constructed, so the arcology would have to be self-sufficient in energy.

7.1.7.6. Context

The context is a fundamentally wild continent, with a relatively recent Inuit culture and later, separate European settlements. Transportation and communications are limited. A number of snow-track vehicles might be needed. The rail line would connect to the port, but there would be no air or highway routes.

7.1.7.6.1. Cultural Considerations

Although there is a form of scientific culture, as a result of exploration and research, the main native culture has been Inuit. The traditional Inuit way of life, including whaling and seal hunting, should have the option of being preserved in reserved areas. The European culture of cattle has been reestablished but may not be sustainable.

Greenland has been working towards a new self-rule status, after a referendum in November 2010, in which just over 75 percent of Greenlanders voted to take back more powers from Denmark after years of negotiations. Greenland's Premier is asking for the expansion of *hjemmestyre* (home rule) into *selvstyre* (self rule). Under the self-rule agreement, Greenlanders will be recognized as a distinct people with the right to self-determination. Greenlandic will become the territory's official language. Home rule will give the 57,000 inhabitants more control over natural resources such as oil, gas, gold and diamonds. Denmark will retain control of defense, foreign and monetary policy.

7.1.7.6.2. Transportation Regional

Most transportation into the continent is by ship or air. There are no formal permanent highways or rail. With the establishment of an arcology, several short, permanent roads may connect several national bases. The arcology should be connected to an oceanic port by a permanent road (that would limit traffic over sensitive areas).

7.1.7.6.4. Wilderness location
The continent is a wilderness and would be established as such by Greenland or by the UN. Continued scientific research would be allowed, but the number of workers and tourists would be limited to preserve a fragile landscape.

7.1.7.6.5. Natural resources
Arable land is zero percent, which is the area of permanent crops also. None of the land is irrigated. Zinc, lead, iron ore, coal, molybdenum, gold, platinum, and uranium have been found in varying amounts. Fish and seals could be harvested in limited numbers, depending on depletion of traditional stocks. Exploration continues for oil and gas. Hydropower could be developed in places. The potential for solar power is relatively large.

7.1.7.7. Discussion
Although there are seasonal variations, especially regarding light, the overall climate is polar. Climate and limited development make it important that the city be self-contained and self-supporting. The projected population of the arcology would double the population of the island, although it should reduce the total impact. Possibly, 15-20 percent of the current population would move to the arcology; immigrants would make up most of the arcology.

The shape of the dome, with its curved spaces, would affect the psychology of the residents and the relationships between things and people. The dome could encourage conviviality by focusing attention and awareness into convergence. This may enhance awareness and conversation. The dome would indicate sheltering from a rough climate. The modular polyhedra spaces could have curved ceilings inside. Curved spaces may have psychosomatic effects on the residents, which could benefit their health.

Greater attention is given to the human scale in an Arcology. Pedestrian distances are measured by walks and in minutes. Other wheeled vehicles, such as bicycles or battery-powered carts, could be available for delivery or recreation.

7.1.7.8. Conclusion: Greenland Dome
The city has been the most active and dynamic outlet of human life. Soleri refers to the city of the future as an arcology to emphasize that a well-built city is always ecological architecture. But, for him it is also the fundamental instrument in the transformation of matter into spirit. The arcology would create a synergy between habitat and nature, body and spirit, and work and leisure. It would generate the urban effect more intensely, which could energize the inhabitants.

The Greenland arcology would be a self-contained habitat of reduced size, with access to the surrounding wilderness. As a single structure, it would integrate the fundamental components of life—dwelling, eating, learning, working—into a frugal form, while accepting a certain amount of ambiguity and disorder. It would become a laboratory for doing and learning, tested through experience, and tempered by the opportunity to fail.

The principles of an arcology, from using marginal land and imploding urban sprawl to habitat density to internalizing and miniaturizing the urban effect and linking the habitat, energy and environment, serve as a model for a stable, exciting construct. The creation of a world arcology in the arctic of the northern hemisphere is an important first step to converting the spread of urban growth into intense, rational settlements.

7.3. *Global Problems: Growth, Inequality, Poverty, Dominance & Slavery*

Growth serves as a mechanism of evolutionary adaptation, by carrying out genetic instructions in the environment; but growth is also conservative and stabilizing rather than innovative and reorganizing. Growth is homeorhetic; in a homeorhetic process, the flow is constant, not a stationary state. Flow processes follow fixed trajectories, called chreods. Growth, from fertilization, then in embryo states, birth, youth, and maturity, represents a homeorhetic process following more or less fixed chreods, programmed genetically and conditioned environmentally. Chreods seem to be like electron paths, that is, probabilistic. Sometimes, growth can be problematic, when a physical body grows too much flesh or a population keeps growing past the carrying capacity. Other things, such as ideas, and wants have no natural size to exceed, but can cause other kinds of problems at inappropriate scales or locations.

7.3.1. *Economic Growth & Population Growth*

Although economics is a social science that studies human behavior, it considers itself a positive science, that examines "what is" with theories, as opposed to a normative science, which addresses "what ought to be." Keynesian economic theory, the predominant theory in industrial countries, holds that the full utilization of resources is necessary to ensure full employment and the maximum social good. This economics depends on economic growth to avoid crisis. The major premises assume that: Population will grow, that social good is related to the equitable distribution of material products, and that if resources are limited, technology can erase the limits. The economist Kenneth Boulding referred to this as a cowboy economy, an economy that has yet to recognize real limits.

Economics became enamored of growth during a critical time in history. Rapid European expansion occurred at rates rarely exceeding a growth of one percent per year, and with unparalleled opportunities for expansion into sparsely settled areas, such as North America, Australia, South America, and South Africa. Many cultures now do not have these opportunities; the continents are claimed, and violent population growth may have wrecked their hope for development by ravaging every resource.

7.3.1.1. The Assumptions of Growth

The metaphor for the economy used to be a simple mechanical model for turning resources into products. It was assumed that to be successful, the economy had to grow and turn a profit continually. Unfortunately, the assumptions of the model were also simple and failed to consider human needs and natural cycles, causing great suffering and great disruption. These assumptions resulted in overgrowth, with increases in complexities and costs. Overgrowth contributed to economic and ecological instability (See Section 7.6.2).

Continued growth of the "free market" is amoral and pathological, benefiting the elite of authoritarian regimes as much as the oligarchs of democratic ones. It refuses to recognize, much less to pay, all of its costs, such as depletion, loss of security—which may be most important—or extinction. The entire system perpetuates mass poverty and justifies it by blaming individuals, but the system itself fails to reduce inequity or poverty. This loss reduces effort; it is responsible for tiredness and low kinds of health, productivity, and esteem, things that are necessary for personal and systemic renewal.

Some theorists, like Paul Samuelson, have concluded that growth is necessary to rid the economy of disparities. The need to grow is intrinsic in this kind of economic system. A large literature has treated perpetual growth as the only conceivable state of affairs. Capitalism depends on growth for stability. In an organic system, however, growth contributes to stability, but it cannot continue beyond maturity, due to real physical and biological limits. Mature organisms grow to maturity, but then they can keep developing without growth during maturity.

7.3.1.2. Growth or Development

Many physical structures, such as talus slopes, grow by addition, until some physical limit, such as gravity or the coefficient of friction, is passed, then they stop growing. Some stability can be gotten from growth in early stages; later, stability must result from limits and metabolism. Growth in plants can delay the onset of senility by ridding the plant of waste products in more diluted form. However, too much growth produces a strain on tissues and early decay. In fact, one herbicide promotes excess growth as a means to kill weeds. A biological organism grows to maturity, which is a stopping point for size. The organism continues to develop, however, experiencing and learning the environmental complexities through mating and then to the end of life. Development may include growth at some stages, but development refers to the ordered continued change after growth has stopped. Mechanisms for growth can become pathologies when central authorities interfere with stable lower orders.

Development instead of growth would equalize wealth more efficiently—after all, economies have been growing for at least 400 years and increasing the disparities. There is no necessary association between development and growth in economics, as Daly and others have shown. Growth means increase. A community is forced to accept an upper limit, beyond which it cannot grow any further. Further growth results in destruction or disruption of itself and nature.

There is another distinction between growth and development. The ecological social approach (or a redistributive environmental strategy) to development makes it irrelevant to discuss global limits to growth. Local limits are far more significant to a majority of the population. Regardless of how much food exists, people will starve unless they can get it. Redistribution of resources and improvement of environmental quality (in the home environment) are more important than increased production by sophisticated technology. The natural capacity of regional photosynthesis must be limiting factor in development, especially in tropical and subtropical areas.

It has been said that international goals are best realized through national self-interest. This must be the old wisdom. It might have been true, if nations were perfectly rational and knowledgeable; they do not seem to be. Nations now seem to be the handmaidens of corporations, whose interest is only in profits for shareholders. The views of shareholders are notoriously short-sighted.

The UN is limited by images and ideals of progress. The UN's solution to economic problems is "sustainable development"—that is, "growth that respects environmental constraints," as if growth respects any constraints. The Bruntland Report indicates a five to ten-fold increase in world industrial output within the next hundred years before population stabilization occurs. While the appeal of growth is unarguable, it is really not likely to be sustainable in any meaning of that word, since sustainable growth does not recognize known ecological limits.

7.3.1.3. Growth of Populations

Agriculture, growing crops and raising animals, provided more food, but it was less nutritious and less palatable. By increasing the population, agriculture increased widespread hunger. The reduction in biodiversity, by monocropping, undermined biodiversity and caused some ecological crises, that resulted in periodic and devastating famines.

Despite famines that caused hundreds of nations to wobble or collapse, the overall human population has kept increasing. By 1900, the rate started to increase steeply. At a rate of increase of two per cent per year— that is below the current rate—the earth's human population will reach 50 billion by 2100. By 2280 it would be 1.2 trillion. That is 300 years from now (1980).

Nations that seem to have adequate resources may be growing too fast. Even the Union of Soviet Socialist Republics, with all its potential agricultural land, and its uncertainties of drought and frost, may be increasing their population too fast, as may Canada and Australia. Population growth can become a political weapon, in a democracy, when two groups coexist, with neither ecological differentiation nor geological separation, and only breeding control for coexistence. For instance, in Sri Lanka, the Sinhalese and the minority Tamils, breed for political control, ignoring population control. Voluntary controls fail; the population increases by almost two and a half percent per year. The problem of population control is a tribal problem, not a racial or economic one. It is a local problem, more than a global one. Even with trade and charity, in most areas population is limited by local resources and local limits; only in a few cases, such as the Netherlands and Hong Kong, can a population be supported by massive ghost acreage elsewhere.

Sir Charles Darwin's view of humanity was that it was not domesticated. Humans were still wild. Unmastered, they have no breeding control; therefore, they will eat to the limits of the natural food supply and press against social and biological limits. The global population explosion, an example of autocatalytic nonlinearity, is not considered a problem for many thinkers, such as Eric Jantsch, who believe that this growth constitutes an essential factor in the creative act of gestalt formation. Growth does lead to intensity at some stages of development in the life of a species, but growth can stop, and development can also lead to the kind of creative intensity that is identified by Jantsch and others with mindless growth.

The principles of ecology can offer information on human societies. For instance, the principle of competitive exclusion states that two dissimilar races cannot occupy the same niche in the habitat. If humanity is wild, and not domesticated, this may help explain war and racism. Territoriality is no longer a rule in human ecology, though the instincts may still be operative. Human ecology defies maintaining its population at an optimum level. The young are overproduced and protected; the least fit are not eliminated. Medical science has also increased the number of old and maladapted dependents of society. Problems with populations bristle with social and political implications. A balance in birth and death rates is necessary for ecological stability. We have controlled epidemic death and infant death diseases. We need to correct the overbalance in births, or risk having nature do it. Toughness and ingenuity might be required.

7.3.2. *Inequality—Economic & Social*

The assumption of inequality is new with agricultural civilization. With surplus, came redistribution and the beginning of inequality. By 4400 YBP in Mesopotamia, there was status differentiation, as evident in the sizes of homes. By the time of Bacon, it was assumed that there was: An absolute, immutable, omnipotent God, everything was sorted into a great chain of being, economic subsistence was preferable, and social inequality was unavoidable. Later, Darwin incorporated a different set of assumptions into his theories: Absolute space-time; atoms as discrete units; economic discrimination, and continued social inequality. These assumptions contributed to the misuse of his theories to justify social and economic conditions at the time.

Many modern political ideologies and economics have been shaped by the principle of endless wealth. Adam Smith once calculated that the real price of anything was just the toil acquiring it. Inequality in a world of abundance could only exist through human suppression and exploitation of other humans. The invalidity of this principle of plenitude came with the recognition of limits.

Government has become subservient to economic actors, according to John B. Cobb, Jr., partly because the ideology of economics is so positive. It proclaims that continued growth will solve most of the problems of modern civilization, from poverty to conflict, although the promise has not been fulfilled. The problems have increased: From food shortages, housing shortages, and energy shortages, to unemployment, inequality of opportunity or goods, environmental deterioration, increase in weapons, and insecurity.

Economies are out of balance. Modern economies, embracing the idea that "nature is capital," draw on the accumulated "capital" of ecosystems for production. By ignoring the real cost of the capital, as well as the costs of natural services, such as nutrient recycling, soil building, and atmospheric renewal, these economics create a temporary wealth—similar to the healthy flush of a fever, perhaps—and a long-term imbalance. When an economy falls out of balance with its local environment, massive disruption often results; industrial economies have only avoided disruption by trading advantageously with other economies, by using fossil fuels, and by promoting general institutional inequality.

The economic government, according to Robert Reich, creates a corporate hierarchy, with pervasive inequality between all levels, rather than a democracy. To keep profit growing under any circumstances, corporations have been willing to accept damage and conflict.

Nations are basically exploitative of other nations and smaller cultural groups, which may not be considered nations because they lack a permanent military: The United States concentrates on Latin America; Europe on Africa; Japan over Southeast Asia; Russia over Eastern Europe; and China over Tibet. The reasons for this continued behavior include: The rapaciousness of society; the acceptance of war; and the economic advantages of large-scale operations. The cultures of industrial nations are based on unethical accumulations of materials. Inequality is maintained by power, not persuasion, and also by the assumption that solutions are extrinsic and external and have to be found by spreading out rather than intensifying efforts to find solutions at home.

The predominant value in small cultures, and then large, was harmony. This minimized conflict that might have resulted from inequality. Confucian concepts of ritual and etiquette helped to regulate social conduct and made people feel good about their station. For example: "Inequality is the nature of things" and "seek no happiness that does not pertain to your lot in life." This may not work at the scale of nations.

7.3.2.1. Distribution of Wealth

In almost every size of human groups status is divided unequally. In hunting groups, better hunters become the hunting leaders. The success of a hunter allows the hunter to distribute the cuts of the game between others, often according to an understood set of rules. In larger groups, with a surplus of materials, the materials are distributed according to status. People have equal access to status positions in society. The number of positions of prestige is adjusted to the qualified candidates. Status is separate from wealth. An animal divided up according to ratios regardless of who kills it.

J. S. Mill narrowed the scope of economics to production and the scarcity of means; he considered distribution to be a political process, since it depended on laws and customs that varied widely in different cultures and ages. One function of culture is to distribute material goods or energy. Economic culture defines the means of production and livelihood, techniques of distribution, and values and norms underlying economic behavior (can be more closely related to kinship. Order is a cultural problem. Order provides stability and security. Cultural order is necessary to deal with the redistribution of wealth and power.

With the creation of more wealth or new wealth, the distribution becomes skewed. Accumulation increases. More kinds of wealth become invented, dangerous, and useless, and more skewed. But, as long as an economy does not reach the limits of wealth, it can keep growing; these new kinds of wealth allow that. Cultures encourage the unequal distribution of resources.

Wealth is based on production in capitalist countries. The production of wealth from growth depends on technology. The technological perspective is oriented toward materials and not humans or ecosystem processes. Nature is considered to be a resource to be exploited. The immediate objective of technology is to create wealth through knowledge. Technological activities are justified on humanitarian grounds, scientific discovery increases the well-being of human society, yet the social consequences of scientific activity are ignored; short-term suffering will be offset by long-term benefits, it is claimed. But because the long-term view is not taken, long-term benefits will be worse.

7.3.2.2. From Difference to Inequity

Inequality is more the result of differential development than of exploitation. According to Boulding the greatest source of the differential is different rates of accumulation of knowledge, capital and organization; the rates are essentially internal properties of cultures. Although a minor element in terms of transfers, it is a large psychological perception, which may need to be compensated for in a global community.

Most of the wealth used by modern economies is nonrenewable. These resources are limited, interrelated and distributed unevenly. Forests are a special problem; although trees can grow to a good size in 30-40 years, forest ecosystems may take 300-600 years to develop and then last for thousands of years. Oil, coal, peat, and some woods are functionally nonrenewable. Geological time periods are required to produce them.

The distribution of symbolic and real wealth is very inequitable as the result of historical trends, old economic rules, and cultural confusion. Karl Marx considered that misery is caused by class conflict about distribution of material things. Some of the problems of distribution have to do with the size of society and the scale of its operations. For instance, in Hutterite communities, usually less than 150 people, the distribution of goods rarely failed; people got their share, rarely less or more. With a larger group of Hutterites, the distribution started to fail, and the group divided.

The modern market distributes some benefits to all, but its scale allows unfairness. Economics are the harmonious distribution of wealth among people. But, problems outside small-cell scales. Kohr points out that Marx failed to link misery to the scale of economics rather than the system. The problem is with overgrowth more than style, which is why socialism based on overgrowth looks the same as capitalism overgrown.

7.3.3. *Poverty & Consumption*

Poverty can be defined as a lack of needs, such as food and clothing. Affluence and inequity seem to be producing new forms of poverty, such as lack of use (use-value of feet in Los Angeles) or the potential poverty of not having what is possible elsewhere in NY or Paris. Modernizing needs creates these new dimensions of poverty, and this leads to new discrimination. A violent cargo cult that seizes traditional cultures. The opposite of this is new forms of wealth, such as useless wealth or harmful wealth that actively subtracts from the enjoyment of life.

Ecological analysis would force us to look at the obvious—generating nonmarketable use values occupies the center of every culture because it provides a satisfactory life to its members. Needs are almost completely defined in terms of commodities. Even relation needs a commodity, travel, to be fulfilled. Once the need is defined and partly satisfied, it becomes a right. From walking to the right for passenger miles at high speed in a mere fifty years. Stung by the suffering of people with new unsatisfiable needs, we have offered to produce more, safer goods. Instead of ecologically analyzing the relationships of needs to satisfactions.

Consumption is touted as the solution to poverty. We all live, thanks to modern advertising, in a dream world of mass consumption. The purpose of expositions changed gradually from instruction in wonder to simple entertainment and buying. The Crystal palace in 1849 shows the former and the 1855 Exposition in Paris, the latter, where they put price tags on things and charged admission. The first department store opened in 1853; this changed the tone of shopping from haggling to inspecting a fixed price item.

Consumers are trained to enjoy waste, violent speeds, harsh medical treatments to extend life, and standard rations (mcRations?). The state has to try to discourage the lack of patriotism that comes from deserting from the standard needs diet. The military is actually a symptom of the orientation of the state. Health and education use a military rationale. Industrial society is constantly mobilized for emergencies, in the battles against, noneducation, poverty, diseases, terrorism. Industrial development has never been nonviolent or respectful to people.

Specialists incapacitate people's autonomy by forcing them to become consumers of care, instead of learning to care for themselves. Half of our needs are made by armed bureaucracies that have been growing since the Louis XIVth Empire. Industrial services see state security the generator of society's production patterns, even if a spin-off of military needs.

7.3.4. *Cultural Dominance: Colonialization*

Dominance is a social phenomenon that describes social relationships. Dominance in animals is related to a social hierarchy that allows the dominant animal to feed first. Dominance in plants is often related to mere numbers or the ability to grow faster and reach the light first to spread more leaves to catch light. Dominance is humans is more complex. Like wolves, human beings interact with the individuals of other species or with entire species. Like other mammals, humans change their habitats to suit themselves. Humans have modified animal and plant associations in a different way from other mammals, simplifying patterns of energy and chemical exchange and solidifying themselves at the end of many food chains as a dominant species. A dominant is a species with greater influence than any other in its biotic community, changing the lives of others and the character of the habitat.

Human populations have increased exponentially, with billions in giant urban ecosystems. Agriculture has produced monumental yields, but only at the cost of tremendous erosion and great subsidies of fertilizers and pesticides. Dams have been built all along rivers, and riverine forests have been cut, altering rivers and fishing grounds. Changes have been made without regard to the long-term impact on the ecosystem or on its human population. We dominate entire ecosystems.

By its influence of all ecosystems, humanity has become a pandominant species. As such, humanity reclaims, overgrazes, clears, depletes, and wastes at a level that threatens the stability and existence of many systems. This pandominance has major effects on ecosystems: Transient perturbations in energy relations (from oil spills and burning); chronic changes/shifts of systems (from dams, irrigation, and chemical wastes); species manipulation (from the import and export of exotics); and interference competition with wild species. One of the ecological consequences of human activity is the degradation of wild habitats for human developments and the introduction of novel elements into the biosphere—elements that have not been harmoniously worked in over time as a result of natural processes. The biomass, or demomass, of the human species probably far exceeds the biomass of any nondomestic species, and that biomass is supplemented by the tremendous biomass of domestic animals, which is four times greater. This biomass forms an equivalent population that consumes much of the same food, such as milk, fish, and grain.

7.3.4.1. Cultural Status

Like many mammals, human beings create social hierarchies, which allows some individuals to get more food and better mates. Status is also assigned according to the hierarchy. Although, in primates, the largest, fastest and usually younger males often dominate, old males can sometimes dominate with the help or permission of females who may prefer an old predictable leader to a young unpredictable one. Status has to do with standing in human society, and with appearance and ownership. Status may come from longevity, of the self or ancestors, as well as from the results of good decisions, from hunting for example, or from owning more than others, or just more things or more people. Status is a powerful human need, and may drive the growth of goods or populations. Perhaps related to population growth and size, changes in cultural status become related to equity, distribution, and dominance. As distribution becomes more unequal and as conflict occurs more between groups, dominance and slavery appear, and are both related to status.

Darwin has been criticized by Malthus for extending the popular theory of economics to the natural world. It is true that the biological considerations of economics inspired an economic description of a biological law, but Darwin enlarged and supported the metaphor. He retained the idea of hierarchy, but status became a form of fitness, specifically in birds and mammals. It can be argued that status has fitness values in human groups also. For instance, a woman is more likely to mate with a man who has higher status.

Status is a social need, which is justified by a culture. Status levels in traditional society included: Nobles, commoners, and slaves. Slaves were captured or purchased. In earlier days, people were sometimes captured by enemy tribes. The return home of the captives, either through payment of ransom or owing to a retaliatory raid, was a special return. Like other property, slaves were given away as gifts. Occasionally, they were killed and eaten, for instance during the Kwakwakawaka cannibal dance. A commoner was simply anyone without a chief's position, potlatch position, seat, or standing place. They are not a class with a function. At times, nobles may retire from potlatch positions and become commoners. Kinship was the main determinant of status. For the Kwakiutl, the display of status validated the social system. The redistribution of food validated the cultural status of the leader.

Inequalities of status and wealth became associated with permanent settlements. Furthermore, other social things developed such as complex division of labor, with castes and slave labor. Trade increased and competition increased. This may have had to do with resources that were abundant and could be stored, and transformed into political prestige and power. Agriculture provides more status, more wives, and more things. It allows armed struggle also. Art, in addition to luxuries and profits, was tied to status.

7.3.4.1.1. Equity & Distribution—Having More

In almost every size of human groups status is divided unequally. In hunting groups, better hunters become the hunting leaders. The success of a hunter allows the hunter to distribute the cuts of the game between others, often according to an understood set of rules. In larger groups, with a surplus of materials, the materials are distributed according to status. People have equal access to status positions in society. The number of positions of prestige is adjusted to the qualified candidates. Status is separate from wealth. An animal divided up according to ratios regardless of who kills it.

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short-term suffering will be offset by long-term benefits, it is claimed. But because the long-term view is not taken, long-term benefits will be worse.

Inequality is more the result of differential development than of exploitation. According to K. Boulding, the greatest source of the differential is different rates of accumulation of knowledge, capital and organization; the rates are essentially internal properties of cultures. Although a minor element in terms of transfers, it is a large psychological perception, which may need to be compensated for in a global community.

The distribution of symbolic and real wealth is very inequitable as the result of historical trends, old economic rules, and cultural confusion. Karl Marx considered that misery is caused by class conflict about distribution of material things. Some of the problems of distribution have to do with the size of society and the scale of its operations. For instance, in Hutterite communities, usually less than 150 people, the distribution of goods rarely failed; people got their share, rarely less or more. With a larger group of Hutterites, the distribution started to fail, and the group divided.

The modern market distributes some benefits to all, but its scale allows unfairness. Economics are the harmonious distribution of wealth among people. But, problems outside small-cell scales. L. Kohr points out that Marx failed to link misery to the scale of economics rather than the system. The problem is with overgrowth more than style, which is why socialism based on overgrowth looks the same as capitalism overgrown. The change in scale drove the changes, from the transition of states, from surplus distributors, to tribute-driven to commercial exchanges. There were political transitions from leaders, to chiefs, to tribute systems, and to economic and political trade systems.

7.3.4.1.2. Cultural Dominance of Peoples

Strength or status can give rise to dominance. A dominant is an animal or person with greater influence in the community. Dominant behavior may be biologically-based or cultural. Dominance gives priority of access to food, sex, or space. In a majority of primates, males are not dominant over females, except where there is a large size difference. Where sizes are roughly the same and where female coalitions occur, there is not much sexual dominance. In some human groups, males may attempt to dominate females with the threat of physical violence, for instance, among the Yanomamo. Among other Amazon peoples, such as Mundurucu, it may be due to control of ritual objects and rituals, for dominating ceremonial life. In spite of the cultural forces dominant at any moment, an individual has the potential to determine a different course of action.

7.3.4.2. Historical Colonialism

What is colonialism? Who does it, who benefits? The history of colonialism. The Phoenicians sent out colonists to found Carthage. Settlers from Carthage founded Barcelona. The Greeks made colonies in Italy, Sicily, Turkey, Libya, and Spain. Norway sent people to Iceland and Greenland, France, and Ireland. India sent colonists to Sumatra, Borneo and Java. The Inca moved villagers to Ecuador from Bolivia. Southern Indians called Tamils, crossed over to Ceylon, which was occupied by the Sinhalese. And, of course the Europeans tried to control all of their global trading by controlling the people and the resources in Africa, the Americas, Asia and the Pacific.

Colonial countries introduced new ethnic rivalries wherever they took over. English imported Indian people from India to work sugarcane fields. By 1970, half the Fijans were Indians. Fijans tended to eat strangers and castaways, sometimes enemies from raids (some recipes were the same as for pigs), but, only men could eat human flesh because of manna.

In Tasmania, aboriginal people had woolly hair rather than curly, were shorter, had brown skin rather than the matte-black of the continental Aborigines. In technology, they had digging sticks and spears, but not boomerangs or woomera (atlatl). They understood curating fire, but could not start it. Their 12,000 year separation for any other people or culture is the longest for any people, even Rapa Nui. The English wanted to create or recreate a European world, without savages. The native peoples did not fit. All of Tasmania was first made into a prison; all the native people killed off. The culture was destroyed. The environment was destroyed. The English were not tolerant of dissent, variety or diversity. Neither seems to be the modern civilization.

Colonial administration required central government and strong armies. The Ottoman expansion into Europe annexed one food-producing region after another. Sustainable intensive farming was abandoned as colonialism gained. There is a direct connection between colonialism and the abandonment of land, possibly related to immigration or slavery.

7.3.5. *Cultural Dominance: Slavery*

To be enslaved means to be owned as property and divested of freedom and rights, or it means to be completely dominated. The word slave comes from the old Slavic word for the Slavic people, who were among the first slaves to be held in Europe.

Slavery is the idea that people can be held in bondage to perform work. The Greeks thought that freedom depended on some slavery. Some societies thought that their economies depended on slavery. It was actually thought that slavery improved the lives of slaves, since they were often considered to be from subhuman groups. It was also thought that it was a personal decision or personal right, although the slave might feel differently. There are of course, different kinds of slavery now. For humans, there are living slaves, but future generations might become enslaved to the decisions of their parents, especially as regards losses and debts. Animals have been enslaved. Machine slaves were the next economic boost. Finally, industrial societies have energy slaves, ten to twenty for each person. Slavery is based on a number of assumptions, such as contempt for the enslaved, or denial that there is wrong.

Different kinds of slavery can be distinguished: Opportunistic, institutional, or comprehensive. Opportunistic slavery was the result of raids or conflicts with other bands in archaic societies. Institutional slavery included labor force collection, as practiced in Egypt in 4500 YBP, or economic slavery for labor collection, as run by the British 300 years ago. Comprehensive slavery refers to the use of wage earners, animals, and energy.

7.3.5.1. Opportunistic Slavery

Many archaic cultures had slaves, who were usually the victims of conflicts between bands. In Nez Perce gatherings and celebrations, slaves were exchanged, along with furs, roots, berries, and fish. Slaves could often intermarry with their captors and acquire status; their children were almost always free. Slaves became a separate social class in some archaic societies. By 5000 YBP a stratified class society had developed in places like China—slaves at the bottom, then peasant farmers, craftsmen, then the elites of administrators, religious and military. In Assyria, slaves could not wear veils. Slaves worked everywhere in Assyrian society, for instance, even running businesses. Some entered slavery voluntarily to pay off a debt.

7.3.5.2. Institutional Slavery

For the Tukano of Peru, the Maku group was a slave class, that is, a source of slaves. The Kwakiutl also had slaves, who were captured or purchased. Like other property, slaves were given away as gifts. Usually, they were captives kept near the door to guard the house. Occasionally, they were killed and eaten during the cannibal dance. Viking raiders and colonists owned their own land and used Irish slaves for work and for wives specifically (based on genetic evidence). As the number of slaves diminished through death or marriage, some farmers lost their land to absentee landlords, who, without ecological or personal feedback, would make poor decisions about crops and practices.

Economic slavery occurred in Mesopotamia, Slaves worked in all levels. Many were prisoners of war; some were criminals being punished; some entered slavery to pay off a debt. But, slaves could also own a business. If a slave married a free person, their children would be free. Slavery became specialized with agriculture, in China and Egypt.

In China, by 1615, slavery was hereditary, for agricultural or household slaves. Slaves reflected the stratification of society as it became more complex. Slaves in the Americas were considered to be needed because the amount of acreage increased with the discovery of new lands; the acreage and the slaves were considered necessary to develop more wealth. Slavery kept labor artificially cheap. This dampened the incentive to develop new technologies, but, new technologies eventually surfaced because they proved to be cheaper than slaves.

The appearance of mechanical devices such as the sugar mill and Eli Whitney's cotton gin helped to support the system of large plantations based on a single crop. The Industrial Revolution after the late eighteenth century swelled the population of towns and cities and increasingly forced agriculture into greater integration with general economic patterns.

Internal slavery was a feature of Europe from the Romans to Middle Ages, but disappeared when feudalism disappeared, and labor was no longer the scarce factor in production. With the opening of America, however, land opened up—or rather was claimed and conquered—faster than it could be filled with European people. Therefore, colonists tried to force native Americans into labor. Native Americans, however, were still dying from European diseases, which made them unsatisfactory as slaves. Europeans looked to another tropical continent, Africa, where the people were resistant to old World diseases. Less than thirteen years after Columbus, in 1505, African slaves were introduced into Haiti. Over 350 years, ten million more people were brought over, in a large trans-Atlantic trading circuit that involved rum, sugar, cloth, and timber as well.

In the American colonies, the independent, more or less self-sufficient family farm became the norm in the North, while the plantation, using slave labor, was dominant, although not universal, in the South. With the British, Americans, Africans, and Spanish, slaves became a commodity in a trading empire.

7.3.5.3. Comprehensive Slavery

After the enslavement of peoples, some dominant cultures turned to the enslavement of nature and then of energy. The English treated tropical lands as enemies to be defeated, then enslaved them in plantations. Their cultural attitude as conqueror of nature led them to treat biogeochemical cycles and soil requirements as temporary obstacles in a world where everything had its price.

The new economics of the industrial age depends on wage slaves, that is, people who need jobs to get necessities in urban areas. An overeducated labor pool led to secretaries and then managers, and to the fulfillment of the managerial revolution. Now, industrial society is able to use energy slaves to accomplish work.

The concept of slavery need not be limited to plants, animals or humans. If we consider our machines as "energy slaves," then Americans each use the equivalent of fifty slaves per day. The computer is an information slave and must be the equivalent of at least three other human slaves. Slave owners love the privilege. And the exploitation of inanimate slaves is more easily justified. In fact, to some extent, the culture of arts and sciences may not be possible without machine slaves. But, at some point, slavery corrupts the owners, making them physically or mentally soft. What is the exchange for summoning these information slaves so easily? The failure to develop intellectual ingenuity? Loss of imagination? Lack of trust in intuition? Let us consider an earlier exosomatic adaptation that helped humanity. Knives permitted hunting larger game animals or deeper roots, but the long-term anatomical result was partial degeneration of the human jaw. Garrett Hardin notes that all exosomatic adaptations bring about "a corresponding degeneration in the endosomatic function," i.e., knives change the function of teeth. The species is then more vulnerable to accidents, since external adaptations, like pacemakers or artificial kidneys, become required for the health and maintenance of civilization. Perhaps writing has changed the function of human memory. Perhaps computers will change the structure of thought and consciousness.

7.3.5.4. A Question of Consciousness

The institutions of slavery raise questions about our relations to each other and to nature. What is our human relation to reality—slave, master, participant, or partner? Cosmology describes the place of a culture in reality. Cultures can determine inappropriate attitudes towards nature and that can result in ruin for the air and land. The worldviews of many people defined other people as nonhumans, who could therefore be improved by being allowed to work for true humans.

Although slavery is officially condemned in virtually every nation, the inappropriate use of people, animals, machines and energy continues, as a necessary part of the agricultural and industrial economies. And, it will continue to be until there is a shift in consciousness that would let us consider the ethical implications of our uses of everything and everyone, especially how these uses perpetuate patterns of domination and inequity, as well as contribute to the degradation of ecosystems and geocycles.

The ideas of dominance and slavery have been integrated into many kinds of designs, from the design of housing and chains to clothing, roads and auditoriums. Changing some of the traditional designs may reduce feelings of inequity and perhaps the actual inequity.

Religion could help control disruptive forces, especially those that result from distribution and power. Religion coerces people into a social contract. Religion and storytelling reduce the variability of individuals wants in a group. The introduction of new stories and myths, concerned with partnership and equality and with the value of other places, species and people, could change our attitudes about them into a healthier context.

7.4. *Global Design Factors: Economic Patterns & Koinomics*

The formal study of how people use their surroundings is economics (from the Greek words meaning 'law of the house'—house is used as a metaphor for human society and for nature). The word has come to mean the management of resources to supply human needs. It is basically concerned with sharing resources to meet physical needs of a people.

Although economics is a social science that studies human behavior, it considers itself a positive science. As a social science, economics addresses human problems. The acknowledged fundamental problem of economics is a contradiction between scarce resources and unlimited human wants. The kinds of resources and the possibilities of using them in production are considered in the scope of economics, as are flows and stocks in homes and businesses, the role of the government, business cycles, monetary details and policy, stabilization and growth, international trade, consumer behavior, production costs, pricing, and resource markets.

Natural economies are based on solar energy and plant productivity, as well as geological heat and energy. Ambihuman systems (those surrounding the human) operate under natural limitations; they are empirical assemblages whose properties have been shaped by chance, filtering, and preservation over millions of years. They stress adaptation to the environment and the survival of a breeding society. Human economies, although basically dependent on the same energy and production, reverse the priorities. The concern is for individual survival by modifying the environment.

Modern market economics recognizes two other kinds of economies: Traditional and Command economies. Traditional (subsistence) economies have been dismissed as providing only a slim margin between life and death. Subsistence economics means simply that surpluses are not accumulated. This might make them more vulnerable to food shortages, although the low ratio reduces the possibility. Command economies have been dismissed as failures, after being ruined by military competition and several shortcomings. Command economies plan for the use of resources according to their population and values. These economies inventoried their resources and planned production accordingly.

There have been many economic variations over the past 40,000 years. Economic systems can be characterized by reciprocity, distribution, and redistribution. Variants of the last system have included tribute economies, command, and free-market, all of which are forms of redistribution.

7.4.1. *Functions of the Modern Model: Abstraction & Accumulation*

The metaphor for the economy used to be a simple mechanical model for turning resources into products. To be successful, the economy had to grow and turn a profit continually. Unfortunately, the myths and assumptions of the model were also simple and failed to consider human needs and natural cycles, causing great suffering and great disruption. The old analogy of the economy as a machine leads to bad assumptions: That everything is a resource; That resources are unlimited; That production must continue endlessly; That the economy has to keep growing to survive; That the purpose of the state was to legitimize exploitation; That the purpose of humanity was to multiply, produce, and consume; and That the purpose of the universe was to supply human needs.

The bad assumptions of the machine analogy lead to false economic beliefs: That mass production is most efficient; That obsolescence is necessary for successful growth; That people's needs and wants are fulfilled by advertised products; and, That quality does not matter very much. These bad assumptions and false beliefs lead to colossal problems in the economy as a whole: Overgrowth, with an increase in complexity and costs (many of them social); Economic and ecological instability; Social burdens (from pressures on families from relocation and powerlessness); Misdirected effort on ill-conceived, low-quality products; and, Slack consumer attitudes and employee performances.

Economics has not been unsuccessful with its models, for instance of buying behavior, but it has become a highly abstract academic discipline. All its abstractions are applied to the real world without acknowledgment of the high degree of abstraction involved. The philosopher A. N. Whitehead warned that the economic method would triumph if the abstractions were judicious, but even judicious abstractions had limits, and the neglect of those limits lead to disastrous oversights. Considering a fictitious human nature under imaginary circumstances and thinking it is real is the fallacy of "misplaced concreteness" according to Whitehead. Daly and Cobb suggest that the classic instance of the fallacy in economics is "money fetishism," where the characteristics of an abstract symbol, such as limitless growth, are applied to real commodities and values.

As an aside, Daly and Cobb point out that modern economics might better be called chrematistics, after the distinction made by Aristotle between chrematistics and economics; the former related to the manipulation of property and wealth to maximize the short-term abstract money value to the owner, whereas economics was the management of the household (community) to increase the concrete value for everyone in the community over the long-term.

Business as usual, with its inertial model of growth, could end in catastrophe for humanity and its environments. Industrial cultures, with their characteristics of simplification, naiveté, homogeneity, and incompleteness, turn wild landscapes into flatscapes, where variety disappears and significance is ignored for the comfortable standards of meaningless continuity. Rapid growth might precipitate a catastrophe sooner, while modest efforts at environmental protection and increased efficiency may only postpone catastrophe for a few years.

7.4.2. *A New Planetary Model Based on Holeconomics & Ecological Economics*

John Stuart Mill wrote that beyond the progressive state lies the stationary state; each advance is to approach it. A stationary economy is not synonymous with a stagnant economy; there is always room for developing and increasing the scope of economic culture. It could be highly sophisticated, dynamic, and imaginative. Mill said: "It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. There would be as much scope as ever for all kinds of mental culture and moral and social progress; as much room for improving the art of living and more likelihood of its being improved." Mill's vision of a stable state was a response to the goal of industrial society. Technological progress would abridge labor, not necessarily increase production. In a state of equity, persons would have room for solitude and leisure development. But Mill's idea was anthropocentric—"man" was not bound to protect nature.

7.4.2.1. Holeconomics (Steady State Economics)

Herman Daly concludes that the steady state economy is both necessary and desirable. He notes that in the definition of economics, as the study of the allocation of scarce means among competing ends, the entire ends-means spectrum is not considered. Only intermediate ends or means are considered, not ultimate ones. He anchors the ultimate means in physics and ultimate ends in religion. Economics falsely concludes that the middle ranges represent the entire spectrum. In another computer model, Laszlo's scenario calls for an across board reduction in population, in investment and resource usage, to create a steady state with the present disparities maintained.

Some theorists, like Samuelson, have concluded that growth is necessary to rid the economy of disparities. But, development instead of growth would equalize wealth more efficiently—after all, economies have been growing for at least 400 years and the disparities have *increased*. There is no necessary association between development and growth, as Daly and others have shown. Development means the introduction of an innovation. Economic development will require technology. Ecologically sound technologies will minimize stress to the environment. Economies could be modeled after climax vegetation and not successional vegetation, where diversity in scale is greater. A community is forced to accept an upper limit, beyond which it cannot grow any further. Further growth results in destruction or disruption of itself and nature. This is the law of the maximum. Production could be stabilized in a steady state economy, a mature economy, like a climax system, where processes and cycles are constant. A steady state economy must be based on natural laws and ethical principles. Natural laws include thermodynamics and ecological theories. Rules of economics, laws of nature, and ethical principles must be related.

There is another distinction between growth and development. The ecological social approach (or a redistributive environmental strategy) to development makes it irrelevant to discuss global limits to growth. Local limits are far more significant to the majority of the population. Regardless of how much food exists, people will starve unless they can get it. Redistribution of resources and improvement of environmental quality (home environment) are more important than increased production by sophisticated technology. The natural capacity of regional photosynthesis must be limiting factor in development, especially in tropical and subtropical areas.

Development calls for social and educational organization more than technological style. Styles of technology must be determined by culture and context. Such development requires a local authority working with suitable economic and ecological conditions. No authority can be effective without the participation of the populace. To stop growth, a strict regulation of the productive system is needed. States should be able to control which products are made, and with which technology. Practical implications of the steady state are that nonrenewable resources will be conserved as much as possible, by recycling, while erosion, depletion and pollution are minimized; energy sources may be greatly decentralized and diverse. Using a field concept for development emphasizes the dynamic transformation of the domain, rather than its structure as an individual. Selective advantage or cost benefit become adjectives or afterthoughts to the domain.

Jane Jacobs, in *The Nature of Economies*, argued that the same principles underlie both ecosystems and economies: "development and co-development through differentiations and their combinations; expansion through diverse, multiple uses of energy; and self-maintenance through self-refueling." *The Nature of Economies*, also in Platonic dialogue form, is based on the premise that "human beings exist wholly within nature as part of the natural order in every respect." Jacobs' characters then discuss the four methods by which "dynamically stable systems" may evade collapse: Bifurcations; positive-feedback loops; negative-feedback controls; and emergency adaptations. Their conversations also cover the "double nature of fitness for survival," traits to avoid destroying one's own habitat as well as success in competition to feed and breed, and unpredictability including the butterfly effect characterized in terms of multiplicity of variables as well as disproportionately of response to cause, and self-organization where "a system can be making itself up as it goes along."

7.4.2.1.1. Holeconomic Wealth

Economists try to bronze the economy in its current structure, but it is a changing system. Since it is changing, strategies that are appropriate at one stage are totally inappropriate at another. This is the remorseless working of tragedy. Any lasting economy must have a dynamic approach. Wealth must be renewable.

Buckminster Fuller's definition of wealth is that it consists of physical energy combined with metaphysical know-how or know-what. In terms of solar energy, real wealth, all humans are potentially rich. This type of wealth should be based on what is valued most: Happiness, clean air and water, good food, technological devices, art, or goods like transport, apartments, and clothes.

Rich sensory experiences can be derived from direct contact with nature. But economists and planners rarely mention these values. Light, wind, dirt, plants, birds, all act during a walk, but not with the meaning of crops or dogs, which is for their utility—they just are. People do not live without these things. These values are based on a healthy ecology. It must be kept healthy; arable land and mineral exploitation must be limited.

There are two roads to wealth: producing a bigger pie (supply) or reducing each portion (demand). This assumes that wealth is defined as supply divided as demand. If supply is limited then wealth can still be increased two ways: Reduce expectations of individuals or reduce number of individuals. Supply may be mostly material things, but not status, for instance; demand has the more psychological dimension. Therefore, wealth will always have a psychological dimension. Bateson thought that economics may be founded on a fallacy. Economists cannot account for intransitive preference: Where 'a' is preferable to 'b,' 'b' to 'c,' but 'c' is preferable to 'a'—as in money being preferable to resources and resources being preferable to wilderness, but wilderness is preferable to money. Preference curves in economics should not intersect.

Values are based on knowledge, which is measured partly in terms of information. And information can be considered a source of wealth. Some business economies are based entirely on providing information. Information is apparently boundless. Yet it can be manipulated. It is information that defines the use of resources by people. For example, hydrogen is worthless unless technologies exist to transmute it to helium and manage the released energy. What is not limited is our use of information. A sophisticated technology needs fewer resources. The natural productivity of ecosystems is less important if food can be grown intensively in tanks using solar energy.

Real wealth has to be attentive to the flows and the capital stock of wealth. Meadows suggest the capital stock could be maintained with the lowest possible throughput. That would require redoing the economy and its technologies and making them more efficient. The trap is seeking the wrong goal. The way out of the trap is identifying goals that reflect the real wealth, then focusing on result not effort.

7.4.2.1.2. Limits of Wealth

Both ecology and economics attempt to understand and predict the behavior of complex, interconnected systems where individual behavior and flows of energy and material are important. There are many other common or similar processes: Resource allocation, optimal behavior, and adaptation. For each ecosystem, and at each level of technology and kind of social structure, there is an optimum size of population that offers a high quality standard of living. The optimum in this sense is a working one based on our knowledge of all of the factors—and we cannot know everything. No one has complete information about the current environment or the results of their actions. Complete knowledge is not necessary, however—only the knowledge of laws of the minimum. For humans, trade can ease the law, but not repeal it. Rachel Carson demonstrated that we lived in a world of limits.

Resources may not be absolutely limited, in the sense that history shows that advances in technology can expand the availability of resources; less is needed to produce more. But, the same history also shows that humans reproduce up to the new limit of misery allowed by the new technology. New advances are used to increase the size of humanity, not its happiness or wealth. Society is growing at the same time as needs are growing, resulting in lessening of natural systems.

The redefinition of wealth in an ecological framework would tie it to limits, which might increase human enrichment and natural preservation. Diversity is a form of wealth. Differences do not necessarily cause conflicts because each can fill the needs of others. Since nature is a non-zero-sum game, many groups can gain at the same time.

7.4.2.1.3. Poverty of Humanity & the Earth

In general, poverty is a lack of things that others have, especially necessary things. There are different forms of poverty. For instance, one form is the lack of needs, such as food and things or money. Another is the lack of use of natural or public services that would provide food and shelter. On the other hand, what is the use-value of feet in Los Angeles? The lack of potential is harder to define, but it means that people who suffer that poverty cannot improve him or herself, or change, or develop. Finally, the lack of luxuries has become a form of poverty. The idea of affluence in a global village creates a new modern kind of poverty, the potential poverty of not having what is possible somewhere in New York or Paris. Modernizing needs creates a new dimension of poverty. This adds a new discrimination by a violent cargo cult that seizes traditional cultures.

Industrial society is constantly mobilized for emergencies with, in the battles against, noneducation, poverty, diseases, and terrorism. Industrial development has never been nonviolent or respectful to people or nature. Some human poverties are poverties of the local ecosystems. Loss of entitlement to a natural resource base needed for foraging or agriculture is a political poverty. Interference with or destruction of the processes of ecological balance and renewal, the loss of diversity, the loss of capacity for the renewal of ecological systems, are ecological poverties.

7.4.2.1.4. Holeconomic Goals

What are our economic goals? Market leadership or development for all of humanity? Subsidizing corporations does not seem to be a good way to achieve the latter, especially when corporate profit grows even when standards of living drop. Regarding consumption levels, how much is enough? When does consumption stop adding to satisfaction? How necessary are Chilean grapes or New Zealand kiwi to healthy consumption in another nation? By matching consumption to ecological limits, the way is open for more psychological measures of wealth.

An economics based on ecological understanding would have many different assumptions. For instance, the capital of an ecosystem would be its physical environment and its gross primary productivity; interest would be the net ecosystem productivity. The production percentage would be the amount necessary to keep the ecosystem healthy. Cultural capital would be the wealth of human knowledge about environments, and cultural interest would be experimentation.

7.4.2.1.4.1. Expanding Capital

Traditional economics has a three-capital model of human wealth: Land, labor, and manufactures. Clearly, this is not adequate; each kind of capital should be expanded. Land is the entire ecological system, complete with other species and biogeochemical cycles, preserves, as well as agricultural areas, resources, and artificial modifications like dams. Labor depends on the traditional capital of a culture, the beliefs and myths and rules for behaving, the institutions. Manufactures depend on culture, and land (resources), and on technology.

Modern economies, embracing the metaphor “nature is capital,” draw on the accumulated “capital” of ecosystems for production. By ignoring the real cost of the capital, as well as the costs of natural services, such as nutrient recycling, soil building, and atmospheric renewal, these economics create a temporary wealth. Decisions regarding resources are made on short-term economic grounds and lead to material shortages and environmental degradation.

Economics must internalize all costs for product cycles, from agriculture to manufacturing. This means finding the real costs first, starting with environmental degradation, lost employment, increased health care, tax credits, defense. The real costs of energy usually far exceed what users directly pay, for nuclear, coal, oil, or gas. When workman’s compensation premiums are paid at a rate determined by a company’s accident experience, then the cost of an unsafe operation is already a recognized direct cost of doing business. These external costs can be internalized directly with taxes, especially one on carbon-containing fuels. Another possible tax could be an anticipatory tax for degradation. This would encourage more efficient use of sources and development of more cost-effective technologies. For agriculture, this means reducing waste and pollution, and emphasizing diversity and disease-resistance instead of gross yield.

7.4.3.1.4.2. Diversifying Institutions

The simplest economic transactions occurred between individuals who gathered food or made tools and then traded with other individuals. With the increase in specialization and complexity, came individual traders, then guilds, and finally corporations. Corporations were formed with the historical promise of providing social services to the national states that chartered them. In the name of secure trade they often explored territories and guarded resources with private armies. Unfortunately, as private good became identified with public good, corporations became less concerned with social service and more concerned with greater profit through greater technology.

As legal entities, corporations have formal expectations that have become imperatives: Profit, for instance. According to Milton Friedman, the only social responsibility of a corporation is to make money, by striving after profit as an efficient agent of production—although Friedman admits that the corporation should conform to the rules and norms of society. Other imperatives, equally important if less touted, are constant growth, aggressive competition, objective or amoral decision-making, efficient exploitation of resources, and the quantification of values. Unfortunately, as an entity with limited responsibilities, these imperatives tend to dehumanize workers and consumers, homogenize people and cultures as markets, foster no commitment to place, and interfere in natural processes. Corporate forms, with their characteristics of simplification, naiveté, homogeneity, and incompleteness, turn wild landscapes into flatscapes, where variety disappears and significance is ignored for the comfortable standards of meaningless continuity.

Corporations, as economic institutions, do have many responsibilities: Ecological, social, community, political, and individual. The first responsibility is to discharge its specific function. Then, it has a responsibility for its impacts; this is one of the oldest principles of law. The institution has a duty, and self-interest, to discharge its function with a minimum of negative impacts. Profit making is a necessary part of business, but not the sole reason for business. The best business serves public goods as well as private interests. Environmental and social problems should get as much attention as profitability, because they are as much a part of the process as sales, finance, and production.

Corporate law holds that management must act in the economic interests of shareholders. Communities could change that law to start to control corporations. The corporation is a noncorporeal entity. But because it is a fictitious person, speech in the form of advertising is protected under the First Amendment. So, corporate speech has little in the way of regulation. Therefore, it may be necessary to regulate corporate speech under a new amendment. Corporations sponsor wonderful shows on nature as a resource, and we become attuned to corporate interpretations and objectives. We need to be more attentive to their real objectives.

We need different kinds of regulations for corporations, ones that limit destructive activities to environment and workers, ones that encourage responsibility to nature and community. This may require changes in economic organization and legal institutionalization. Corporations should be anchored in the community. Although they must not act beyond their competence, a larger community responsibility is merely expanded self-interest. They need to build concern and responsibility for the common good into their vision, values, and behavior. Common good does not necessarily emerge automatically from conflicting interests.

The corporation is defined as a collective citizen—we need to enforce the duties of one. How to make the corporation accountable to the community? The problems of corporations are structural, inherent in the forms and rules by which the entities operate. Corporations increase their power because of our failure to grasp their nature. We could restructure the market to favor long-term investment over speculative profit. To give back to the community, we could require a percentage of new stock offerings go to government for the public. The state grants the charter to a corporation; the state could revoke the charter to protect the interests of the state (as citizens). Corporations have many human rights but few human responsibilities. Even when their actions cause death, the corporation cannot be jailed or executed. Perhaps we should change that law also and be willing to disband it.

7.4.2.1.4.3. Emphasizing Development of Wealth Over Growth

Economics has always been concerned with measuring wealth. Wealth once meant tangible things, land, ships, houses; then labor and production; and now it has come to mean negotiable symbols such as cash and stocks or unlimited information. Yet, no single description is adequate. Economics tends to devalue many things. Our economy is crippled by the unspoken principle of immediate interest maximization. We allow economics to discount the future value of benefits. That also means that our children's and grandchildren's lives are worth less than ours; are they? A common strategy in Rome was to defer the true costs of government by debasing the currency. The cost is shifted to the indefinite future. We have been doing the same, but the future is becoming more definite faster.

It is said we are in an information age, that information is the ultimate resource, that land and resources are less. But information without form is nothing (in-ation?). Information only lets us use resources and land more efficiently. The basis of wealth for a long-time will be land. Even more so because we do not know its complete value, as many native peoples have found out when coal or pharmaceutical plants were discovered on their lands—as a source of information.

The narrow definition of wealth means that it can be increased only by producing a bigger supply of goods or reducing the demand for goods. This assumes that wealth is defined as supply divided as demand. Supply may be mostly material things—but not status, for instance—while demand has the more psychological dimension. Therefore, wealth will always have a psychological dimension. This dimension is not limited by strict logic. Wealth can therefore be expanded without being limited to supply or demand for materials.

Economics is distorted when reduced to quantity and technique; there is always a psychological and ethical dimension to be accounted for—motives, values, needs, and aspirations. Economics needs to be restructured to take this consciousness into account. The assessment of personal or cultural wealth, for instance, is mostly psychological; wealth may be measured by how many valuables one has, which may be physical, like feathers or salmon or gold or land, or by how by much status, which may be behavioral, as enjoying deference or a good reputation.

Pitirim Sorokin indicated that the wealth of an area was a function of its physical attributes and its culture. In fact, the attributes are only possibilities until appropriate cultural perceptions and technologies exist. The redefinition of wealth in an ecological framework would increase human enrichment and natural preservation.

Ecological and economic processes and values are often the same. Benefits can be assessed in a common metric. The GNP is an inadequate way to measure well being. It measures only increases in spending. The International Standard of Economic Welfare (ISEW), developed by Herman Daly and J.B. Cobb Jr., expands consideration to literacy and longevity as well. More is needed, however, to measure wealth and happiness in addition to general welfare. The measure needs to be expanded to include more of the human growth needs recognized by the psychologist Abraham Maslow. It also needs to recognize an expanded definition of the self, to include the ultrahuman beings who support us.

We make trade-offs in social systems without assigning dollar values. We could do that with ecosystems. The valuation could be scientific or be based on human labor. New values of natural resources, such as option value, are being recognized now by economists. Option value reserves a resource for future use or for existence value (paying for something to exist that will not be used). One thing business can do is put a price on nature. But, let us make it a real price, reflecting the real cost of replacement. Let us base some costs, such as oil, on human labor and technology. Let us make all those prices high, too high rather than too low.

Nothing is value-free—not technology, not education, not economics. We just do not always see the values. Values are time dependent; ecological time is much longer than social time. Our social values depend on ecological values.

The goal of economics should be mature development, not growth. Growth has been a substitute for equality; in that sense it has been necessary to forestall revolt. There is no necessary association between development and growth. Development means the introduction of an innovation. Economic development will still require technology. Ecologically sound technologies could minimize stress to the environment.

7.4.2.1.4.4. Accommodating Limits

The transition to a sustainable state does not mean returning to an all-natural, that is nonhuman, condition for ecosystems. Human activities have always had some impact, as do the activities of all species, on ecosystems. Sustainable development requires recognition of the large number of limits. The popular definition of sustainable development is inadequate; the Bruntland Commission defines it as "meeting the needs of the present while not compromising the ability of the future to meet its own needs." But, as Herman Daly has pointed out, this definition is contradictory in practice; it really means "expanding the needs of a growing population without inflation." Daly offers 3 rules of sustainability to make the concept consistent and meaningful: (1) harvest renewable resources only below or at the rate of regeneration, (2) limit wastes to the assimilative capacity of the local ecosystem, and (3) require part of every profit for investment in renewable resources.

The ecological approach to development makes it irrelevant to discuss global limits to growth. Local limits are far more significant to a majority of people. Regardless of how much food exists, people will starve unless they can get it, as is happening so often, now. Every community is forced to accept some upper limit, beyond which it cannot grow any further. Further growth results in destruction or disruption of the community and the natural communities on which it depends.

Complex societies depend on production of resources. Increased complexity requires more information processing and more integration of disparate parts. The costs of communication increase. Complex societies need control and specialization. Yet, investment in complexity yields declining marginal returns because of the increasing size of bureaucracies, increasing taxation, costs of internal control.

At some point society is investing heavily in a course that is less and less productive; increased costs just maintain status quo. In a mature ecosystem, a larger percentage of energy is used for maintenance of the system, until net community production approaches zero. The system also becomes more efficient, supporting a larger biomass with the same amount of energy in weblike food chains. If society were to parallel this development it would probably be very stable. Societies can fail (and disappear) when they become inefficient and spend more energy than exists in the system flow to maintain the system.

The theory of complexity shows that complex systems do not allow predictions; they are influenced by factors that are not statistically significant. Yet, the climate is roughly predictable and stable, where the weather is unstable and unpredictable. The best policy is one that balances long-term productivity and competitiveness with short-term benefits.

The economy is not an automatic mechanism for good. We cannot predict which transactions will have good effects. We have to understand it and direct it. We expected faithfully that the market would promote the general welfare. But, people work to maximize their own good, as Hardin has pointed out, and self-interest makes it difficult for us to acknowledge our dependence on nature and on others. Economics started as a branch of moral philosophy. In a large sense, morality is a set of rules for living together, and economics is still a branch of moral philosophy.

7.4.2.2. Ecological Economics

Business as usual, with its inertial model of growth, could end in catastrophe for humanity and its environments. Industrial cultures, with their characteristics of simplification, naiveté, homogeneity, and incompleteness, turn wild landscapes into flatscapes, where variety disappears and significance is ignored for the comfortable standards of meaningless continuity. Rapid economic growth might precipitate a catastrophe sooner, while modest efforts at environmental protection and increased efficiency may only postpone catastrophe a few years. An ecological economics could provide another order for the long-term.

7.4.2.2.1. Ecological Integration

Human beings, and especially economists, focus their consciousness on the visible parts of the world, and forget the invisible that makes everything possible. Theodore Roszak suggests that the necessary invisible background must be described. He characterized economists as urban intellectuals automatically endorsing growth with ecological stupidity. He called for a nobler economics, one that is not afraid to discuss spirit, conscience, moral purpose, and the meaning of life. Schumacher and Roszak have grasped that economics is a subdiscipline of ecology. Other economists are K. Boulding, N. Georgescu-Rogen, and M. Friedman.

Ecology and economics must be integrated. The goal of economics cannot be growth. It must be tailored to the ecosystem; its central tenets must be consistent with ecological principles. An ecological economy is survival-oriented, not profit-oriented.

Economic and ecologic systems interact. Economics must recognize that ecological health is vital to its own continuation; it cannot make large mistakes. The concepts of economic value must be redefined. Resource use is an ethical question. It is not known how species and communities are regulated—by environment or internal interaction. A free market has to be limited by conservative calculations of ecological balance.

Because human and natural systems are interlocked, there must be a common framework for ecology and economics. Economic decisions are based on human reference and not nature. Human reference is not large enough. Economics is the study of budgets, material and energetic. Modern economy is a rheology, a study of things. Human economics grows from positive feedback due to feeding on the wealth of the past; it will have to reverse its charge sometime. Most local human development was achieved at expense of other people, descendants, or from other species. Ecology is the study of natural budgets, material and energetic. Ecological and economic processes and values are often the same. Benefits can be assessed in a common metric.

Environmental quality cannot be treated as a scarce economic good. Daly maintained that the final benefit of economic activity is service or psychic income; it is yielded by stocks of capital maintained by material flow. The capacity of nature is limited, that is, scarce, but it is also irreplaceable and essential to life. The modern price mechanism ignores the possibility that something may disappear; it assumes substitutability.

Both ecology and economics attempt to understand and predict the behavior of complex, interconnected systems where individual behavior and flows of energy and material are important. There are many other common or similar processes: resource allocation, optimal behavior, adaptation, and energy flow. How do species and associations persist in evolutionary time under environmental stress and change? Perhaps some economic systems are long-term resilient and stable like ecological systems. No one has complete information about current environment or results of actions.

7.4.2.2.2. The Ecological Framework

The ecological provides the appropriate framework for economics, as exchanges are based in natural ecosystems. A new paradigm of economics is based on new ideas, analogies, and metaphors. This is the ecological paradigm, where: Real ecological limits exist and must be respected (what Rachel Carson showed so well); all beings have value for themselves; people live in a mixed community of beings; people have similar basic needs and wants; intelligent development can supply these needs and some wants; and, small-scale, quality processes can be developed efficiently.

The new ecological economics is based on an orderly view of the world, a cosmology. Ecology and economics must be integrated. The goal of economics cannot be growth. It must be tailored to the ecosystem; its central tenets must be consistent with ecological principles. An ecological economy is survival-oriented, not profit-oriented.

Because human and natural systems are interlocked, there must be a common framework for ecology and economics. Current economic decisions are based on human reference and not nature. Human reference is not large enough. Economics is the study of budgets, material and energetic. Ecology is the study of natural budgets, material and energetic. Ecological and economic processes and values are often the same. Benefits can be assessed in a common metric. Both ecology and economics attempt to understand and predict the behavior of complex, interconnected systems where individual behavior and flows of energy and material are important. There are many other common or similar processes: Resource allocation, optimal behavior, adaptation, and energy flow.

Economic and ecological systems interact. Economics must recognize that ecological health is vital to its own continuation; it cannot make large mistakes. The concepts of economic value must be redefined. Resource use is an ethical question. It is not known how species and communities are regulated, or if by environment or internal interaction. A free market has to be limited by conservative calculations of ecological balance.

A new theory is needed to relate economy to ecology. That theory must include externalities in consideration. And it must include intangible cultural values. It would be better to expand the circle of economic categories to include more factors that affect the economy, than to simply switch to supply side from demand. Traditional supply/demand theory uses current supply and demand of energy to determine current prices, ignoring renewability and long-term availability.

Theodore Roszak realized that human beings, and especially economists, focus their consciousness on the visible parts of the world, and forget the invisible that makes everything possible. The necessary invisible background must be described. He characterized economists as urban intellectuals automatically endorsing growth with ecological stupidity. He called for a nobler economics, one that is not afraid to discuss spirit, conscience, moral purpose, and the meaning of life. Roszak, Schumacher, Boulding, Daly, and others have grasped that economics is a subdiscipline of ecology.

Environmental quality cannot be treated as a scarce economic good. Daly maintained that the final benefit of economic activity is service or psychic income; it is yielded by stocks of capital maintained by material flow. The capacity of nature is limited, that is, scarce, but it is also renewable, as well as irreplaceable and essential to life. The price mechanism ignores the possibility that something may disappear; it assumes substitutability, that is, one form of capital can be substituted for another, and this leads to the disregard for any other form.

7.4.2.2.3. Ecological Economic Wealth

Values are based on knowledge, which is measured partly in terms of information. And information can be considered a source of wealth. Some business economies are based entirely on providing information. Information is apparently boundless. Yet, it can be manipulated. It is information that defines the use of resources by people. For example, hydrogen is worthless unless technologies exist to transmute it to helium and manage the released energy. What is not limited is our use of information. A sophisticated technology needs fewer resources. Ecosystem productivity becomes less important if food can be grown in tanks using solar energy.

Economic value is a function of our state of knowledge; penicillium was just mold before Fleming amplified antibiotics from it; wheat was a natural grass before being hybridized with a weed, goat grass. We should preserve much of nature for its undiscovered wealth. The technocratic vision treats all interests as human interests; but even so, this cannot be used to reduce all to instrumental value. Not all human values can be quantified and assigned common dollar values. Even if human values have objective meaning, not all of them will have dollar values; therefore not all natural processes can have dollar values, but all have some kind of values. R.F. Dasmann notes that birds or dolphins have values to observers that do not fit any yardstick. Ecological economic wealth is based on the flows and capital from the evolved operations of the planet.

7.4.2.2.3.1. Information and Resources

Any economy must consider the needs of its members, as well as the limitations of its resources. Surprisingly, political and psychological factors have been and may always be more important restraints on food supply than physical limitations. Deprived peoples have difficulty striving for better crops and supplies; planners have difficulty envisioning an agricultural system operating on ecological principles in specific areas.

The problem of food mirrors lesser problems. There are shortages of land and energy; there is overpopulation; there is degradation of land and people. Any solution must address the whole complex. At least half the population of the earth is suffering from malnutrition, according to Borgstrom. Although some shortages are caused by transportation and logistical difficulties, food production is still falling behind population growth. Food is the first of one of three types of resources: Fastly accruable (i.e., renewable); slowly accruable (basically nonrenewable); or, very slowly dispersed (really nonrenewable).

Most of the wealth used by modern economies is nonrenewable. These resources are limited, interrelated and distributed unevenly. Forests are a special problem; although trees can grow to a good size in 30-40 years, forest ecosystems may take 300-600 years to develop and then last for thousands of years. Oil, coal, peat, and some woods are functionally nonrenewable. Geological time periods are required to produce them. Mineral reserves may be understated by a factor of 5 (*Limits to Growth*) or 1,000,000 (Hudson Institute). But they may be located so far and so deep that it would cost more energy to extract them and move them than they are worth, unless we used a "renewable" energy source—the sun.

Slow accrual and slow dispersal resources should be equally available to all cultures. It is impossible to sustain any quantitative arguments about resources and population pressure on them without a comprehensive overview. Demands on food, fertilizer, energy, and metals are related inseparably. Organic and inorganic assets need to be assessed together. Population carrying capacity cannot be formulated until both resources have been quantified.

We depend on vegetation for far more than food—for newsprint, construction, furniture, clothing, and packaging. Furthermore, with shortages of minerals, many substitutes are expected to be organic. The measurement of total production of vegetation is difficult and complex. Wild plant communities, that could form experimental controls, have been altered over thousands of years. Original wild communities were efficient and flexible.

The International Biological Programme embarked on a large number of projects to assess the biological productivity of all the main types of terrestrial ecosystems. Efforts based on these materials have been made to compute the actual net primary productivity (NPP) of land vegetation at the present.

7.4.2.2.3.2. The Real Wealth of Nations

Samuel Eyre based his own calculations on these and other criteria to calculate the Net Primary Productivity (NPP) of the original wild vegetation of the planet. Eyre, in his book *The Real Wealth of Nations*, calculated the NPP for wild areas of the earth and for wild and domesticated areas of individual nations. National boundaries have different potentials. Australia, Zaire, Canada, and Brazil have the highest potentials. Among the most poorly endowed are the heavily populated European, Eastern Asian and West Indian countries and the dry Middle East and Southwest Asia.

Eyre then calculated the terrestrial production per capita: At the world population of 4 billion, and an above ground NPP of 50 billion tons, we get 13 tons per head. Currently the average person in the United States eats equivalent of one dry-weight ton per year, including waste and meat production. In addition, over half a ton of timber per person is consumed in paper and packages. He considered that an average of 10 metric tons per capita potential NPP was necessary for self-sufficiency (approaching the limits of the planet).

Eyre also devised a common denominator to consider organic and inorganic assets together. Population carrying capacity can be formulated only using both. He assigned a nutrition equivalent unit weights of metal, but this calculation depended on a dollar value for food and minerals.

The advantages of primary production as wealth are that the wealth is sustainable, plants are renewable, and minerals can be recycled. The disadvantages are that the net community production (NCP) is not considered, which takes all of the food chain into account, dollars are used instead of fair human work units and the technological production costs of food are not considered. Many countries, such as Surinam, with very high NPP figures, have low NCP figures, and therefore low potential for development.

Until human labor is equalized across cultures, dollar value only reflects the unfairness and inequality of the past—this is not to say that unskilled work is the same as skilled work, but that people performing similar kinds of work should expect equal rewards. Many external costs, such as those by forests for cleaning and holding water, never enter the calculations of modern economics.

The original vegetation cover of the planet was extremely diverse. The potential natural productivity of wild vegetation is 120 billion tons of dry organic matter per year. But not all is available for human exploitation. The proportion of NPP above ground would only be 80 billion tons. These are all rough approximations. This is the theoretical amount that would be produced by wild vegetation with no major environmental changes.

Much of this is not usable by humans. For example, in the production of forests, 65% of above ground production is not used by most lumbering operations. Possibly, over all ecosystems, the representative average of unusable material is only 50%. Taking most of the material is not desirable anyway because mineral nutrients are locked up in plants. Complete extraction of plants would result in removal of from one to two thirds of potassium in the whole ecosystem. Although there is plenty locked in rock particles, this is released very slowly.

But the land has been "improved" to pastures and crops. Some crop productivity, usually at experimental stations, is capable of producing high NPP, in total dry weights. The most productive of crops can approach the NPP of the original cover, but average crops produce less than half of the natural cover. The highest figure was achieved in Japan, where substantial dressings of fertilizer were applied. In countries where no fertilizer is applied, the annual productivity is unlikely to be more than one quarter of the native vegetation.

In tropical climates, the NPP does not appear to increase in proportion to increased sunlight. The tropical plant also uses up far more energy for its own metabolism. The hotter the environment, the higher the metabolic rate; so temperate zones produce higher yields than tropical. Although tropical ecosystems offer less potential for high levels of secondary production, microorganisms (autotrophic and decomposing) and invertebrates could be potential converters to quality animal food.

In a world no longer regarded as unlimited, it is important to know the annual production of organic material. The potential food producing capacity of the earth is represented by conflicting views. Many ecologists fear that agricultural activities have strained the earth's productive capacity, while supporters of the Green Revolution regard food shortages as simple organizational problems. These extremes cannot be adjudicated until there is some idea of the productive capacity of lands under their original wild vegetation and of the amount of material produced in cultivated replacements.

In *Productivity of the World's Ecosystems*, Rodin, Bazilevich and Rozov estimate the phytomass of land at 2.4 x 10^{12} metric tons of dry weight—*82% of this is concentrated in forests*. Since those figures refer only to a standing weight, it is important to know the rate of production. The total primary production of land is 1.72 x 10^{11} metric tons per year. Forests produce over 49% of that.

Eyre estimates that the total annual terrestrial NNP has been reduced by 38.5 billion tons since the advent of agriculture. The complete removal of all forests, converted to cultivation and pasture, would lower the NPP to 27.6 billion tons, assuming all savannas, prairies and scrublands remained unaltered.

The basis of all wealth at this stage has to be the operation of the planet. The planet hosts the life forms that create the various kinds of productivities. The planet provides the cycles that keep necessary nutrients and elements available. And, the planet has produced the human abilities to generate new forms of wealth from ideas and inventions. The protection of all these forms of wealth requires common rules of conduct on the global stage.

This wealth should be managed by koinomics, the equal apportionment of 'resources' to all living, interacting participants in the global or local commons. This involves recognizing the entire legacy of the planet as it is created, developed and maintained by its tenants, and allowing reasonable access by nonhuman beings for their needs, since we ultimately depends on their 'services.' For human beings, it means limiting our interference with living webs and biogeochemical cycles.

7.4.3. *Global Economics*

Humans have been trading items for over 40,000 years, starting with ochre, stone, copper, furs, and continuing with gold, tea, or people, by foot, camel caravans, or sailing ships. Then, with steam-driven ships taking intercontinental trade, grains and meats from many countries, such as Argentina, Canada, and the US. Then oil. Then shirts and manufacturing, electronics and computers. Because of the advantages of specialization, many nations do that. This creates larger webs of interdependence, which is a crucial characteristic of globalization. It is not the same as trade between self-sufficient nations. Perhaps this can level dominance so that nations come to resemble species in an ecosystem.

Globalization is a supranational trend that has been emerging for the past 500 years, as a result of human explorations of the planet. As a result of differential trade and wealth, however, the range of wealth has spread and social inequality has increased. Globalization accelerated from the 1400s. At first, there was a movement of people and immigrants. Then there was a movement of materials and energy sources, followed by a virtual movement of money and capital. Then there was a specific movement of information. Nations have less control over economic things.

The first wave of global trade destroyed many of the traditional societies of the Americas and produced incredible suffering. Globalization was destructive on several levels at first, not only diseases, but conquests and exotic exchanges. American crops, grown in harder conditions, grew where native Euro-Asian crops grew less well. This allowed expansion of areas and populations. Exotic crops went everywhere, even manioc into Africa. The coming together of zones was destructive to native peoples. Not just from trade and competition but from livestock, exotics, and diseases.

A later wave of globalization destroyed traditional economic systems. European exports, especially in textiles, undermined regional livelihood. These processes enriched the Atlantic shores, but it also widened the inequities within nations. Thurow states that governments did not decide to start global trade and marketing. But, that is what they did through East India and Hudson's Bay and other companies. There is also change to a popular cultures, with clothing, foods, and songs being dominated by a few.

Many of the modern trade agreements are causing suffering and violence. The gross domestic product of the world increases, but what is produced? Who produces it? Eighty percent of the lowest produce only twenty percent of the global output. Globalization is a set of factors that offer advantages to traders or companies, but can weaken individual states (or possibly deterritorialize them).

7.4.3.1. Global Capital Conversion & Erasure

Capitalism has some advantages, as did command economics. Neither system is especially ecologically sensitive. Neither is really egalitarian. Capitalism does drive innovation, using science and technology, but, capitalist economies depend on continued growth of production and sales. Of course, as many people make more profits with luxury items, the market switches to rich houses instead of cheap ones, yachts instead of boats, and luxury cars instead of high-mileage cars. Perhaps, also, there is some confusion between growth and development. Profits seem to be more important than just growing production. Perhaps capitalism could thrive on development the same as simply growth. Profits can be made with recycling and solar technology, so they can be compatible with more sustainable lifestyles.

Lester Brown considers capitalism so destructive because it does not have a way to account for ecological values. The dishonest partial-market of capitalism causes certain problems. It ignores the indirect costs of the support systems. It ignores social capital. It ignores thresholds and limits. And, it allows partial deficits, without their true costs.

Capitalism has certain cultural contradictions that may undermine itself by producing norms that do not contribute to the operation of the market. One of these could be that abundance makes work ethics unnecessary. Another might be the elitism of a privileged class that might argue for socialism. As a disruptive force, capitalism may break apart traditional obligations that we want. It would create a new order and allow new norms.

Fukuyama asks if capitalism depletes social capital. The social capital that had been built up by organized religions or cultural traditions. These are part of complex processes that regenerate social capital. Capitalism offers the poorer classes higher living standards, higher than many monarchs had. It thus defuses hostility that would come from knowledge of greater inequities. Thus, capitalists generate consumer loyalty through a massive scale of gift-giving. This also allows the capitalist system to survive and change.

But, capitalism and modernity have given many people worse conditions. The continuous accumulation by an ever-growing population forces a continuous conversion of resources into goods. This process uses fossil fuels to erase the capital of natural ecosystems. Corporations liquidate ecosystems such as forests because it is currently economical to do that rather than keep them as long-term capital. The pressure of deficit financing and the allure of short-term profit can overwhelm common sense about borrowing and liquidating. Furthermore, the capital is often an abstraction to a board that is remote from it.

7.4.3.2. The Positive and Negative Effects of Global Economics

Globalism allows trade and access to any product or luxury. This access allows many to assemble comforts and technological marvels to enrich their lives. Globalism increases the size of the frame of reference, so social relations have a larger context. But, globalism shrinks distance and increases interdependence. Perhaps globalization does break down barriers and enhance cooperation. Despite its limits, the North American Free Trade Agreement (NAFTA) in 1993 did integrate issues of environmental quality and protection with trade.

Donella Meadows has reservations about the global trading system. It is a system with rules designed by corporations, run by corporations, for the benefit of corporations. It limits feedback from anyone else. The meetings are closed so there is no feedback. It forces nations to race to the bottom, weakening social and environmental safeguards.

One severe problem with globalization is the lack of global feedback. We do not see the response yet of consuming the capital of local ecosystems or the global ecosystem, since we can always trade for more resources from somewhere else. The biosphere that supplies resources and services, as well as absorb wastes (materials and emissions), is limited by amounts and rates. The ecological limit is a limit to consumption, which is related to technology, population, and wilderness. Lack of ecological feedback is what allows limited resources such as forests continue to decrease in price. The stock is not increasing, but, technology is more efficient, and economic rules are bound by their two-year horizon—and new global rules allow better access to remaining stock. Living on the planet's capital we feel we can transgress ecological limits indefinitely, or at least until the capital is exhausted, then it's on to the rest of the solar system. Sturm et al. note that 44 countries consume approximately one-third more ecological services than their capacity can provide. Thus the global economy is poorly positioned for competition in the future. Significantly for their study, 16 of 20 eco-efficiency leaders are also competitive, so either it is not mutually exclusive or it offers an advantage. Canada is positioned well, due to its ecological remainder potential. Japan is competitive because of its efficiency, and it saves its own resources.

The arguments in favor of globalism, however, contrast it to the erroneous belief that the past was nasty and short, teaming with suffering, disease, and tyranny from others. Globalization acquires the patina of myth, that it has a destiny to save civilization. One myth of globalization is that it is saving and managing the planet. Another is that nature is a machine that can be simplified and streamlined. The metaphor of the machine is only a metaphor. Nature is not a machine and cannot be easily simplified with only desired effects.

Globalization disconnects identity from location. Globalization can de-territorialize culture, which has already happened to some cultures, through a disguised form of colonialization. Globalization presents the myth that cultures, through reterritorialization, can take root in new locations and develop new foods and new dances. What about distinctive foods, songs, views? Are they place-based?

Globalism allows most people to stay in place, but then experience the displacement that globalism brings to them. Most human social existence continues to be local, of course due to physical embodiment and attachment to home. Neighborhoods are based on proximity, more than ties or shared values.

Aspects of globalization tighten intersystem linkages and hierarchies. This tends to distance resource users from the immediacy of their dependence on systems. This also weakens feedback loops that are essential for responding to adjusting services. Increased interdependence can make the network more fragile.

Another concern with globalization is homogenization. Globalization could still occur without homogenization, but that would require respect and limits. Diversity and globalization are not totally incompatible.

Does globalization screw up the categories that we use for human behavior: Economic, political, social, environmental, or cultural? Global capitalism undermines traditional cultures by offering consumerism in the place of guides for behavior. Social roles seem irrelevant by comparison, if the good life can be bought without effort. This leads to a new kind of proximity. Inequities are made more visible. Threats to shared environment are more visible. Dangerous impacts from conflicts are brought closer. It might set the stage for a violent clash of cultures.

How can globalization react to Islamic militants? How can it react to sea level changes? To the collapse of China, Europe or US? Terrorism, organized crime, and other emergencies will occur as often as other conflicts, but can be minimized in smaller nations.

Economic globalization allows design information to flow faster between nodes on a global scale. Consumption patterns can be recognized at a global scale. Globalism sucks values and people from their local context into the global context. Or perhaps destroys much of the local context, releasing people to the global. People in a strong culture may resist, which may revitalize the local. Local designs can communicate the identity of the place on a global scale. Capital becomes globalized. The economic nodes host exchanges that can bypass the control of sovereign nations.

A one-world planned economy is an even greater threat. It is based on unlimited industrial production, unlimited commodity consumption, increased exploitation of nature, and the free flow of resources and labor across cultural borders. This kind of planning requires the abandonment of local controls on development, trade, or lifestyles. All countries are expected to open their markets to outside investment, eliminate tariff barriers, reduce government spending (especially to the poor), convert small-scale, self-sufficient farming to agribusiness, and open all land to resource gathering. Planning is thus characterized by a utilitarian globalism that denies value to the systems that support it.

Circumstances are more difficult than ever. Globalization stamps its undifferentiated image on the world. Traditional town based industries have largely disappeared as technology increasingly frees us from ties of place. The individual freedoms of the private car have not been won without a cost to the quality of the places where we live.

7.4.3.3. Globalization & Deglobalization

Globalization allows connections to other cultures and extends relations. But, do we have the moral development to live mutually and fairly with these other cultures, often constrained or limited by luck, geography, resources, or history? Probably not.

Alvin Toffler foresees the emergence of an electronic neural system for a global economy, without which any nation will be doomed to backwardness. What kind of backwardness? Lack of fast things? Lack of professional enslavement? Lack of art, play, or culture? Lack of food, tradition, freedom, or happiness? He describes the fast economies that are forming and concludes that slow economies will have to speed up their responses or risk becoming uncoupled from the fast lane.

It might be good for countries to be uncoupled. Uncoupling economically might be a sound option for traditional societies unwilling to make the same mistakes as industrial ones. Local communities are based on traditional cultures, which have long-term lasting power. Traditional cultures often have wealth-leveling properties, absolute property ceilings, fixed wants, and production coupled with need—all of which results in a stable economy. Efficiency and productivity are less important than use or appropriateness.

Toffler says that the nonindustrial countries are faced with a shortage of economically-relevant knowledge. Are they? What kind? The knowledge of how to find or grow edible and medicinal plants? The knowledge of how to make appropriate houses and cooking utensils? Toffler touts knowledge-based agriculture as a cutting edge of economic advance; how knowledgeable can it be, if it ignores the erosion of soil and beneficial insects? Traditional communities have lost more knowledge than we will have in the near future. What happened to our rich biological and mythical knowledge of animals and plants?

We are not talking about withdrawing from the international economy. We are suggesting reorienting our economies from the emphasis on production for export to production for the local market; about drawing most of our financial resources for development from within rather than becoming dependent on foreign investment and foreign financial markets; about carrying out the long-postponed measures of income redistribution and land redistribution to create a vibrant internal market that would be the anchor of the economy; about deemphasizing growth and maximizing equity in order to radically reduce environmental disequilibrium; about not leaving strategic economic decisions to the market but making them subject to democratic choice; about subjecting the private sector and the state to constant monitoring by civil society; about creating a production and exchange complex that includes community cooperatives, private and state enterprises, and excludes TNCs; and, about enshrining the principle of subsidiarity in economic life by encouraging production of goods to take place at the community and national level, if it can be done so at reasonable cost in order to preserve community.

We are talking, moreover, about a strategy that consciously subordinates the logic of the market, the pursuit of cost efficiency to the values of security, equity, and social solidarity. To use the language of the great social democratic scholar Karl Polanyi, about re-embedding the economy in society, rather than having society driven by the economy.

Deglobalization, or the re-empowerment of the local and national, can only succeed if it takes place within an alternative system of global economic governance. What are the contours of such a world economic order? The World Trade organization (WTO) is a monolithic system of universal rules imposed by highly centralized institutions to further the interests of corporations. To try to replace the WTO with another centralized global system of rules and institutions exhibits the same logic that produced the WTO. Logic can be a trap. It is more important to produce a framework for diversity that to create a new set of global rules, based on slightly different principles. We need to challenge our fascination with the techno-optimistic 'gigantisms' and question the need for a single set of global trading rules. That diversity yield more profit in the long run.

Toffler also heavily praises the speed of transactions in industrial society. Speed is also a problem. Many cultures and systems have different speeds. In Bra Italy, they promote slow food. Italian municipalities have created a slow cities cause. France favors slow economics, that boasts fewer working hours, longer vacations, and job protection. Volkswagen went to a 28.8 hour work week to avoid layoffs in the mid 1990s. European

Union wants work councils to protect local products. This is a good answer to globalization. But, it seems based on Community anarchism more than a national movement to limit globalization to those things which it would be good at, and only those things.

7.4.3.4. The Base of Difference

Is globalization a universalization of the potential of one international society? Is international society just an aggregation of national societies? Are those just an aggregation of communities and individuals? Is aggregation the right word? No. Nations and communities are not thrown together. They develop over centuries or generations. Is there an international society? Is it a society of societies? It might be better described as a framework that allows coordination and not replaces the nations and communities.

How is international law different? It did not arise from all living together. It may be an expansion of or abstraction of all societies and states. Allott states that there cannot be society without law or law without society. Obviously, this is wrong. Foraging societies do not have or need laws. International laws will not be based on an international society.

Is cosmopolitanism having the sense that there are no others, that everyone is the same? This is different from the recognition of people having universal needs of kinds of behavior. A cosmopolite perspective must include awareness of many other cultures with unique solutions for unique places. There is legitimate difference and plurality. The true cosmopolitan might possibly live in the local with awareness of global.

The power of globalization to cause crises in countries would be lessened if the countries were self-sufficient in food and education. In a global economy, the economies of scale are not as important as they were nationally. Therefore, nations do not have to be large at all to have scale advantages. Therefore, ethnic groups could form their own nations. Higher standards of living are possible by trade and specialization, based on self-reliance.

Putting social arrangements and trade within a global framework, with agreed-on rules, with a realization of equity, should reduce the suffering and inequity. The distribution of some powers to an international social framework could serve common global interests, such as defense. At the moment, many countries, such as Japan and those of the European Union have decided not to invest in large military buildups, not to make decisions about Kosovo or Iraq. Instead, The U.S. tries to police everything as a global power, but is unable to avoid a dreaded imperialistic stance or achieve any kind of balance—that might be achieved by the UN.

Because of the recognition of universals among human cultures, people want a common human culture that does not exist. But, that is not the same as uniformity, regardless of peoples themselves. If a global ecological economics were based on national ecological economies, with international recognition of uniqueness and limit, then the globalization process might be less destructive.

7.5. *Global Problems: Corporations*

A corporation can be defined as a legal entity independent of the persons who created it; or, as a group of people who act as an individual; or, as a large belly (is there a possible connection?). The oldest surviving corporation of any sort is the Benedictine Order of the Catholic Church, which was founded around 529 A.D. The oldest surviving business corporation in the world is probably Sweden's Stora Kopperberg, which was founded in 1288 and is now known as StoraEnso. The first significant American industrial corporation, the Boston Manufacturing Company, was established in 1813.

7.5.1. *Corporate Independence without Limits*

The first corporations were quite limited to public service, such as private highways, and did not challenge the host nation. As a result of changes in technology and several social changes, however, corporations were able to overcome limitations to their business.

In 1886 the U.S. Supreme Court made the ruling that corporations were persons, entitled to rights and privileges given to individuals by the Constitution and Bill of Rights. The corporation is legally fictitiously a person, an individual, although now they may be immensely large, rich, immoral, and powerful, supercitizens.

Supreme Court Justice Louis Brandeis noted that U.S. citizens were reluctant at first to grant corporations privileges for doing business, even though they were recognized as being more efficient. The reasons for this reluctance were: Fear of encroachment—on liberties and opportunities for individuals; fear of subjection of labor to capital; and, fear of monopoly. Where privileges were granted, there were restrictions on the size and scope of corporate activity.

Gradually state governments removed those limitations. The corporate system evolved like a feudal system, according to Brandeis, where American society came to be ruled by a plutocracy, where a few old, white men control hundreds of thousands of people through corporate mechanisms.

Even more controls have been lost since the 1950s. The stockholders have lost control to management, thus ownership and control have become separated. Managers can pursue a course without the direct supervision of the owners. Antitrust laws failed to control corporations. Regulatory legislation as a legal limit on corporate power has also failed. The labor unions are no longer restraints on corporate power.

7.5.1.1. Constitutions Federal & Corporate

The U.S. Constitution was written during a specific social context, at a certain level of technology, and at a certain point in the development of the industrial revolution. The forces that have developed as technology and corporate organization developed are not consistent with democracy and its ideals—and in fact, the constitutional and economic vision of that time have been rejected. The system resembles an iceberg; the visible parts look like a democracy with a free market, but the invisible base determines where the ice heads. The dark down-side majority determines how things function. Because it was not foreseen by the U.S. Constitution, this situation has escaped the traditional controls and limits. Corporate icebergs can direct the free market, by-pass democracy, and dominate people's lives. Corporations are powerful and indifferent to human life as well as to the free goods of nature, which is why not everyone gets lifted with prosperity or why nature is also decaying. This new system that has arisen from the alliance of government with private corporations, using modern technologies for profits.

Corporations have developed their own constitutions for operating for profits. Among managers there are shared knowledge and assumptions, acquired in schools and social situations. These assumptions become the real operating constitution of corporate government. Skills that will advance the interests of the corporate government are the ones that are selected, but understanding of the world below them or of the effects of their decisions on that world are not considered important. What are the shared assumptions?

1. Impersonal economic forces (a myth not often recognized) produce better choices than planning by thoughtful people.
2. Economic growth is the measure of well-being of society as a whole and benefits everyone (another myth).
3. All important social values are quantifiable and measurable (trust, loyalty, and beauty are outside but can be willed by strong people).
4. Treatment of people as employees does not effect the rest of their lives, regardless of layoffs and coercion.
5. The market will supply all social needs, although the massive efforts made by advertising to influence people to buy unhealthy and unnecessary things are not detrimental to needs.
6. People are rational actors whose behavior can be controlled. They are dominated by economic interest but should forgo interest for others and the community.
7. The product of this system is the best system, not necessarily good people or a healthy society and environment.

Based on these assumptions the elite managers make decisions that affect all of society, although this consensus may not be conscious. The access to position and wealth has become controlled by corporations now.

7.5.1.2. Corporate Rule

Corporations are ruled from top down. Rules are not adopted democratically, or enforced with the fairness required by law. Because of the success of corporations, other institutions, such as schools and colleges, follow the corporate model.

People obey the dictates of corporations to avoid being laid off. Employers then demand subservience and obedience far beyond what governments require with laws. And, the punishment, of loss of job, is more effective than the threat of imprisonment. Independent thinkers are discouraged from government jobs, the result of background checks and standards for conformity. Punishment, of course, is a modern version of ostracism or exile.

Corporations have become exempt from the Bill of Rights, because the Bill applies only to actions by the government and its agencies. They do not allow employees freedom of speech or due process.

Under the flag of efficiency, institutions have adopted an authoritarian model. An authoritarian workforce has advantages for a corporation. Civil liberties can be suspended in the name of profitability. The technology and communication works better in authoritarian mode. Its wealth gives it power. So much so that it does not require the use of force, although the public government allows it to use other forms of coercion.

Is this the operation of a free market, where workers can negotiate for benefits or working conditions? Or can corporations coerce workers into accepting a job under any conditions, to avoid being one of the surplus unemployed? Possibly a free market could favor a healthy society if balance was maintained. The coercive market upsets that kind of balance. The economic government has chosen to devalue labor to be able to compete on a world market. By causing lower labor costs the corporation saves on labor, but larger costs are imposed on individuals and the society that has to support the unemployed and under-employed.

The efficiency of large scale is an axiom of modern economics. But, the efficiency is enforced by corporate control of resources and employees. Corporations that control the entire process of acquiring resources, manufacturing, distributing and marketing have advantages. Thus, the market is not free; it is fixed by corporations. Price and production are controlled by planning, research, and programming, not by a free market.

7.5.1.3. Corporate Growth

In the past, at least as recently as the 1930s in the U.S., public government worked to protect people from the harm caused by private government. But, economic power has been leveraged to political power, where corporations can deny free speech to employees outside of the work place. The economic government, according to Robert Reich, creates a corporate hierarchy, with pervasive inequality between all levels, rather than a democracy. To keep profit growing under any circumstances corporations have been willing to accept damage and conflict.

The growth of corporations caused a growth in government in response, mostly to help those hurt by large corporations: Small farmers, small businesses, and individuals. According to Reich, the government expanded its constitutional powers, not by amending the constitution, which would be the appropriate way, but by allowing the Supreme Court to give broader interpretation to the Constitution. The government ended up trying to regulate parts of the economy or those parts that corporations were unwilling to perform. At least until government simply became a willing partner in the changes. Economic government dominates public government, which helps it.

In the past corporations exploited child labor, until government intervened. Corporations could dismiss employees without offering them assistance, but the government started to provided social security, and unemployment and training benefits. This response to the narrowing of economic opportunity and independence has been termed the 'welfare state.'

Individuals cannot, and corporations will not, take responsibility for public services such as highways, airports, national defense, national parks, schools. So, government takes sole responsibility (as it should be responsible for national things). National defense for instance, has enriched many corporations, but the corporations do not even provide efficient or competent work, in many cases. Public resources such as oil and forests flow to corporations as subsidies. Radio and television licenses were distributed to corporations. Now, corporations dominate public airways. Public lands used to be the support for individuals. Now, they support corporations.

As private corporations became larger and international in scope, local and state governments have been unable to regulate their activities. That would take a strong local or national government or international body. In their own interest corporations work to reverse the intent of the people. For instance, although U.S. President William Clinton in 1992 promised a pro-employment policy, the minimum wage was not enacted, and interest rates were raised. What the people voted for was reversed by invisible management of corporate government.

The legal system becomes another tool for power, to justify the distribution of wealth, as a result of favors. This destroys the neutrality, fairness and dignity of the law.

7.5.1.4. Corporate Tyranny/Corporate Terrorism

As long ago as 1958, John K. Galbraith observed that the public sector became more affluent as the private sector was impoverished. Public poverty has become deeper. The money is not missing; it simply migrated to the private sector. Urban parks and wilderness suffer neglect or destruction; parks and forests used to be the symbols of freedom. The free market did not decide that; corporate managers did.

The broad and deep middle class of the U.S. in the 1950s acted to stabilize life. Now, the new structure of the work place, with its steep hierarchy in megaglobal corporations, is destroying the middle class. Security is lost; community is destroyed. Corporations control the workplace without interference by government, unions or competition.

There are new kinds of tyranny, not just from governments now, but from corporations. U.S. citizens once fought taxation without representation, but they seem reluctant or indifferent to fight economic decisions without representation. Is corporate tyranny more acceptable than governmental? Is abuse of power by kings not acceptable, but abuse of power by corporations okay? Are unjust executions by government terrible, but cancer from toxic wastes from corporations acceptable? Is government mismanagement reprehensible, but abandonment of communities by capital just a part of business?

We fought taxation without representation. Economic tyranny could also be reduced by balancing society more, by recognizing the immeasurable values that exist before being economized in an economic dimension. Control of corporations could lead to a better balance of natural, human, and economic environments.

Some actions of corporations are acts of terrorism and should be outlawed. Corporations have had critics killed; they have had tribes wiped out and buried in mass. These corporations, especially energy corporations operating in foreign lands, need to be held accountable and punished (and perhaps disbanded and sold for damages). As fictitious individuals with legal identities, these corporations must be bound by national and international legal systems.

7.5.2. *Corporate Intersections: Ownership & Capitalist Scale*

Ownership has changed meanings many times in the past 40,000 years. At first it was rare and may have applied to only a few personal items such as ceremonial clothing. Now that humanity has divided up the earth, every part is claimed and owned. Every forest is owned, even if the tribal residents do not become aware of it until some company starts logging it. One would think that this gigatrend of ownership has ended with the finite territory of earth, but it shows signs of continuing through the solar system.

Large-scale ownership patterns may be relatively recent. In China by 594, the state of Lu instituted land taxation instead of expecting direct labor. Individual ownership and free market may have appeared afterwards.

In England, a forest was originally a tract of land owned by the sovereign and used for hunting; the word also referred to a dense or profuse growth of trees. By the eighth century, forest referred to the royal woods, where the right to hunt was reserved by the king. Other rights, however, such as the right to cut wood for home fires, remained free for everyone. The forest then became a legal term that applied to a large tract of land, governed by laws, with its basis on the right to hunt. At one time, almost a third of England was royal reserve. Enclosure of common fields gave many ownership of the fields.

With ownership comes management; with management administration. Administration, from the Latin words meaning to serve, means the activity of an institution in the exercise of its powers and duties; it also means the management of an institution. Ownership also has effects on productivity and disposition.

Some people are not permitted to own things. For instance, tribal ownership is usually ignored by federal governments. Private ownership is influenced by taxes and regulations. Federal ownership can limit or accelerate the use of resources, such as forests; Canadian forests, for instance, where 90% of all land is in provincial Crown hands, are vulnerable to the fads, style, and influence of industry—in the U.S., where 72% of lands are private, industry has far more people to convince.

Perhaps the most important condition is the security of land tenure. Management has never invested in land that is regularly changing ownership from the government to tribal to individual or back. Religious organizations that have persisted for centuries have done well at preserving individual trees or stands; both Chinese yellow pine and dawn redwood, long thought to be extinct, were found in temple gardens. By contrast, the Queensland Australia management system for moist tropical forests was closed down by a political decision after a state-federal struggle for control. Long-term stability, with secure ownership by state, culture, or tribe is a necessity for permanent forests. This means intergenerational management.

Perhaps ownership will reflect a change from individual and corporate to land trusts and community. We need to find the best combination of ownership, trusts, easements, and plans to ensure that the forest will be cared for in the long-term.

7.5.2.1. The Use of the Commons (No-costing)

Economists try to bronze the economy in its current structure; but it is a changing system. Since it is changing, strategies that are appropriate at one stage are totally inappropriate at another—this is the remorseless working of tragedy, where successful strategies are applied in inappropriate circumstances. Tragedies imply conflicts larger than the individual or even society. The external order of things or the cosmic plan is challenged, even if the cosmos is the size of a city. The source of tragedy for economics is a fatal flaw of the world-view. This is the root of Hardin's tragedy of the commons. The tragedy of the commons occurs only when people are locked into a system of self-interest through economic gain; it could not happen in a culture that understood common holdings. Hardin's definition of tragedy is the working of fate. But economic tragedy results from the failure of a cosmology: humans are responsible, not chance or fate. We can choose between the tragedy of the commons or that of Leviathan, or we can expand the cosmology using ecological knowledge and wisdom and the limit economics to a sustainable place in the cosmology.

Sustainable development requires recognition of a large number of limits. The ecological approach to development makes it irrelevant to discuss global limits to growth. Local limits are far more significant to a majority of people. Economists claim that the minimum does not apply in a growing system; alas, our system has been growing through transformation and not real growth. We convert ecosystem economies into human ones.

Complex societies depend on production from resources. Increased complexity requires more information processing and more integration of disparate parts. The costs of communication increase. Complex societies need control and specialization. Yet, investment in complexity yields declining marginal returns because of the increasing size of bureaucracies, increasing taxation, and costs of internal control. If complexity can be restrained, the society may be healthier.

If complexity, especially in an economic sense, increases too much the entire society can collapse as its disadvantages outweigh the advantages. Various authors, summarized by Joseph Tainter, have concluded that economic reasons explain the collapse of many societies historically, from the Maya to the Ottoman Empire and the Ik (of northern Uganda).

The current economic style is too great, fast and reckless for ecological systems to absorb its impacts. The scale of things is an independent problem that can ruin the best intentions of policy. A bigger system to control systems that are too big might be a mistake.

Every economy depends on the stability of the environment and on the stability of social institutions. The environment provides air, water, and land, and provides renewing, both physical and psychological. Institutions, from sanitation, police, schools, churches, and community centers, provide a supporting network. As these institutions wobble or fail, or environments do, economies may have to subsidize or replace them to survive.

An economy has traditionally been seen as a morally neutral body, but even if it has only to conform to the nominal rules of society, it is already a moral agent. Economies are no more neutral than other organisms. Many areas of moral concern already are recognized, including worker safety, affirmative action, advertising truth, foreign investments, and harm to the consumer, public, and environment.

Responsibility occurs wherever the interests or rights of a person, society, or ecosystem are significantly affected by the actions of economic actors. Responsibility can be understood in terms of costs and benefits, that is, through operations and their consequences rather than abstract behavior. Every action entails a gain and a cost (or profit and loss). Profits and losses are distributed privately, socially, or environmentally. Unfortunately, the modern system privatizes the gain and externalizes the loss to the "commons," considered as a pool of "unowned resources," where in traditional societies, it was surrounded by rules for use. As long as this is possible, it is profitable to charge the cost to the environment.

Externalizing costs works fine in an uncrowded world, where the costs are negligible and can be absorbed by natural processes. Resources were traditionally seen as free for the getting; air and water were seen as free sinks. Modern economies, embracing the notion that "nature is capital," draw on the accumulated "capital" of ecosystems for production. By ignoring the real cost of the capital, as well as the costs of natural services, such as nutrient recycling, soil building, and atmospheric renewal, these economies create a temporary wealth. Decisions regarding resources are made on short-term economic grounds and lead to shortages and environmental degradation.

Modern industrial culture places an emphasis on individualism and competition. Cooperation, with an understanding of rights and responsibilities, is based on cultural understanding. This kind of understanding, once prevalent in many cultures, is the reason why the tragedy of the commons (Hardin) did not always occur with common resources. Cooperation is crucial.

7.5.2.2. Capitalism and Growth

The English encouraged trade to increase their wealth. This lead to government regulation of the economy to ensure growth by granting monopolies, or mercantilism, an early example of regional trade going to global trade. Mercantilism allowed the accumulation of capital. And, capital required more energy and new technologies. This lead to the separation of people from the land and resources, at least in England in 1650, during capital production, or capitalism. Later, there was a shift to assembly-line factories using fossil fuels. As immense legal individuals, corporations created a form of monopoly capitalism.

Capitalism flourished with the agricultural revolution that began in England in the 1700s; the other half of the revolution was science, which also benefited capitalism. The two, capitalism and science, have not quite been compatible. They have different logics and different goals. Many times capitalism forces environmental destruction, due to the limits of the system. The gamble is to win big or lose big.

Capitalism rose when kingdoms were becoming more democratic, but capitalism is not linked with democracy; it does not contribute to democracy. In fact, it can adjust quite nicely with many totalitarian states or dictatorships, such as Russia, China, and Saudi Arabia, all of which have fast food restaurants with fizzy drinks.

7.5.2.2.1. Perpetual Growth

But, capitalism has felt the need to grow. The need to grow is intrinsic in this kind of economic system. A large literature has treated perpetual growth as the only conceivable state of affairs. Capitalism depends on growth for stability. There is some analogy with plants. Some stability can be gotten from growth in early stages; later stability must result from limits and metabolism. Growth in plants can delay the onset of senility by ridding the plant of waste products in more diluted form. However, too much growth produces a strain on tissues and early decay. In fact, one herbicide promotes excess growth as a means to kill weeds.

The production of wealth from growth depends on technology. Economic growth can produce great wealth for some. Fortunes await those who can increase the demand for unnecessary items, such as electric swizzle sticks or pet rocks. Free enterprise provides initiative to any willing to show a profit without regard for the immediate consequences. The economist Paul Samuelson illustrated the skewed distribution of wealth with an income pyramid made out of children's blocks: if each layer represented $1000.00, the peak would be as high as the Eiffel tower, and most of us would be within a meter of the ground.

Wealth is based on production in capitalist countries, and on useful production in Marxist countries. The difference is mostly rhetoric. Production is measured as Gross National Product (GNP), which measures flow, not stock, which is equally meaningful. The GNP adds the dollar value of all goods and services, including cigarettes and lung cancer, oil wells and spills. There is no deduction for environmental damage or deaths. GNP also measures services, such as banking, many of which do not raise industrial output. However, gross production may not be as desirable as thought. The world prices of food and industrial raw materials have increased far more rapidly than those of manufactured goods. It can be seen that economic growth is not equal to progress.

Inequality is more the result of differential development than of exploitation. According to Kenneth Boulding the greatest source of the differential is different rates of accumulation of knowledge, capital and organization; the rates are essentially internal properties of cultures. Although a minor element in terms of transfers, it is a large psychological perception, which may need to be compensated for in a global community.

7.5.2.2.2. Perpetual Borrowing

Capitalism has developed other difficulties. It is disruptive of resources and culture; the unequal exchange of goods, and the advertising of goods as necessary, leads to accumulation. Many of the characteristics of capitalism are destabilizing to a national economy: The goal of perpetual growth, the continuous accumulation of goods, the myth of progress, increased inequality and polarization, and the hierarchical division of labor, as well as of nations.

These difficulties have forced corporations to liquidate capital assets, such as old-growth forests, rather than keep them as long-term capital. The answer might be provided by recent economic history: After the second great depression starting in 1932-3, the U.S. government tried to flatten out the boom and bust cycle of our capitalist economy by manipulating taxes, interest rates, and money supply, by subsidizing jobs, and through corporate welfare. Although the government discouraged monopolies, it did nothing to regulate oligopolies—the control of the market by a few large companies. Prices are set by the costs of production, including bloated bureaucracies and executive salaries, rather than by demand and supply in the free marketplace. As the automated production of goods became more efficient, goods-producing jobs declined. On the other hand a large, well-educated labor force, mostly women, was available at relatively cheap salaries. Information processing and human services proved to be far less efficient than automation. Marvin Harris suggests that corporate bureaucracies wasted labor and lowered productivity faster than automation could save or raise it. Corporations were no longer efficient enough to expand production out of sale-generated income and took on additional debt.

As economists point out, debt is inflationary because borrowing puts more money into circulation. Rising interest rates caused cash-flow problems, which many large corporations responded to by lowering quality and by passing the costs of borrowed money on to consumers—which allowed them to borrow more at even higher rates, which the government had raised to cool off borrowing. Corporations have gradually increased their dependence on deficit financing to supply capital. Harris notes that corporate debt has gone up fourteen times while federal government debt has gone up only three times, as a percentage of gross national product. As more money was owed, more was paid to service the debt and less was available for cash flow. More short-term debts were taken on to keep up cash flow. Corporations can borrow faster and pay more to borrow, but can keep raising prices to consumers so they can keep borrowing—or liquidate some of their assets, which is probably why Burlington Northern and other land-owners allow massive clearcuts: Cash flow needs due to long-term inefficiencies and massive short-term debts. The impulse to save a corporation may override the need to save the natural heritage, such as old growth forests.

7.5.3. *Summary: Frivolous & Savage*

United States residents are criticized by the French, not unreasonably, for having a "frivolous" culture based on "savage" capitalism. Capitalism increases the pressure for uniformity, in a single pattern of existence. Formal development is more concerned with an assembly-line model—simple, isolated, efficient, and easy to maintain. We become remote from, and indifferent to, the system that supports us. We acquire unrealistic images of the world and harmful values, and then make bad decisions based upon them. We have not developed qualitative indicators of ecological health or quantitative measures of social health, much less an ecocentric view that would value preserves of nature for themselves.

Capitalism, as practiced by uncontrollable corporations, has been accelerating and enlarging its markets. The effect of their dominance has been to redesign the economic and political patterns that developed near the beginning of the Industrial Revolution, according to J.G. Speth. These patterns decentralize control and shift power away from nations to the corporations themselves, which are free from national regulations. At the same time, the failures of the corporations to protect resources and labor push those costs onto all the nations and ecological support structure.

Flexible regulated markets can be efficient instruments in the distribution of durable goods, but, coercive, unregulated markets can never produce and distribute everything, especially spiritual values or social justice or sustainable environments. Government should still provide public goods, from public education and culture to employment, social welfare, and penology. Most important is ecological survival.

Figure 877-6.
Centers of domestication
of plants & animals

7.6. *Global Design Solutions: Charting Ecologically Responsible Corporations*

The metaphor for a corporation used to be a simple mechanical model for turning resources into products. To be successful, a corporation had to grow and turn a profit continually. Unfortunately, the assumptions of the model were also simple and failed to consider human needs and natural cycles, causing great suffering and great disruption.

To be really successful, corporations need to adapt a more comprehensive model, one that reflects stability, cooperation, justice, and respect for nature. With an ecological model, the ecological responsibilities of corporations, to themselves, to nature, and to human communities, are described.

7.6.1. *Corporate Organisms*

A corporation is defined legally as an individual person, although one that is defined by law and exists only in contemplation of the law, hence it is artificial, invisible, and intangible. A corporation is not the stockholders or officers; it has its own entirely separate and distinct existence. This kind of artificial person was the invention of commercial interests; the first corporations in Britain were granted charters by special acts of parliament to provide services for the state. Most corporations have characteristic legal features: individuality, permanence, limited powers, continuing succession, action in the corporate name, limited liability of members, transferability of member's interests, and representative management. Charters have become easier to get, until now corporations can be formed under general law. Corporations have been adapted to meet most modern business and social needs. Real persons can do anything not prohibited by law; corporate actions are derived wholly from law and limited to the charter, although charters have become very comprehensive statements that allow a great variety of activities.

In the publication *Integrating the Enterprise* by Digital Equipment Corporation, it is stated that "Digital is a living organism," tending toward a state of dynamic equilibrium by adapting to circumstances as fast and economically as possible. This is a natural-enough metaphor, and it leads to interesting deductions.

Like an organism, each business is born, grows to a certain size, then matures and dies—perhaps a natural span is hundreds of years, like the Oxford University Press, for instance, or perhaps only a year like so many new businesses. Biologically, maturity marks the end of physical growth in humans, but not necessarily the end of emotional, intellectual, and social development. Like an organism, the corporation, unconsciously through its officers and managers, starts to act to preserve itself before completing its formative objectives, such as maximizing profit. Like an organism, a corporation lives in place and alters that place to some extent by living, although some of the larger ones risk destroying the mixed community of humans, animals, and plants (and all their associations) on which they depend. Every organism must fit in its community and environment. It must be integrated and limited—self-consciously so in the case of humans and corporations.

Corporations are unique organisms. Corporations are more than just groups of people without structure. Corporations are described by analogy with individuals. But, each has unique characteristics: the corporation has a right to property and free speech, but not a right to worship or vote. They can be longer lived than their human components.

7.6.1.1. *Problems with Corporate Organisms*

The old analogy of the corporation as a machine leads to bad assumptions: that everything is a resource; that resources are unlimited; that production must continue endlessly; that the corporation has to keep growing to survive; that the purpose of the state was to legitimize exploitation; that the purpose of humanity was to multiply, produce, and consume; and that the purpose of the universe was to supply human and corporate needs. The machine analogy also leads to false economic beliefs: that mass production is most efficient; that obsolescence is necessary for successful growth; that people's needs and wants are fulfilled by advertised products; and, that quality does not matter very much.

Some companies have started to work around these beliefs. Kodak and Head, for instance, have succeeded with custom production, high-quality, long-lived products that people did need. Other corporations are suffering problems as the results of bad assumptions and false beliefs. These problems include: overgrowth, with an increase in complexity and costs (many of them social); economic and ecological instability; social burdens (from pressures on family from relocation and powerlessness); misdirected effort on ill-conceived products; slack employee attitudes and performances (sickness, accidents, turnover, layoffs).

In the effort to control their problems, corporations have sought more control. The corporation tries to avoid being vulnerable to change and uncertainty, fluctuation, and market conditions by relying on planning and control. Corporations try to ensure stability by taking over the supplies of materials, controlling their subcontractors and the buyers of their products, controlling the work force with pay and incentives (as well as by cultivating identification), and managing demand by sales influence and advertising. Many corporations try to be flexible about resources, using what costs the least, say, cheap energy to replace expensive labor. Corporations, especially multinational ones, seek raw materials everywhere, in any nation, under any ocean. Corporations become international, mining, assembling, and selling in three different continents. Where developing countries were once regarded as sources of raw materials, they are now used as bases for manufacturing, and they are becoming growing markets.

This control is possible because corporations have acquired such great power. Large multinational corporations have great power to control national economies and ignore environmental laws, partly because of their historical promise of providing social services to national states. Unfortunately, as private good became identified with public good, corporations became less concerned with social service and more concerned with greater profit through greater technology. Greater technology lets the power to change overwhelm the power to see the consequences. So, social amenities, such as clean air and fresh water, are violated legally—after all, no right of contract or fair use of property has been breached. Corporations exercise enormous influence over our lives, probably more than governments or churches. Furthermore, the size of some companies means that their influence is felt like shock waves through societies and environments. Multinational corporations are a force in the business world and a major influence on world affairs. Size and complexity give them special power, not only financial but political. Power is supposed to evaporate in a purely competitive economy, but capitalist economies are not purely competitive; power accrues to corporations.

Usually the goals of a company are generously, nobly, and broadly stated as intentions to support the best interests of owners, managers, shareholders, employees, the public, and, lately, the earth. Many corporations pride themselves on their generosity and personnel standards and on their good corporate citizenship, although the public concept of good is being extended beyond traditional bounds as citizens become aware of the interactions of business, politics, and the environment. Even corporations that claim to make clean products in safe ways often seem to depend on "dirty corporations" for power and packaging, as well as for paper and materials.

Business as usual, with its inertial model of growth, could end in catastrophe for humanity and its environments. Industrial cultures, with their characteristics of simplification, naiveté, homogeneity, and incompleteness, turn wild landscapes into flatscapes, where variety disappears and significance is ignored for the comfortable standards of meaningless continuity. Rapid growth might precipitate a catastrophe sooner, while modest efforts at environmental protection and increased efficiency may only postpone catastrophe.

An organic model offers the best alternative, with its emphasis on energy efficiency and alternative sources, its major commitment to environmental protection and the internalization of environmental costs, and its change from growth to stable, sustained development. Such a model would provide organic assumptions and beliefs: that resources are limited, that human value is only part of ecosystem values, that humans are more than consumers and producers, and that the quality of life is more important than quantity of possessions.

Like organisms, corporations may have an optimal size and a home place; organisms that occur out of place are often called weeds, and organisms that grow too large monsters. Perhaps corporations should be limited in size and tied to one place.

Healthy organisms, even humans, are educated to take their place in a culture that limits their impact on the environment, proscribes their actions towards one another and towards others outside the culture, and trains them to reproduce themselves and renew the culture. Most corporations act like improperly socialized individuals who have not been taught how to take a proper place in society and how to be responsible for their actions; instead, corporations hide behind their legally limited liability.

Any organism, like robins to fermenting berries, can be addicted to certain things in certain circumstances. Corporations have become addicted to cheap energy and easy defense money. It is possible to create circumstances that limit or cure the addictions (for robins, the berries fall to the ground and get covered with snow).

7.6.1.2. Ecosystem as Metaphor

Perhaps the metaphor itself is not adequate. Even organisms take a large part of their identity from their context, from the surrounding environment. It might be more productive, since corporations actually contain organisms, mostly human, to consider the corporation as an ecosystem. Ecosystems occur in a large diversity of sizes in nature, from a rotting log to one covering most of a watershed.

7.6.1.2.1. *Definition*. An ecosystem is defined as a biotic community and its nonliving environment functioning together. An ecosystem is also a self-organizing, chaotic system with emergent properties. Ecosystems develop in time. That is, a community develops by a reasonably orderly, directional process that involves changes in structure that results from community modification of the physical environment. Although the physical environment imposes limits and determines pattern and rate of change, the community controls the succession. The result is a relatively stable configuration characterized by a high biomass (or information content).

7.6.1.2.2. *Characteristics—Energy*. The "strategy" of ecosystem development is increased control of (or homeostasis or homeorhesis with) the physical environment—to protect itself from perturbations. There is a fundamental shift in energy flows, as increasing amounts are used for maintenance. The structure of a community changes: organic matter increase, inorganic nutrients are used internally (instead of being extrabiotic), biochemical and species diversities become high, and pattern diversity becomes well organized.

As more and more energy is used for maintenance, the net community production approaches zero. Agriculture keeps an ecosystem immature in order to harvest the larger yield in immature systems. The mature system becomes more efficient, as it supports a larger biomass with the same amount of energy. The food chains become more weblike (dominated by detritus chains as opposed to linear grazing). Mineral cycles become closed and the nutrient exchange between organisms and the environment slows.

The life history of organisms undergoes change as well. Organisms tend to be larger (perhaps as a result of shift from inorganic to organic nutrients), with longer, more complex life cycles and narrower niche specialization. Population growth slows, with emphasis on the quality of life of organisms. Internal symbiosis becomes more developed, conserving nutrients and resisting perturbations.

7.6.1.3. Corporations as Ecosystems

Corporations share some of the properties of ecosystems. These properties may be useful in understanding how corporations could be understood as ecosystems and may have acquire other characteristics such as maturity and stability.

7.6.1.3.1. *Development in Time*. Corporations have been evolving for hundreds of years. There have already been shifts in the meaning of corporations and in the forms of organization and style: From a stable product line to continuing innovation process, from a product based definition (shoes) to a process (information), from a single pyramid of organization to constellations of satellite concerns, from the static to the flexible, from product line management to networks and innovations (the management of change), and from stable forms to temporary. Mature systems have a greater ability to trap nutrients for cycling. Corporations have settled in an artificially maintained pioneer state, feeding on the extra productivity.

7.6.1.3.2. *Energy Use.* If corporations follow similar patterns over time as ecosystems, we would expect their "food chains" to become more complex, with most of the energy flow following detritus pathways. Optimizing material and energy use, reusing `wastes' as resources (food webs between companies, where wastes are products, not side-effects), and closing loops by recycling. Reciprocal adaptations between plants and animals, or between producers and consumers, leads to mechanisms that reduce grazing and increase feedback.

7.6.1.3.3. *Low Productivity, High Stability*. A mature ecosystem produces many things, most all of which are used by the system; wastes are broken down into component chemicals by microbes, while other resources, like nitrogen, are fixed to roots by other microbes. The tightening of the biogeochemical cycles is an important trend. Corporations sometimes parallel the aging of an ecosystem, from a pioneer state to a mature state.

7.6.1.3.4. *Life History, Symbiosis*. The longer lived the corporation, the less clear the divisions between private and public and economic and environmental concerns. Short-term individual concerns meld into long-range corporate and social concerns. The short-term pressures may seem immediate and irresistible, but the long-term goals cannot be ignored for long. We may need electric power or paper now, but the cost cannot be the destruction of the source of those needs. We need the social and environmental health and stability first and always. Partnership between unrelated species, say mycorrhizae and trees, becomes notable. Corporations would team up with other companies and social and environmental groups (the pattern could be industrial symbiosis). Pollution is the most limiting factor; possibly we could predict new corps arising to deal with pollution.

7.6.1.3.5. *Differences*. Although ecosystems can be long-lived—thousands of years for tropical rainforests—corporations can disband at any time. Furthermore, unlike ecosystems, corporations still seem to be bound inflexibly by the rule of two-year payback. This means that decisions are based on short-term return and not on long-term durability.

Furthermore, although large organisms are the case for mature ecosystems, the scale of many corporations is too large; the patterns are unsustainable—large institutions lose touch with their constituents, become self-absorbed and less responsible.

The differences between ecosystems and corporations allow for the possibility of changes. Human communities can redefine corporations and limit their impacts. They can change the charter of corporations for the benefit of the community. Corporate responsibility is more complex than a simple linear cost/benefit analysis. Using the metaphors of corporations as organisms and ecosystems, it is possible to outline a new set of responsibilities for corporations and a series of behaviors that human individuals and communities can do to integrate corporate behavior into the communities.

7.6.2. *Ecological Responsibilities of Corporate Organisms*

The public responsibilities of corporations, according to Harvard management, are to grow and prosper (thereby providing customer satisfaction, employment, taxes, and contributions to the economy) and to control their hazards. According to Milton Friedman, the only social responsibility of a corporation is to make money, by striving after profit as an efficient agent of production, although he admits that the corporation should conform to the rules and norms of society.

Profit making is a necessary part of a for-profit business, but not the sole reason for business. The best business serves public goods as well as private interests. (This is similar to Ruth Benedict's original anthropological meaning of synergy as it applied to individuals. In secure, nonaggressive societies, an individual serves her own advantage as well as that of the group with the same act. The institution ensures mutual advantage; the acts are mutually reinforcing. High synergy institutions transcend the polarities of selfishness and altruism. Virtue pays because the rewards for selfishness coincide with benefit for the society. The social structure of low synergy cultures ensures opposition and counteraction; the advantage of one individual is a victory over another, as in a zero-sum game.) This is necessary for employees, since they have to feel like their work is meaningful and contributing to the public good. The path of production should therefore serve public good as well as profit.

Environmental and social problems should get as much attention, because their part of the process, as sales, finance, and production.

Economic recession may bring a re-examination of values, not only by individuals who may have less material wealth, but also by corporations that have emphasized growth. The public may insist that corporations consider social performance as well as strictly economic performance. The single economic purpose may only be the focus in a social ecological environment. Economic actions, such as where to build, who to relocate, hire, or dismiss, will be subjected to greater public scrutiny. Corporations will have to adapt to changes in standards. Business cannot assert primary self-interest at a cost to the public or environment. Corporations need to keep track of their environmental impacts. Many problems that corporations face are connected to the problems of the environment and society.

Every corporation depends on the stability of the environment and on the stability of social institutions. The environment provides air, water, and land, and provides renewing (both physical and psychological). Institutions, from sanitation, police, schools, churches, and community centers, provide a supporting network. As these institutions wobble or fail, corporations may have to subsidize or replace them to survive. Schooling for example, is often inadequate to provide literate, numerate, ecolate, or imaginate workers. Police may not be able to provide secure conditions on corporate grounds for female workers. Public transportation to plants from town may not be available in enough volume.

A corporation has traditionally been seen as a morally neutral body, but even if it has only to conform to the nominal rules of society, it is already a moral agent. Corporations are no more neutral than other organisms. Etymologically, the word moral means simply "living together.' Sometimes even routine business (nonmoral and nonenvironmental) matters become deeper ethical conundrums about justice. Many areas of moral concern already are recognized: Worker safety, affirmative action, advertising truth, foreign investments, and harm to the consumer, public, and environment. Corporate responsibility occurs wherever the interests or rights of a person, society, or ecosystem are significantly affected by the actions of the corporation.

Responsibility can be understood in terms of costs and benefits, that is, through operations and their consequences rather than abstract behavior. Every action entails a gain and a cost (or profit and loss). Profits and losses are distributed privately, socially, or environmentally. Unfortunately, the modern system privatizes the gain and externalizes the loss (to the "commons," considered as a pool of "unowned resources," where in traditional societies, it was surrounded by rules for use). As long as this is possible, it is profitable to charge the cost to the environment. Externalizing costs works fine in an uncrowded world, where the costs are negligible and can be absorbed by natural processes. Resources were traditionally seen as free for the getting; air and water were seen as free sinks. Modern economies, embracing the notion that "nature is capital," draw on the accumulated "capital" of ecosystems for production. By ignoring the real cost of the capital, as well as the costs of natural services, such as nutrient recycling, soil building, and atmospheric renewal, these economies create a temporary wealth. Decisions regarding resources are made on short-term economic grounds and lead to material shortages and environmental degradation.

Similarly, labor was seen as minimum value. For example, the idea that "labor is a resource" implies that, like any common resource defined by industrial society, labor is cheap and can be used up. The real costs of free goods and externalities have had to be accounted for, yet—this often influences the selection of corporate priorities and growth. Furthermore, the production and distribution system for most corporations is linear (straight throughput) and not circular (complete recycling), although this is logical economically, given our frontier resource-use accounting. Major changes are occurring, though. The scale of civilization now makes externalization unfeasible. The costs of pollution and waste are being internalized; other inputs, such as labor and capital, are becoming more expensive. Corporations will have to internalize or be forced to internalize. With the internalization of costs (since the losses as well as benefits will accrues privately), the system will benefit from intrinsic responsibility.

Corporations need to work cooperatively to make sure the costs and benefits are extended equally throughout the system. They could start by sponsoring the rational use of rare resources through taxation. Influence the government to determine priorities for wilderness areas or special landscapes. Beautiful, fragile, unique, or endangered ecosystems and species must be protected at the expense of commercial activity.

Corporations have at least three large, ecological responsibilities.

7.6.2.1 To be Economically Healthy

The first responsibility of a corporation is the maintain its own health, to mature organically, limiting its size and impact to the locality.

7.6.2.1.1. Create a department with ecological authority to envision long-range plans and impacts. Corporations need to react more quickly, to monitor their ecological and social environments for emerging patterns that determine their future. They need to anticipate and participate in the social and natural framework. A new department, with global, anticipatory functions could provide direction and continuity. Such a department could be justified in the same manner as military forces. Military expenditure is a nonproductive cost; its benefits are general and long-range, that is, it must discourage war in the next decade as well as in this one. Its scope of advice would include educational services as well as advertising, capital acquisitions as well as new products, plant engineering as well as security.

7.6.2.1.2. Plan all foreseeable consequences of a product. Advanced technology permits the power to change to overwhelm the ability to foresee the consequences of change. Avoiding the opposite actions of intentions (the enantiodromia recognized by the Greeks as the operation of tragedy) is extremely difficult. Good intentions are not enough: Labor-saving devices may contribute to unemployment and social problems; foreign aid may result in starvation for more millions as local agriculture cannot compete; the environmental management of some species for sustainable yield causes population collapses.

7.6.2.1.3. Determine the optimum corporate size. Limit the size of the corporation. After a point, growth results in inefficiency and nonadaptibility. Development, on the other hand, can continue for hundreds or thousands of years. A smaller size could mean more flexibility and faster response to local conditions. Recognize material limits. The global economy is probably too large already to be supported by the natural systems of the planet. What is the upper limit to the economy of scale? Accept limits to growth based on materials and on nonrenewable or dangerous sources of energy. This should not limit development based on advancing technology and knowledge.

7.6.2.1.4. Adjust corporate strategies to changing values. Smaller social and cultural groups have different and diverging values, so corporations are going to have to adjust to a diversity of values instead of to a monolithic standard. Now, the structure of power is disintegrating (with information replacing things as wealth). The knowledge-driven economy is more decentralized and customized. This moves us towards customization of production and away from mass production. Change the shape of the corporation to a framework coordinating separate divisions sharing information. Each could react much more quickly to market conditions.

7.6.2.1.5. Work to delineate a new information model of production in which the stages of a process (capital, materials, workers, design, advertising, selling) are simultaneous and synthesized. The conception of the product is extended from design (even customer contributions and design of working conditions) to aftercare, including ecologically safe retirement and disposal (recycling). The notions of efficiency and productivity are changing. Innovation and computer technology shortens product life cycles. Production diversity is increasing. Convert the information model to an understanding model. Information is just data without appropriate structure. Provide a structure and material base for understanding through communication, education, and training.

7.6.2.1.6. Enter partnerships with the employees. Address the optimum productivity of employees. For instance, government studies show that half-time employees are more efficient than full-time ones. So adjust the work force to fewer, more flexible hours (thus avoiding layoffs during the transition). Increase worker participation. What is extent of worker participation in management of workplace? New forms of ownership could mobilize workers in a more efficient and democratic economy. Productivity is declining, so is job satisfaction. Efficiency and productivity are often less important than use and appropriateness. Better pay and shorter work weeks have not compensated for lack of worker control. Offer more control. Streamline the organizational structure. Organizing workers hierarchically is costly. The best path for organization is lateral modularity, not bureaucratic hierarchy. The levels of management could be reduced drastically.

7.6.2.1.7. Promote the principle of least effort, allowing the company to consume less, recycle, use longer, and avoid waste. Corporations could develop renewable energy sources. Reduce office costs through energy conservation plan. Use renewable energy sources. Corporations need to maximize recycling. Energy and materials can be used and reused, flowing through the system. Ship by the best transportation, probably rail. Cars are ecologically unacceptable forms of transport, yet companies intrinsically recognize them with large, free parking lots. Discourage commuting; encourage telecommuting or even alternate forms of transportation (bicycling, buses, and trains). Minimize wastes, for instance, by using permanent packaging. (Milk bottles and cola bottles can be reused forty or more times.) Conduct a complete series of audits, including an energy audit for every building, an environmental audit to determine negative impacts, from acid wastes or product disposal, and a problem audit, including inherited problems. Produce an annual impact statement.

7.6.2.2 To Preserve the Health of Natural Communities

The second responsibility is to maintain the health of the natural communities—because environmental health is the basis for community health, and community health is the basis for economic health and worker health. The quality of life depends on the quality of the environment. If the environment is degraded to raise the quality of life, the effect will be very limited and never be self-sustaining. Fitting economic costs and needs to the limits of ecosystems and monitoring the economic process would reduce wastes and pressures on natural processes. The coupling of agricultural productivity to a solar budget, and the conscious restoration of degraded systems, would contribute to the health of ecosystems. Sufficient wilderness would allow the self-maintenance of global cycles. With the increase in security, wealth, and self-esteem, human populations could be dependent on ecosystem productivities and still be diverse and unique.

7.6.2.2.1. Be accountable for ecological impacts. Corporations will be held more accountable for their technological impact. New technology will be more closely regulated. Corporations could anticipate this by favoring open appraisal of new technologies. By studying the potential consequences, physical, social, and ecological, as far as possible into the future, of its innovations in information technology, a corporation can gain credibility. Otherwise, it can wait and be forced by public and governmental pressure.

7.6.2.2.2. Avoid interference with natural processes. Technological processes must be brought into balance with the cycles of the earth. They must not damage or degrade natural cycles. Avoid unnecessary harm. It may be appropriate to use trees or to compete with black bears for tree use, but it is never wise to destroy the ecosystem of trees and bears. Laws on pollution and noxious wastes have been notoriously lax and sometimes wrong-headed. Minimal acceptable tolerances are legal, yet people often prefer zero amounts of many substances. Minimal compliance with them is virtuous in comparison with many companies, but it would be better to lead to higher standards. Work toward setting zero-level goals. Do not dump exotic or dangerous wastes. Do not discharge quantities of `safe' wastes.

7.6.2.2.3. Integrate loops and material flows; internalize cycles.

7.6.2.2.4. Corporations maintain building and plants in thousands of locations, each requiring support. Corporations need to ground their operations and impacts in the limits of the ecosystems: Convert to ecological practices. Forgo economic development of key ecosystems, which should not be available for human use. Consider adjusting economic pace to natural rates; do not cut trees, for instance faster than they grow. Consider minimizing use of ecosystem productivity to the net ecosystem productivity, rather than the gross productivity, especially as regards fisheries.

7.6.2.2.5. Promote ecological design, which starts with questions. Is the product low-cost, aesthetically pleasing, and ecologically wise? Where does it fit in society? Ecological design, both responsible and socially responsible, must be radical, that is, rooted in a community in place. Membership in a place, in fact, leads to community. Corporations must become responsible members of the community. It would encourage an ecological approach to systems and processes in the whole environment, where the product, with its plant, engineers, and advertisers, is a link in a long biomorphic phylogenetic chain reaching from knotted ropes to surgical microchip memory implants. Ecological design has important characteristics for responsible technology: The products are designed by interdisciplinary teams considering all parameters and consequences; ecological sciences offer creative insights into design through a search for underlying organic principles; the product must be related to the particular environment, the tool is a link between human and environment.

7.6.2.3 To Support the Health of Human Communities

It is hard to protect communities when the way most business is done tends to disrupt community life. Because of its size, power, and intentions (for profit), the corporation should take higher risks than the surrounding communities. This will ensure the safety of products.

7.6.2.3.1. Support the community. Work place isn't just collection of individuals. It is a number of groups. Group interaction can change attitudes. A working community can build mutual responsibility. Show proper behavior; learn community etiquette.

7.6.2.3.2. Design the corporate structure and size for the community. Limit unnecessary movement or disruption. Plan the shape, size, and products of the corporation to fit the local community. Encourage self-reliance in communities. Communities can be self-reliant by producing enough food and shelter, by limiting their population to what can be produced, by using local products and raw materials (soil, minerals, plants), by using general and not specialized machines, by having multipurpose factories, by networking with other communities, and by doing without things that are not needed (bombs, food additives, or plastic bottles).

7.6.2.3.3. Behave ethically. An ecological corporation could use corporate buying power to promote acceptable technologies and discourage unacceptable practices. Deal less with nuclear weapons contractors and more with solar energy companies. Deal less with one-shot paper companies and more with recycling paper companies. Boycott paper companies involved in Rainforest destruction or old-growth forest destruction. Avoid banks that invest in anything that brings a high return (from third-world debt to Amazonian destruction and South African discrimination). Favor peace-oriented companies as business partners. And refuse to participate in work that is socially destructive.

7.6.2.3.4. Participate in the economic and social functioning of the community. Economic development and social progress are necessary for the welfare of humanity, but must be conducted with environmental knowledge. The goal of economics and politics is to provide suitable and comfortable human habitations and meaningful activities. Human settlements must be planned and constructed within environmental constraints and according to ecological priorities. Work to preserve the structure of the natural and social communities. Corporations can encourage decentralization and restore schools, clinics, and shops to local communities. Offer cooperative control with the community. Change the pattern of ownership to reflect employee and community participation.

7.6.2.3.5. Promote ecological education in a total context and interdependency. Encourage cultural traditions to stop letting social and spiritual needs be subverted by economic ends. Help lead the young into their adult responsibilities through training and participation (perhaps apprenticeship programs). Educate for appropriate ways to achieve wealth and well-being. Teach appreciation of services rendered by nature through flows and cycling. Point out the unexpectedness of consequences of even simple corporate interventions and innovations (positive feedback, biological concentration of poisons, and synergetic effects of simple new chemicals like CFCs). Trace the complex and reciprocal relations of soil, climate, vegetation, and human activity.

Emphasize that a fixed set of ecological parameters in an ecosystem can not be maintained sustainably, because the system is dynamic and changing. For example, where do computers fit in schools? Children do not need computers to develop the powers of thought, but they do need an ecological curriculum where animals display greater powers of mind than computers or machines. The important technological advantages of a computer, word-processing, database searches, complex connections, and rapid computation, are not really needed before high school, unlike myths, languages, and physical activities.

7.6.2.3.6. Implement community responsibility. In education, integrating business with humanities; the responsibility for the welfare of the citizens belongs in the community, as does education, safety, and the whole infrastructure. In management development programs and management as source of influence by setting goals, modifying structures, and introducing criteria for measuring progress. By the Board of Directors, the architects of responsibility and stewards of all resources. By the government, in its legislative, judicial, and regulatory functions. providing rules and permitting freedom.

7.6.3. *Summary: Changing the Model*

The corporation, regardless of its legal definition, is a long-lived, collective, impersonal body. Yet, it has more physical, legal and moral power than any one individual. Its investment is long-term in actuality. Many stockholders keep their investments for decades or a life-time. They are not concerned about only one dividend. Like the corporate organism, they want the long-term outlook to be positive; they want to know that their investment is stable and that the quality of life it encourages or supports is continuous.

The complexity of environmental problems should not permit escape of responsibility. The context of corporate responsibility falls within the spectrum from individual responsibility to social responsibility (the designation of property or trading conventions—capitalism or communism). Perhaps that responsibility could be enforced if the entire earth were incorporated and concerned with maximizing its own values: healthy beings in living contexts. Certainly not having `free' services and resources would force corporations to internalize all costs of production.

In any case, there are strategies that a corporation could pursue to become ecologically minded. Instead of treating decisions as trade-offs, an ecological corporation could aim at a congruence of moral, economic, and ecological objectives. Responsibility could be manifested in organizational structure, manufacturing, and marketing practices, without departing from economic decision making.

Such a corporation could bring corporate research and development capacity to bear on the transition to a sustainable society. Where technologies play a role in the transition, companies can assume social responsibilities equal to their size and wealth. By commanding their vast resources, corporations can ease the transition to a sustainable society (which would actually meet their needs for stability). The model of corporate life needs to change, from dependence on continuous growth (of profits and waste), to be being based on stability, sustainability, cooperation, justice, and respect for nature.

7.6.3.1. Redesigning the Business Model

Corporations could be subsumed under an ecological business model that emphasized the diversity of institutions, such that nonprofits and trusts could compete with profit-making institutions. So much of business is an “underground” reciprocal form that the strengths of those forms have to be considered and factored into the entire business model. These forms might be far more useful and beneficial on a smaller scale of operation.

7.6.3.2. Redesigning the Economic Model

The overall model of the economy itself has to exhibit concern for the survival of the members of a society as well as the social and ecological structures of which they are members. The model has to be able to respond to crises by changing its function to repair the breaks or wobbles rather than simply increasing consumption. The model has to be self-examining, to identify destructive economic principles, standards and trends and then analyze the forces that form them and drive them. For instance, is the momentum of the dominant economy causing it to be slow to respond to negative trends? Or is it our value system, much of which is based on the metaphor of machines?

We need to change the operating rules—the principles, standards and practices—to allow profit only after natural systems and human needs have been restored to health and protected. Koinomics incorporates those rules; resources rights are distributed to all beings equally, before human beings can exploit theirs for their needs. Profit is a recent idea that arose from a system concerned with raising capital for exploration and trade. It has become a trap that has been made a critical factor of modern economics, which is riding a sudden exponential expansion based on fossil fuel use, resource dumping, the continuation of extreme inequities—and complete indifference to environmental costs and human suffering. Profit is being driven by the conversion of resources and fuels to commodities.

Yet, it does not have to be. A koinomic model shows how human welfare could be increased without growth or profit, using rules that limit drawdown or overshoot, or any of the other catastrophic trends that are deepening. It would slow resource depletion while increasing productivity and efficiency. It would reconnect processes into cycles of reuse and lower waste streams causing pollution and dead-end sinks. More than just the purchase of basic goods, the economy can provide a spectrum of services, while protecting the sources of energy, materials, and labor. It can make the strong connections to ecosystem and community health, to the availability of good jobs and security of homes and work places. With strong connections to education and healthcare, with limits to salary differences, the ecological model could provide an ethical responsible approach that could lower poverty rates, unemployment rates, and all forms of sickness. By understanding the limits of ecological and political systems, by respecting the properties of healthy ecosystems, place and cultures, koinomics could still provide for the needs and luxuries of most all of humanity (allowing self-sufficient cultures to remain mostly outside of a new economic system).

Of course, a good government could oversee the shift in economic models and coordinate the responses of other governments. The government could intervene if necessary to set the standards and goals that an ecological economics could implement ethically and efficiently. Common lands need to be regulated for the health of the lands first. Public goods, in the form of clean air and water, biodiversity and monumental places, need regulation for use and protection. A government can offer incentives as well as regulations and laws. Incentives can range from tax shifts to and higher wages for less desirable (or more dangerous) jobs. Government can strengthen national economies, which are the basis for self-sufficiency and self-reliance, and control the global economies to make them more committed for their social and ecological responsibilities. This may mean controlling and regulating global corporations so that they cannot take advantage of some resources and citizens to continue an unsustainable hypergrowth to make obscene profits.

7.7. ***Global Design Factors: Religion & Secularizing***

7.7.1. *The Role Of Religion in a Reconstructed Redesigned World*

By John B. Cobb, Jr.

If the world is organized from the bottom up, with relatively small, relatively self-sufficient, relatively independent local communities, a fundamental question is how these should relate to one another. The danger is that among these communities it will be the war of all against all. Each will evoke strong loyalty from its citizens, but in a world of increasing scarcity, each will view the others as threats. The need is for the citizens of each to also feel a loyalty to the larger community of communities. The specific question in this essay is the role that religion may play in this situation. To consider this, we will first survey the roles it has played in the past, dealing chiefly with the West.

For tens of thousands of years our ancestors lived in tribes. In tribal communities full identification with the tribe and commitment to the other members of the tribe had evolutionary advantages. Indeed, they were often essential to survival. The tribe was typically more than the band that constituted the immediate extended family. There were often complex relations with closely related bands from which marital partners were drawn. The tribe to which all were loyal went far beyond the more intense relations in the extended family or band. All the bands typically shared a common language and culture.

The tribal boundaries were usually clear both in terms of membership and territory. Others were expected to stay in their own territories. The tribal members constituted "us." The others were "them." The division of the world into "us" and "them" was foundational to self-understanding. Much of the time tribes lived and let live, but there were often conflicts as well. "They" were experienced primarily as threats or as those whose resources "we" coveted.

Agriculture, urbanization, and civilization did not change this tendency to divide the world into "us" and "them." The "we" might become more inclusive, and the "they" more clearly defined. The Greeks divided the world into "Greeks" and "barbarians;" the Jews, into "Jews" and "Gentiles." But unlike the generally peaceful life internal to tribes, Greeks also identified themselves as Spartans, Corinthians, and Athenians and fought one another as well as barbarians. Jews also sometimes struggled against one another.

What does this have to do with "religion?" The root meaning of "religion" is binding together. In tribal life, what binds together is culture. As outsiders we may ask whether the culture is secular or religious, but this distinction is not understood from within the tribal context. Part of the transmission of culture is through stories that we call mythical, dances and other ceremonies, recitation of tribal history, and secret lore. Sharing all these binds people together.

Within the ancient empires, people of different cultures could live at peace side by side as long as there were fair rules that applied to all. Each sought to preserve its own way of life together with its stories and ceremonies, but they had no objection to other ethnic groups preserving their different ways of life. The empire did not object as long as all acknowledged the political control of the ruler. This acknowledgment typically required an overlay of additional ceremonies and stories.

Around the middle of the first millennium BCE, a new phenomenon appeared. Belief systems arose in some tension with culture. These systems attempted to affirm what is universally true in distinction from the many beliefs transmitted by the many cultures. To some degree they could be accommodated to the tribal ways of life. To some extent they challenged and transformed these.

In terms of our Western history, the most important developments were in Greece and Israel. What developed in Greece we call philosophy, and in recent times we think of philosophy as secular rather than religious. But for the Greek philosophers, what they sought was an inclusive wisdom that did not intend to omit a distinct sphere that could be called "religion." Some philosophers were tolerant of the existing myths and practices; others desired ultimately to eliminate them and have people live in terms of what is universally true and valuable. For them the new distinction came to be between those who understood the truth and those who lived by uninformed and uncriticized custom. There also arose a variety of movements that were philosophically influenced but developed cultural patterns that made their followers into distinctive communities that were not defined by traditional ethnic groupings.

In Israel the prophets brought about a transformation of the tribal deity of the Jews into a single Creator God of all. The beliefs and practices of the tribal period were continued but purified and transformed. This introduced a distinctive pattern. The transformed universal vision was at the same time the culture of a particular people. So, for example, whereas the followers of the Greek philosophers and of the new trans-ethnic communities performed whatever rites the empire required, the Jews as a group refused to acknowledge the divinity of the emperor. This evoked persecution, but also concessions. The habit of tolerating all ethnic cultures and their beliefs and practices was in tension with the imperial demand for worship of the emperor.

The universalistic implications of Judaism led to missionary activity. A good many Gentiles were attracted, but the requirement of circumcision discouraged most men from full identification. Hence Judaism remained predominantly an ethnic group, and it was generally treated as such by the political authorities.

Christianity emerged from Judaism, and this introduced on a large scale a new relationship between culture and what was now clearly a universalistic religion distinct from culture. Christianity abolished circumcision and other Jewish requirements in favor of the inward attitude of personal faith. But it retained the monotheism that rejected worship of anything or anyone other than the one, creator-God. Although it sought the toleration that had often been granted to Judaism, its disconnect from any ethnic group made its spread a greater threat to imperial authority. It evoked a more extensive and continuing persecution.

Within the church, ethnic differences were largely transcended. Loyalty was shifted from tribe or nation to God. But a new division was created, one between believers and unbelievers. Unlike the "we-they" distinction in tribal and ethnic societies, this one was voluntary. "They" were always invited to join "us." This meant, on the one hand, that the fully humanity of the others was recognized and affirmed. It meant, on the other hand, that they were personally at fault if they refused to join. Christians were at one and the same time expected to love "them" and to hold "them" responsible for their failure to accept the saving truth.

When Christianity became dominant in the empire, it supported the use of political power to weaken the "others" and put pressure on them to join. Eventually Christianity became largely coextensive with the population of large geographic areas. It then took on many of the characteristics of an ethnic religion, only now it was the ethnic religion of Christendom as a whole. To be born into Christendom was to be a Christian apart from any significant personal choice. This created a more inclusive "we" than had previously existed in the West. The "them" was now defined religiously as the remaining pagans, the Jews, and the Muslims. Often pagans were forced to convert, Jews were persecuted, and wars were fought against the Muslims.

Of course, there were wars as the kings and nobles of Christendom jockeyed for power and possessions. But they were limited wars that did not involve the population as a whole. Wars within Christendom became more consuming when the Reformation put an end to its basic unity. The religious wars of the first half of the seventeenth century brought an end to Christendom and inaugurated the era of nationalism. "We" and "they" came to be identified differently in each nation. Religion played a minor role, although it was typically appealed to as an enrichment and sanction of ethnic nationalism.

Those who decided to transfer power from ecclesiastical institutions to political ones were themselves Christians appalled by the mutual slaughter of Christians. They rightly believed that political rulers could put an end to this mutual slaughter within the boundaries of each state. But those who sought to achieve peace in this way were disappointed. Nations fought nations as bitterly as Protestants had fought Catholics.

A new understanding of Christianity emerged. If one returned to Jesus' own message, one did not find a call to force others to join the Christian church, to persecute Jews, to fight Muslims, or to kill those who interpret the Christian faith differently. One certainly did not find any support for the idea that Frenchmen should slaughter Germans for the glory of France. One found instead a call to serve the one God who loves and cares for all by loving and caring for all.

To love and care for all is not to neglect those who are closest by. With them, or some of them, one needs to be in a personal community of a sort that is not possible with those whom one does not know or even with those with whom one does not share commitments and ideals. But the "we" of the immediate group does not preclude a "we" of a larger group with whom also we share much, or of a still larger group with which we share very little. Perhaps even more important, the commitments and ideals one shares with those at hand include and emphasize the call to love also those who are quite different from us, the "them" who are so easily treated demeaningly. To love "them" is to affirm them as they are rather than to try to make "them" be like us. Today there are tens of millions of Christians by whom this understanding is taken for granted.

This balance of loving local community intensifying concern for the well being of others outside the community is not universal. There are other tens of millions of Christians for whom being Christian establishes the "we" that vilifies "them," the others, for failing to be like "us." Sometimes these two groups of Christians define "us" and "them" as separating them from one another. The corruptions of religion by imposing the "we-they" dichotomy are numerous. And as noted above, a universal religion can make this dichotomy all the more vicious. Nevertheless, if we are looking for what is needed, it is important to recognize that it already exists on a large scale. We do not need to invent a new religion.

I have described the form of Christianity that can support the social-political-economic structures that the world needs. Other religious traditions have their ways of supporting the same goals. Other early religious groups responded to challenges that threatened the health or existence of the individual members. We know that knowledge is necessary to maintain harmony with other living beings in the universe. Religion maintains harmony, so knowledge itself has inescapable religious overtones. The primal religions of archaic foragers have precepts that could allow them support integrative forms of conduct that address local and universal needs, also. For example, in the Australian Aboriginal "Dream Time," dreaming links connect all human beings in a big culture. The dreaming takes place everywhen, so it is past, present and future-oriented. The law of dreaming provides moral authority for behavior, so that even practical actions, such as burning grasses, are religious acts that perpetuate life. That 'religion' binds the group but allows for the respect and binding of other groups as well.

Jews have rarely given major attention to trying to convert others, and they have rarely persecuted those who are not Jews. Most of them are happy to live and let live. At the same time most of them believe that they should act for the good of the whole and not only for Jews.

Of course, the centuries of persecution they have endured at Christian hands has encouraged ethnocentric tendencies in Judaism, and there are today many Jews for whom the call to serve non-Jews has little resonance. But a form of religious life that fits the needs of the world we seek is alive and well in Judaism.

Today there is a widely held image of Islam that makes it appear a particular obstacle. Certainly there are Muslims for whom the "we-they" distinction is also a bitter enmity. But if we take the longer view, we find that Islam has a record that is much better than that of Christianity. The Qur'an calls for tolerance of other "people of the book," and on the whole Jews and Christians have done well in dominantly Islamic countries. The Golden Age of Spain, when the three communities lived side by side in peace, was under Muslim leadership. More recently Sarajevo repeated that pattern for decades. In India, some Muslims are extending this kind of tolerance to Hindus and Buddhists as well. The framework of Islam may seem restrictive to western people, but it does help its people to understand the importance of having a larger nature to protect the public good.

Each of the three major Abrahamic traditions has its distinctive way of supporting both the local and the universal needs of a restructured world. Each of them also has the potential of supporting the local at the expense of the universal, simply intensifying the deep-seated tendency to divide the world into "us" and an alien and hostile "them." Unfortunately, secularists are often chiefly aware of this form of religion and treat it as an enemy. It would be far better for them to support the forms of these traditions that meet the requirements for a healthy, bottom-up, world. They should recognize that cultivating both local community and concern for all is not a matter of a casual decision. It requires lifelong work in community building and mutual care, as well as having repeated reminders of the humanity of persons who differ greatly from us and as well as learning how to support them in their own projects.

Individual secularists sometimes replace the destructive religion they rightly oppose with a constructive balance of local and universal commitments. They are rightly admired. However, secularism as a public movement does not have the resources to generate this kind of dual loyalty. It provides little with which to counter the universal tendency to divide the world into "us" and a negatively viewed "them." Even the binding together of the "us" is threatened by tendencies in secularism toward an extreme individualism. More commonly, the "us" becomes a nation or even a class or political movement within a nation.

This does not mean that theism is necessary. Buddhism has long provided a nontheistic alternative. It achieves the all-inclusive concern that is so needed by expanding the "I" to the all-inclusive level. But to achieve this at a more than verbal level requires extended meditational disciplines. Buddhism does not supply the easy solution Western secularists so often seem to propose.

In brief, all religions have to be more open to other religions. They have to add a pillar to their thought structure that permits the binding of all human beings into the earth, with all other living beings. Many religions, such as Judaism, Islam, Christianity, and Buddhism, have already learned to transcend ethnic differences and local cultural limits to become more inclusive. Religion has a critically important and delicate role to play in ending the endless conflicts and wars that politics and economics have so much trouble resolving. Religion can do this by stressing the universal beliefs already shared by every culture, beliefs that include living together peacefully and sharing the bounty of the earth with all living beings, including people of different faiths. To love and care for all does not mean to neglect others with different faiths, but to love them and respect them as they are. Religion can suggest a model for avoiding excess, either material or spiritual. Religion is still the best way to provide the context for living with others and for contemplating big questions about life.

Figure 771-1. John B. Cobb, Jr addressing a Conference

7.7.2. *Secularizing the Great Ways as a Global Strategy*

Religion has been treated rudely by modern science and some of its practitioners, such as Richard Dawkins, but it offers meaning and a direction that science or modern philosophy have not. John B. Cobb Jr. issues a call to action to secularize religions to ground them in the earth and use their ancient strengths to face catastrophes in his book *Spiritual Bankruptcy* (Nashville: Abington Press, 2010). The book is subtitled a 'Prophetic Call to Action.' However, the book could have as easily been titled or subtitled 'Secularizing Christianity and all Religious Ways to Confront Catastrophes'—because that is the focus of the book, the catastrophes facing humans and all other living beings on the planet and how to find a way to turn in a more healthy direction.

Secularizing, however, is fraught with dangers. It can lead to secularization. Cobb is careful to always separate the two processes. *Secularizing*, which is close attention to the natural world as the ground of existence and the source of life and the spiritual, inspiration and beauty, is not the same as *secularization*, which is exclusive attention to the human world combined with the rejection of other dimensions of the natural, and of the traditional and religious explanations of those dimensions. To repeat, secularism is the rejection of traditional knowledge, whether it is traditional ecological knowledge or the spiritual beliefs of the great Ways of binding people to each other and to their places. By contrast, secularizing is the linking of those ways to all grounds of existence, through recognition and respect. Secularization, as another form of narrow reductionism, has allowed civilization to indulge in the madness of ignoring the worsening and increasing catastrophes—worse, civilization is accelerating the rush to an almost-certain collapse.

John B. Cobb Jr. is a Protestant theologian. His sensitivity to ecological, as well as economic and political, problems has led him to address these as critical issues. He has spearheaded the broadening of Christian thought as well as ecological and economic thought. As a classic synthesizer, Cobb begins with the long history of religions, which he interprets as 'Ways' to distinguish them from their social development as religious institutions.

Cobb's work is subtle, because he has to address the fact that as a millennial religion, the initial focus of Christianity was on salvation and heaven after the predicted end of the world. Through an interpretation of the sayings of Jesus, Cobb demonstrates how Christianity became a secularizing movement. And, through a history of Christianity, he shows how it sometimes succumbed to secularization.

He devotes equal attention to the history of civilizations, as their secularization in many aspects, including philosophy, education and science, allowed them to make great, temporary advances in technology to benefit humanity. The focus on a mechanical explanation of the world made it easier to understand and manipulate to advantage. But, the mechanist model, embraced profitably but uncritically by science, ignored the vast area outside the focus, which has proven to be a critical part of the whole.

7.7.2.1. *Starting with Ancient Ways*

Cobb contrasts secularizing with religion, especially the 'great' religions: Hinduism, Buddhism, Confucianism, Taoism, Judaism, Christianity, and Islam. Then he proposes referring to these as the traditional Ways of humankind, to make the distinction that religion has become more concerned with superiority or escape from the travails of the world than with binding people together within them. This is another distinction, between Spiritual belief and the more prevalent institutional religiousness that seems to come about with large-scale success of a Way. Cobb emphasizes that to be a good Christian, it is necessary to recognize that the deepest element of the Way of Christianity is a focus on the betterment of worldly conditions, and that those who are most faithful to their Way are also the most open to the wisdom of other Ways. Any one Way should liberate its believers to critically evaluate every aspect of that Way!

Cobb makes the important "we/they" (or us/them) distinction both in a religious and cultural perspective. This simple distinction has allowed many sins, from abstraction and objectification to violence and slavery. It has allowed some Ways to reject others.

Religiousness seems to function ambiguously, now, when it addresses critical problems such as poverty and extinctions, which with many others require immediate attention. These themes and divisions, from us/them to religions/Ways and religious/secularizers, repeat and are expanded throughout the book. Cobb suggests that one Way that might have immediate relevance is the primal Way of indigenous peoples, whose wisdom is a direct form of adaptation to challenges, such as droughts and extinctions. Secularism and religiousness are obstacles to responding to the dramatic challenges and changes occurring in most ecosystems and cultures today.

Overall, Cobb strikes a good balance in his arguments. For instance, he treats these divisions not as lines of total separation, but as tendencies and concentrations of characteristics that might be found in any Way.

One of the first topics that he addresses on confronting catastrophe is a discussion of humanity's collective insanity. This is a frightening topic. While Cobb has used this as a small theme in his works, it was always outweighed by his positive approach. Paul Shepard, writing at the same time, emphasized our insanity and identified its origin in the agricultural shift.

Cobb identifies instances of insanity. He notes that despite the early promise of American laws on the environment, these were soon replaces with laws favoring business and economic globalization that worked against environmental standards and health. Products and enrichment became more important than basic health. These attitudes, combined with economic growth, have been leading to disaster. He reluctantly concludes that humans are collectively insane. Every decision associated with economics is implemented automatically and immediately, while every decision associated with protecting people or the ecological services on which they depend is watered down, postponed or ignored. Politicians make the decisions, business people buy them, and academics support them. Only a few alert citizens worry about the conditions or question the decisions. Only a few seem to understand the gulf between normal course of operations and the untaken necessary responses to radically changed conditions. Only they seem to want comprehensive plans and immediate mobilization. Thus, the vast majority of those with power choose to use it to enrich themselves and worsen the prospects of most natural and human communities. To be fair, Cobb also identifies strains of insanity in secularism and science.

The religious can display insanity also, especially when they emphasize the unworldly. Cobb states that the unworldly *can* "ground the sense of the importance and dignity of each human being here and now" (Page 7), although it can also direct attention and commitment away from the importance of this life.

Later, he points out that the religiousness cultivated in popular Protestantism ignores critical biblical and historical teachings to emphasize patriarchy, imperialism, free enterprise, and capitalism that may be opposite of traditional teachings of charity and equality. Thus, secularization links religion to economics.

Secularism, in academics and science, but especially with business corporations "rarely contributes to saving the earth." (Page 9) It more likely hastens and contributes to problems and catastrophes. Higher education, for instance, communicates an ethic of "getting ahead" economically, no longer promoting the quest for the common good. One reason for these kinds of problems is that secularism seems to have difficulty proposing any 'ought' statements for people to follow to respond to crises.

7.7.2.2. *Secularism Unbound*

Cobb provides an overview of the rise of secularism from the classic age and renaissance to the industrial revolution with its new science and economics. Modern philosophers and scientists have been hard on religion; Sigmund Freud suggested it was a childish illusion; Karl Marx dismissed it as an opiate for the masses; Richard Dawkins likened it to a disease like smallpox, but 'mimetic.' Many suggested science as the only alternative. Too many alternatives are presented as polar opposites that deny so much else. Cobb suggests that there is a third option: To recover and refine the wisdom of the past. People used to critically examine their inherited ideas, to clarify their meanings in the current age. Cobb presents this as an example of the secularizing of tradition. Older wisdom can be appropriated, Cobb realizes, without abandoning scientific and technological accomplishments. In fact, wisdom could redirect science into creating harmonious societies in an ecological civilization.

Cobb's own work has been secularizing Christianity. He regards the Bible itself as an account of secularizing an ancient Way. And, participating in this tradition of secularizing is the most faithful form of Christianity (and the essence of his book). The simple and often radical message of Jesus has been concealed or corrupted by the religiousness of many.

Cobb calls for us to turn away from secularism, in science and education, politics and international relations, and replace it—not with religiousness— with a secularizing wisdom of the great ways. Cobb offers examples of secularizing in Greece, in Israel, and by Jesus. He suggests that Jesus is best understood as belonging to the liberal wing of the Pharisees, who affirmed the primacy of 'love' commandments, which he developed into a centrality of love, which could trump other political or religious laws at times.

Jesus also rejected the idea that bad things happened to people because they deserved it. Jesus renewed the prophetic concern for a just society. His central message was that a different order was coming, the *basileia theou*, the 'commonwealth of God (although it is also translated 'kingdom' of God), available to all and governed for the sake of all.

Cobb claims that intertwining with religiousness, there has been a tradition of secularizing from Jesus onwards. In becoming important parts of society, monasteries and convents devoted themselves to deeds of charity as well as to rigorous spiritual practices. Francis of Assisi was an influential reformer, who turned his attention to the whole of nature, and an example of a secularizing approach. Christianity has long had an ideal of the Stewardship of Creation. Although its implementation may have peaked with St. Francis, it has not been uniform. Perhaps resecularizing it and extending it to the planet would offer a more binding way to justify and guide human action.

Christianity does focus on personal fate after death. And, this encourages more egoism than concern for the rest of Creation. Cobb reasons that as long as participation is in the community here and now, in the larger extended community in nature, there is no contradiction with the Christian, or other Way, beliefs in what lies beyond death.

Cobb traces otherworldliness, sex and violence through the formation of Catholic theology, and the Reformation, to the rise of liberal Protestantism and the crisis of liberal theology.

The period of the Enlightenment considered religion and politics in the light of reason (the previous age in fact). Although religion tended to the religion of one's community. The Enlightenment ideal granted no authority to tradition. Truth would commend itself through individual reason.

In the seventeenth century "centralized national governments worked against the primacy of local communities." (Page 64) Of course, this is still true to an extent. The national capital took over took over previously widely distributed functions. Increased mobility also loosened ties with the community.

Cobb traces problems with this and individualism to later theories of government, beginning with Thomas Hobbs, who believed that any government that offered security, more than in brutish nature, deserved obedience.

Modern philosophy also tended to rid thought of its traditional beliefs and cultural heritage. Cobb examines this trend from Descartes through the British Empiricists and German idealism. Despite new idealists in the 20th century, logical positivism emphasized that only science could make predictions that could be checked or verified by anyone—and without the scientific method, language had no meaning. By the time of deconstructive postmodernism, philosophy, there was little left as a foundation of philosophy. Cobb suggests that what is left is a radical secularist form of pragmatism.

The shifting focus of philosophy turned to linguistics with Ludwig Wittgenstein and others. Language was reality and had to be analyzed that way. Cobb notes that speculative thinkers like the ideals found it difficult to avoid entanglement with the ancient Ways. Secularist thought has continued to be deconstructive and is unfavorable to a synthetic vision. Although it agrees to abandon a quest for certainty, it limits its scope to be plausible. A more constructive philosophy is needed. Philosophy needs to examine ecological issues and make political policies to deal with catastrophes.

7.7.2.3. *Education Bound*

Cobb continues by noting that the quest for synthesis has given way to description and analytical philosophy. He traces this trend into education, which has narrowed its scope from that described by Plotinus and Novalis to focus on job training. Cobb notes sadly that blind narrow training only lets youth continue and accelerate the blind movement to a precipice.

The University of Phoenix and City University are examples of the new secularized business model of education, where a business school cancels any course or program that students do not want or that does not make a profit. The owners of for-profit colleges want a profit as large as possible. This distorts education into a one-dimensional tool for careers.

Professionals need more than specialized knowledge. But, training gave up the synthetic task. The university makes no pretence of supplying a coherent vision of the atomic world. Interest in the big picture is abandoned. Fragmentation and division of knowledge allows large invisible trends and extreme dangers to be left out of any accounts.

Cobb sees hope for many colleges with an ethos and for some Christian institutions, because of the emphasis on values and meaning, to prepare students for life and for serving society. Religion has a central ethics and it addresses meaning, which Viktor Frankl showed so well was basic to human strength and health. Unlike secularists, secularizing Christians have definite and strong values. They want to benefit others (and hold this in common with many others who may otherwise be secularists). Benefiting the world means steering it from looming but avoidable ecological catastrophes.

Some colleges are responsible ecological communities, and help prepare students to heal society and the living world. They understand how important the concern is for the feeling and suffering of animals, especially laboratory and farm and zoo animals.

The threat to the living planet is so great that any scientific or philosophical big picture *has* to be shaped by it. Cobb continues, "All Christian institutions should organize" (Page 106) to mitigate coming disasters. A secularizing Christian curriculum should lead to deeper and broader thinking for the relevant needs of our time.

7.7.2.4. *Getting Beyond the Temporary Triumph of Economism*

The academic discipline of economics extends secularization further. Cobb suggests that it has become something different now, 'economism,' the belief that the economy is the most important dimension of human life, and that life and society should be organized around it. Other disciplines, from science to education and politics, should also serve it.

The traditional thought was that the economic order must be just, that is, rewards should be appropriate to the contribution made to society (rather than simple egalitarianism).

The larger the market, the more economies of scale can be implemented. The ideal used to be a national market. Today it is the global market, with no restrictions on the movement of labor, capital or goods. Alas, all the ruling powers accept the teaching of economism (a mutant form of scientism that is unscientific) and shape their policies accordingly.

One result of the dominance of economism in national and global policies is the loss of justice. And now it is easy to measure justice in terms of the distribution of incomes and wealth. Even the principle of Pareto optimality does not help. According to this, any action is good if it increases the satisfaction of some without diminishing that of others. But, the principle also opposes transferring wealth from the rich to the poor. So, it does nothing to decrease the widening gap. The measure of progress in economism is wrong. It ignored economic welfare. Cobb and Daly created a better measure of economic progress, the Index of Sustainable Economic Welfare, which used genuine indicators.

David Ricardo's faith in national community feeling was used as a basis for the doctrine of comparative advantage, where a nation would produce goods where it had the greatest advantage and import others. Yet globalization is indifferent to national communities. Most national markets have been merged into a global market. Economism strives for larger markets. It is indifferent to the value of local communities, here tradition works against industrializing agriculture and rampant consumerism.

Several factors have worked against economism. Cobb mentions labor unions, nationalism and conservation. Labor unions protected workers from too much corporate craziness, although they are still being weakened. After World War 2, the new international order broke down international barriers and weakened nationalism (which had acquired a bad reputation during the extremes of the war and before). And, in the 1960s, conservation movements created concern for the earth. This movement, Cobb notes, had more passion than a secularist movement. It also incorporated an ecological perspective and spirituality. Cobb calls this movement "Earthism" (Page 120). Of course, other forms of Naturalism had strong spiritual components.

7.7.2.5. How Can We Secularize without Secularism?

Cobb addresses reactions to secularism. A system that does not start from traditional wisdom can produce a lot of information as well as a 'great deal of craziness.' The secular humanist polemic against Christians is indiscriminate, as many Christians are liberating themselves from the negative aspects of Christianity.

Some reactions against secularism are also crazy. Cobb addresses religious fundamentalism, which reactionary religious teaching only fills the holes left by the profitable higher education institutions. Education based on modernism obscures the heritage of Israel and Christianity in western history.

Cobb mentions Parapsychology and New Age Religion as approaches to secularizing. Although secularism offers no guidance about the ends of life, many secularists have personal commitments to reversing the ecological damage of education and economism.

"This book argues in favor of secularizing," Cobb states (Page 140). He argues that the shift from religion to secularization has freed people from one set of evils, but "has plunged them into another." Economic theory is anthropocentric, but the humans described have no humanistic values.

7.7.2.6. *How Can We Begin Over?*

Cobb concludes that secularism fails to provide guidance in this time of overwhelming crisis due to its limits, which can be seen in philosophy, science and education. These areas work against seeking value and meaning, understanding and coherence, and commitment and appropriate action.

Yet, the ancient Ways cannot save us, either, having succumbed to a hardening and misdirection away from the kind of institutions and practices needed to change our path and behavior.

But with secularizing, the ancient Ways can contribute to what is needed. A new philosophy, with new tools and theories, however, is needed to inspire and guide our actions to recognize the living earth and its organisms, to recognize the values of living beings, to understand relation between them and human beings, to integrate new changes and findings that do not fit in the old paradigms into new paradigms that make sense of our knowledge, paradigms such as nonlinear history, holism, systems, and process philosophy (of Alfred North Whitehead).

Instead of sense experience as a basis for certainty, philosophy can begin with the totality of human experience and the history of relationships of ecosystems and planetary cycles.

The philosophy of Whitehead pays attention to relationships of experience, naming how a present experience can 'prehend' the previous. To bind up the past and solidify the present. The world is composed of events and experiences. Large events, such as a world war, are made of many smaller events, with billions of personal events and experiences. Relations can shift from external ones to internal ones, and the prehensions can change from physical to conceptual, uniting experience and events through the idea of causality.

Whitehead's idea of causality included divines causality as well. Affirming the immanence of God in the world strengthens the ability of traditions to secularize their positions in a changing world. He replaces the mechanic model with an organic one, where beings are always interacting with each other and their environments. The relationships among facts are as important as the facts. The connections between facts and human experience are of extreme importance.

This philosophy could change science, education and economics. Where economism seeks growth, an ecological economics would start with goals, such as the sustainable well being of humanity and the health of the global system.

Cobb points out that economic activity can be increased in ways other than disruptive, displacing growth. One, promoted by Gandhi and others, is to help individual communities produce for their own needs.

7.7.2.7. *Secularizing and Turning*

Secularism has failed to response to emergencies and crises. It is shortsighted and destructive. Although religion still plays a large role in human affairs, it also fails. It continues to anthropocentric, separate, superior, self-destructive, and sometimes violent.

Hope lies in developing new perspectives and senses of relation with a changing biosphere. Christianity has a great potential to be secularized, as do other ancient Ways. Gandhi, for instance, secularized Hinduism to bring it to bear on real problems of humans and communities in healing and creative ways. Martin Luther King Jr. was able to secularize Christianity to energize a large following to nonviolent work for justice. Cobb mentions the contributions of Jimmy Carter, Dorothy Day, Cesar Chavez, Toyohiko Kagawa, and others.

Clearly the ancient Ways continue to inspire millions of people. At the same time, there has been change in church teaching, especially with the movements identified as liberation theologies, which listened to the voices of the oppressed and struggling.

We are moving towards horrible disasters, from collapsing ecosystems and a warming atmosphere to extinctions and a collapsing global civilization. These require a reversal of direction, as well as changes in lifestyles, economic distribution and the protection of large areas of nature. Yet, because the trends are depressing, morale is poor in groups that try to promote change. Morale has to be addressed.

This book tries to overcome the confusion, especially in the Christian community, between secularizing and assimilating to a secularist culture. Secularizing is essential to addressing current problems, whereas secularization is accommodation to a dominant culture that refuses to see or adjust to those problems, even accelerating towards the dimly recognized disasters.

The dominant thought for centuries has been reductionist and materialistic, promoting self-interest as rationality. The failure to oppose and reject this and its expression in economism has serious consequences. Traditional Christian and philosophical ethics seem to be counterproductive.

After economic globalization was pressed under Reagan and Clinton, the consequences for the developing world were terrible. Recognizing this, the World Alliance of Reformed Churches issued the Accra Declaration, which noted the convergence of suffering of people with damage to the natural world, locating the cause in an unjust economic system.

Traditional Christian teaching of frugality and sharing is relevant to rampant consumerism. The followers of Earthism are also teaching simplicity, self-reliance and frugality. But, this means less growth, and with no growth, there might be fewer choices of styles and tools, although the rich having fewer choices might not be a catastrophe. Eating local food might result in fewer choices.

New ways of thinking can incorporate ancient wisdom of the Ways, as well as new perspectives needed to create a perspective of the global ecological and cultural crises.

A secularizing Way, especially Christianity, can offer a rich history of concern as well as passion and organization, a broad view of a unified world, and a revolutionary attitude. People have revolted before against irrational institutions with irrational moral codes. Secularism was one form of revolt that rejected tradition but encouraged dangerous behaviors. Secularizing tradition was another form of revolt that tried to adapt to changing environments and cultures.

To free ourselves from our insane course of action and respond to the global crisis, regardless of the cost, "then we must have a passionate concern for the earth as a whole" and all its beings (Page 180). This is a call to work with God for all of God's Creation.

To create a new culture, with new ways of relating, to ourselves and to the earth, we must free the idea of morality from the rules of any one Way. Although Jesus' vision is of immense importance for the salvation of the world, converting everyone to Christianity would not save the earth. Christianity as a group has never before focused on saving the earth. So, everyone in every Way needs to be reminded that the global situation should have the highest priority now in thought and action. Furthermore, action motivated by love and goodwill will not be enough. We need science and technology. In Jesus' words (Page 182), we must also learn to be "as wise as serpents."

Our efforts have to be passionate, but also guided by comprehensive plans and sophisticated organizations, otherwise they will be countered by better efforts organized by those who benefit from and want to maintain the status quo at any cost. So, Cobb's approach is a revolutionary approach. There are many sparks, he notes, but we need the movement to be on fire. A secularizing Christianity can offer urgently needed responses to national and global crises. We all have to take action *now* to turn from catastrophe to a healthy way for civilization on a healthy planet.

7.8. Global Design Solutions: *Global Ecological Planning & Monitoring*

Our local communities are proud to attract more people and larger industries, but do so thoughtlessly, without regard for the limits of population size or the rate of energy use, without sufficient consideration of the effects on the quality of our lives or on the quality of the environment. Although we make plans for people and their activities, the plans are usually reactions to growth and change. The formal development from planning results in a complex of problems, from pollution to ugliness.

We have always tried to exceed the physical and biological limits of places rather than recognize them and be guided by them. This eutopian framework suggests an approach to comprehensive planning based on the biohistory of an ecosystem, the cultural values of the people, and knowledge of the limits for sustainable development. This approach makes the limits explicit and set sustainable goals within those limits. As a synthetic framework, this approach provides for the health of the ecological system, as well as for the health of its human inhabitants.

7.8.1. *Central Planning*

At first a means of controlling people through zoning, central planning has expanded its reasons to include sanitation, economics, and aesthetics as well. Although central planning grants some consideration to support areas and aesthetic factors, cultural traditions and the natural environment are not often primary concerns.

Planning in general means deciding on goals to be achieved in specific situations. For central planning, the goals are usually small and not comprehensive, such as the rate of emission of sulfur oxide, and usually end up being a compromise in cost-benefit analysis. Planning tends to neglect or dismiss the distribution of negative, uncertain, or nonmonetary effects. Furthermore, we seem to have no mechanism for developing long-range plans. Certainly, there seems to be no way to deal with long-term, slow catastrophes, from erosion to climactic change.

Most plans address *problems*, from waste water treatment to air pollution monitoring. Everything else, from employment to pests, is also considered as a problem, and not a direct effect of the cultural implementation of some idea or technology. Most plans seem to be extremely good at compiling area data, from topographic to climactic. These plans are concerned with determining the adequacy of the infrastructure, such as utilities, streets, or sewers, to support actual and projected population growth. Development plans, for water or power for instance, are comprehensive in the sense of seeking to meet all needs of the public, agriculture, and industry. But, they fall prey to all the assumptions of the industrial culture. They tend to be multipurpose with the aim of providing maximum net benefits through management of watersheds, fish and wildlife, and flood control. Both uses of "multipurpose" and "maximum benefits" are based on misunderstandings. Multipurpose in practice means human use, and maximum benefits have proven to be dangerously unstable. Modern resource management strives for maximum sustainable yield, based on partial knowledge of population size and great ignorance of population flows.

Development plans also tend to call for the eventual development of *all* resources in an area; Brazil's Plan 2010, which would develop all of the Amazon with 136 high dams, is a good example. A one-world planned economy is an even greater threat. It is based on unlimited industrial production, unlimited commodity consumption, increased exploitation of nature, and the free flow of resources and labor across cultural borders. This kind of planning requires the abandonment of local controls on development, trade, or lifestyles.

All countries are expected to open their markets to outside investment, eliminate tariff barriers, reduce government spending, especially to the poor, convert small-scale, self-sufficient farming to agribusiness, and open all land to resource gathering. Planning is thus characterized by a utilitarian globalism that denies value to the systems that support it.

As a result of central planning, the patterns of life have become the products of market forces and stylish transportation operating in a sterile, abstract order. Capitalism increases the pressure for uniformity, a single pattern of existence. Formal development is more concerned with an assembly-line model—simple, isolated, efficient, and easy to maintain. People become remote from, and indifferent to, the system that supports them. They acquire unrealistic images of the world and harmful values, and then they make bad decisions based upon them. They have not developed qualitative indicators on ecological health or quantitative measures of social health, much less an ecocentric view that would value preserves of nature for themselves.

7.8.2. *Ecological Planning & Limits*

A number of proposed plans to heal the earth and improve human communities have been presented in popular books. Many of them are too philosophical and general, suggesting that we could change values without showing how or urging us to alleviate some of the symptoms without addressing the disease. Other plans, such as the *Limits to Growth*, are too global. And still others, such as *Design with Nature*, are less concerned with limits than with basic conservation. *Goals for Mankind* offers a similar compendium of global goals that can essentially be summarized to be health and freedom for people in a healthy environment. Many of these plans offer admirable models, but little in the way of specific goals or paths.

A plan should consider the whole system. Communities should be designed for an optimal fit within the limits of the system. Ecological planning considers an optimum or satisfactory population within one ecosystem, although it is connected to others by trade for some necessities or luxuries. This kind of planning is a conscious adaptation of the benefits of technology to the traditional idea of physical, as well as cultural, limits. Direct observation and traditional knowledge yield far more "information" about the societies of animals than autopsies and mathematical models. An outline of a comprehensive plan is presented, to deal with some of the implications, as well as question them.

1. Identify our place within its natural boundaries. Most places exist in a uniquely identifiable ecosystem, with recognizable boundaries and a unique history and character.
2. Calculate the optimum amount of wilderness to preserve the natural cycles indefinitely. If the current area is less than our calculations, restore the difference and set it aside as a reserve.
3. In the remaining area, zone areas for appropriate use, including conservation, preservation, reservation, and artificial areas (with historical, cultural, and functional importance).
4. Identify the resources needed for human use, including raw materials and the

productivity of the areas. This productivity can be used to calculate a base line population.
5. Apply cultural modes—in style, values, and technology—to set limits on technology and population. Preserve the cultural values. Renewable resources will sustain a population longer than energy capital like oil or gas.

As part of the formulation of a plan, we have to examine the natural and cultural histories of a place. We need to understand interactions in the ecosystem, as it was with no humans, as it was lightly settled, and as it is now, dominated by humanity.

7.8.2.1. Limits & Planning

Our modern cosmology, with its basis on machine metaphors and the principles of plenitude gets in trouble because it does not understand how basic the concept of limits is to the physical universe, to life, to ecosystems, and to human constructs, such as cities and economics. Limits are important at all levels, starting with the physical.

The limits of the universe, like the speed of light or quantum of a field, put limits on freedom. Events are limited to localities; size limits function; history limits development. Biological order is built on physical and chemical orders. That is why life is limited to such a narrow range of conditions. And that is why the most complex orders are vulnerable to changes in their substrates; energetic radiation can alter and destroy an individual, a small change in climate can destroy crops and civilizations.

7.8.2.2. Limits: Ecosystem/Global

Ecosystems and organisms depend on a complex set of conditions, which can be limiting factors. Organisms are affected by the quantity and variability of materials, if they require a minimum of them. Organisms are also affected by their own limits of tolerance to those materials. Life is limited by elements and physical factors. Such as light, water, gas, or salt. Life is limited by too little of an element (Liebig's law), as well as by too much of an element (Shelford's law of tolerance).

An ecosystem is forced to accept an upper limit, beyond which it cannot grow any further. Further growth results in destruction or disruption of itself and nature. This is an ecological law of the maximum. To survive, an ecosystem depends on the interactions and balance of many variables, most of which are not well understood. William Ophuls noted that nature abhors a maximum. While it is meaningful to speak of an optimum diversity, as the result of limits and the interaction of many factors, a maximum diversity may never be reached. As Paul Weiss noted, the patterns of organic nature are a combination of order and diversity; order involves constraint while diversity requires freedom for difference. Maximum order would result in a static universe, where a maximum freedom would create a nonordering chaos.

This is why is it *not* a tragedy of cosmic proportions when species such as sharks or sow bugs fail to respond to the lure of possibility. These species have fitted themselves to relatively unchanging environments and do not need to change for the sake of change or for the sake of diversity. We may not know what is the minimum, optimum or maximum forest cover for a particular watersheds. Science might try to identify minima or maxima but philosophy can aim at optima or satisficia. We are so ignorant of the complexities of ecosystems that it is suicidal to pretend to "maximize" their use for resources. A free market has to be limited by conservative calculations of ecological balance. It is almost impossible to estimate the economic value of natural balance.

The ecological social approach, or a redistributive environmental strategy, to development makes it irrelevant to discuss global limits to growth. Local limits are far more significant to the majority of the population—regardless of how much food exists, people will starve unless they can get it. Such an approach would also mean limiting humanity and its technological effects, limiting human use to local impacts, and letting other beings live without interference. It is not necessary to dominate or replant the forest completely to save it. Ecological planning has to consider the limits of ecosystems, as well as the limits variability and stability, in deciding how human activities mesh with domestic or wild ecosystems.

7.8.2.3. Limits: Human Psychological and Social

Some of our human problems are the outward manifestations of inner causes, as Ervin Laszlo argues. Our perception and thought structures have limits, as do tools based on them. Science has been logically limited, so far, with a predicate logic. Most theories are based on Aristotelian logic that is deductive and bivalued. Analytic science has reached its limits. Data and information developed by hard studies have undercut the paradigms that guided their investigation. The compartmentalization of scientific fields has exposed the complex connections of the subjects. Early science saw the world as mechanism; modern biology is seeing it as resembling an organism. Organismic trends can be seen in sciences, from relativity and Gestalt psychology to ecology.

Psychological limits may be the basis for some of the great failures of human life, for instance, the 'failure of imagination,' that limits our understanding and visions of future. We can explore planets and modify genes, but cannot seem to offer functional education or meaningful jobs, dignity in retirement, or goals for living. We insist on individual rights and freedoms, but neglect the whole framework for individual success. We cannot imagine the importance of difference or challenge. Our international system is going to produce a boring uniformity and a painful collapse. Humans can even create virtual worlds by limiting what could be received; for instance, if a being could see in the x-ray part of the spectrum. Yet, human imagination is limited, as is human knowledge. Many organisms exist of which we know nothing. Their worlds have little meaning in a human world. The 'failure of feeling' keeps values and morality as local effects. We do not extend respect or love to distant others. Our personal values and beliefs do not let us. Finally, the "failure of nerve" dooms us to cleave to the familiar, to ignore other alternatives, and to fear change or equality.

7.8.2.4. Limits to Human Cosmologies

Cosmologies have a sense of place, with its beings and features, which is necessary for information on how to live and to get food. The ecological benefits of rootedness are that people will take care of a place if they realize they are going to be there for a thousand years. Having a place means that the inhabitant has stock in it and participates in its unfolding, through planting and caring. Detailed understanding of plants in a locale allow gathering of food and medicine. People live in place, being in place as used here means in a human scale in unique surroundings. In place, they acquire a sense of community, nonhuman and human, as well as a shared set of values and concerns, and health and spiritual benefits. Many modern cosmologies, modified by advances in technology, pretend that the limits can be exceeded. The new scientific cosmology of biotechnology is still economic in a primitive sense. Only the myths have changed to include greater manipulation. It is still concerned with utility, growth and efficiency, as short-term goals. The problem with efficiency is that it is defined within such narrow limits. True efficiency means continuity over long periods of time, as with natural processes. Long-term exchanges in nature are not efficient in the industrial sense. The large sense of economics is the measurement of nature.

7.8.2.5. Economic Limits

The focus of economics, however, is rather narrow, in that the concept of resources is very limited and the unlimited wants of human beings are not much discussed. There is no psychology or ethics; there is no ecology or aesthetics (thoughts about beauty). There is no concern with the triviality of the free choice of a worthless 'doodad.' There is no concern with the welfare of the other beings that share the ecological community. Economics has to attempt to understand and predict the behavior of complex, interconnected systems where individual behavior and flows of energy and material are important.

Modern economics is committed to growth, but growth has limits. Development has fewer. There is no necessary association between development and growth, as Herman Daly and others have shown. Development means the introduction of an innovation. Economic development will require technology. Ecologically sound technologies could minimize stress to the environment. Economies could be modeled after mature vegetation and not successional vegetation, where diversity in scale is greater. Even ecological economics has limits. Any community is forced to accept an upper limit, beyond which it cannot grow any further. Further growth results in destruction or disruption of itself and its environment. This is the law of the maximum.

There is another distinction between growth and development. The ecological social approach to development makes it irrelevant to discuss global limits to growth. Local limits are far more significant. Redistribution of resources and improvement of environmental quality (home environment) are more important than increased production by sophisticated technology. The natural capacity of regional photosynthesis must be limiting factor in development, especially in tropical and subtropical areas.

The earth is finite economically as well as physically. No matter how technologically expert humanity becomes, the multitudinous beings of the earth cannot be 'produced' in the same manner as three billion years of evolution. Nor can we throw away the ambihuman dimension and ignore at that cost. There is no romance or honor in throwing away every life that we can. Economic culture defines the means of production and livelihood, the techniques of distribution, and the values and norms underlying economic behavior—and this can be more closely related to kinship. But, economics is ultimately transcribed by limits of human comprehension and imagination.

7.8.2.6. Political Limits

Politics is the art and science of human government. The first goal of politics is to ensure the survival of the human community. Then, it has to maintain the affairs of that community. Politics is the interactive means of providing the basic food and necessities of a community.

As survival is survival in nature, politics rests on an ecological foundation. The organization of a community must be in accord with natural laws. Political participation depends on information, much of which can be provided by observation and science.

Government has become subservient to economic actors, according to John B. Cobb Jr., partly because the ideology of economics is so positive. It proclaims that continued growth *will* solve most of the problems of modern civilization, from poverty to conflict, although the promise has not been fulfilled in the past 800 years. The problems have increased: Food shortages, housing shortages, energy shortages, unemployment, inequality of opportunity or goods, environmental deterioration, increase in weapons, and insecurity.

These problems continue due to the limits of politics. For example the size of society is a real limit; if there are too many people, within a limited territory or limited system, politics cannot provide them with an identity or control them. Size limits the distribution of things, such as food, housing, jobs and wealth, also. The time frame of the political society is also a limit; the short-range visions of national interest are often inimical to the long-range ecological requirements of the support system.

The participation of the members of a society is also a political limit. Communities have always had face-to-face limits, in terms of numbers of face-to-face encounters. In terms of distance, communities have always limits, also. The politics of community is small-scale and local. It is moral consensus is applied to daily operations.

Leadership is another limit; the pool of applicants is usually relatively narrow. The desire to use power is a limit. The will to power does not seem limited to the community, as does participation. The will to power can be found in human communities over 10-13,000 years. It seems to have evolved from the simple domination of other community members to all of nature.

Security is a problem for local communities and national governments. It becomes more difficult to protect against most any kind of weapons. Perhaps the solution is a global one, with the coordinated change in national policies and worldwide distribution of excess wealth. Human psychological limits can become limits for politics. Some facts result in motivation or fear—fear of the future in general, or of the reactions of others. One response is a defensiveness in face of an unpredictable future.

7.8.2.7. Limits of Human Populations

A population of the human species, like any biological population, is a group of individuals of one kind that allows the exchange of genetic information in a specific place. A population has unique properties that can be described statistically, such as biotic potential, density, dispersion, birth rate (natality), death rate (mortality), age distribution, growth form, and structure (in terms of isolation or territoriality). A population also has certain other qualities that can be described quantitatively or qualitatively, such as: dynamicism, variability, adaptability, reproductive fitness, and stability (especially persistence, the ability to leave descendants over time).

The population is the unit that evolves in nature, according C.J. Krebs. Populations interact in neutral, positive, or negative ways. Competition, which can be negative or positive, limits the number of species in a niche (this is the competitive exclusion principle, which Garrett Hardin states as: complete competitors cannot coexist). Niches must be different for species. Krebs states that the fundamental niche of a species has an "infinite number of dimensions," making a complete determination impossible. The limits of a niche can limit a population.

Many factors other can limit population: The environment (weather, water, heat), change (or catastrophe), food Supply (with minerals, trace elements), territory, predators, and psychology (the choice of or desire for certain foods or places). These factors also filter a population so that less fit individuals die before reproducing.

The cost of evolution by filtering (or selection) is so heavy that most of the time most populations are not perfectly fit to their changing environment, which they are changing in fact through living. Evolution never expresses total fitness; it requires destabilization, a risk accompanying all innovation. Self-presentation offers the possibility of new symbiotic relations or of extinction.

7.8.2.7.1. Population Change & Growth

Variability in resources and weather, as well as dynamics with other populations, cause changes in a population. As a result of these influences and interactions, a population can grow or shrink or die out. It can stay in place or disperse.

Natural growth of a population is related to development and maturity. Population growth occurs when the birthrate exceeds the death rate, or when immigration from other populations exceeds emigration. Under many circumstances growth confers a survival advantage. At some point a population stabilizes.

7.8.2.7.1.1. *Human Population History*. A population of individuals grows, or overgrows, like a population of cells in a body. And, individuals, like cells, receive signals from the environment that tell them when to die. Unlike cells, however, which rely on chemical signals, these other signals are in the form of food supply, climate, and predators. Some animals try to avoid such signals by moving; some plants try to avoid those signals by growing larger or producing chemical defenses. Human beings have used movement and technology to overcome those signals. And, we have become very good at converting ecosystems to food systems and using technology to control our home environment.

Regarding the success of human population growth, it is possible to relate it to explicit changes in ideas and technology. Agriculture, for instance, sparked an acceleration in population growth. It offered more food in one place. It allowed a sedentary lifestyle, which permitted larger families, especially to increased labor requirements. This increased population density in small areas. And, it triggered a demand for more food to feed more people in a permanent area.

The ideas of storage and urban settlement allowed more people to live together. But, large populations allowed diseases to survive, also, including those that would die if human populations were isolated. Other changes that permitted growth included improvements in sanitation, water and waste flows, and building.

Urban cultures responded to population growth by intensifying resource extraction (which still continues with the green revolution and genetic engineering), by relying on more technology (that can result in overfishing or overharvesting), by integrating support systems, e.g., transportation and banking, by increasing centralization, bureaucracy and stratification, and finally by migrating.

Cities grew and continued trading at larger scales. Early globalization affected populations by introducing diseases from other groups into isolated populations, resulting in catastrophic losses of peoples. This lead to changes in immune systems, also more symbiosis between hosts and agents, and much later, to public health changes like sanitation.

7.8.2.7.1.2. *Growth of Human Populations.* Human populations have been able to overcome many internal and external problems, from stupidity and greed to overconnections and collapse. The growth of the total human population over the past 60,000 years is an obvious gigatrend, but single populations advanced through losses and gains, depending on conflicts, diseases, and droughts, as well as on advances in technology and social structure. In Europe for instance, the Black Death and then Thirty Years Way killed 85 million and 110 million people respectively, which caused losses in populations that took centuries to recover. Despite setbacks from diseases and wars, the most explosive growth trends, measured by doubling rates, can be compared to changes in lifestyles, as illustrated in Table 782712-1.

Table 782712-1. Doubling Rates Related to Major Lifestyle Changes

Style	*Years to double*	*Population*	*Date*
Foragers	6,760 years	10,000,000	12,000 YBP
Farmers	1,922 years	500,000,000	400 YBP
Urban Workers	200	1,000,000,000	200 YBP
Energy Slaves	33	6,000.000.000	3 YBP

Human population history can be represented graphically with a long j-curve that is exhibiting exponential growth. Most marriages had over 2 surviving children. The population 2000 YBP grew to 250 million. By the time the Industrial Revolution was developing in 1700, the population was 500 million. In 1800 it was 1 billion, and by 1900 1.6 billion. By 1950 it was 2.5 billion. And, it increased to 6.1 billion by the year 2000. Again, the increase has not been uniform. Some nations in Africa and Europe have experienced declines in populations, for various reasons.

By 1960, in many western nations, such as Norway, the rate of increase started to decline. Some theorists related this decline to the increase in wealth and security. Others suggested that education and new methods of contraception were responsible.

7.8.2.7.2. Discussion of Population Futures

The drawdown of resources, in fact the use of a significant percentage of productivity—enough to threaten biological and ecosystemic renewal, has allowed the increase of populations as well as the expanse of luxuries to exceed the limits posed by annual productivities of food and fossil fuels. Paul Ehrlich has related the impact of population to the population size, its affluence and its use of technology (in the IPAT equation). However, many other factors can influence impact, especially our cosmology, that is, our image of nature as a machine capable of indefinite modification and perfection through substitution and repair, contribute to the overall impact. Industrial economics, also based on the machine model, and partial democratic politics, which continues it, have justified the overshoot and the destruction. Paul Shepard concludes that this has become a form of madness.

The demographic transition, which was hypothesized in 1945, suggested that as people got richer and more urbanized they tended to have fewer babies, in fact so few that they would not be able to replace themselves. Over 60 nations, with half the global population, have transitioned and have shrinking populations. The magic number for replacement rates is a birth rate of 2.1 or higher. This should keep the population stable. Some nations, including Bulgaria and Russia, are experiencing population loss, from emigration or from new diseases. Some nations responded to the decline by encouraging more immigration. Others, including the United States and France, are experiencing population growth again. In August 2009, a study in *Nature* magazine revealed that 18 of the wealthiest nations have birthrates that have started climbing after decades of demand. There are two basic factors that influence population change; one is the total fertility, the number of children a woman would expect to have, and the other is the level of the Human Development Index (HDI), developed by the United Nations. This measure combines per capita gross product, education and life expectancy to measure the development of a country. After the end of the decade, the HDI approached the highest possible number in many nations. The authors concluded that increased birthrates suggest that wealthy nations do not need to fear population implosions that could destabilize the nation. That birth rates in the wealthiest nations are rising again, reversing earlier declines, may be the result of heavy immigration, as people with higher birthrates migrate to these countries, instead of being the result of a rebound in native births.

Recognizing higher rates in some developed nations, some scholars are challenging conventional notions about the environmental impact of more people, leading them to embrace what they call counterintuitive solutions such as larger cities. Unfortunately, having larger cities is not the same as a having a higher population--the two are not equal. Larger cities may indeed reduce the impacts of a stable population, but often both are increasing. José Guzman claims that a world population of 7.8 billion people could inflict greater damage on the environment than one with 10.8 billion. So what? Any larger flow of materials means that the larger population will inflict greater damage. The poor people may inflict less damage on the environment, although a shift in wealth could cause more damage. However, if global human population is stable at a high number, it will still do more damage to the environment. One argument is that with shrinking populations, there are not enough young workers to sustain a vibrant economy or to pay for social welfare programs to support that the poor and elderly. All of these arguments assume that the current economic growth is maintained. Some people also say that low birth rates could create a perpetual economic crisis. This again is true only if we cleave to the industrial economics scenario.

The demographic transitions may assume a stable population. However, a population characterized by low replacement and high immigration, like the United States, can have an increasing overall population.

Stewart Brand warns that a plummeting birth rate could be terrible news for the environment, since the trend could cause social and economic chaos. That may be true with the assumption of the current economic situation with its requirement for growth. Brand also claims that wars will be more likely in the crisis, and there will be more damage to the environment from wars. And, that prediction has to assume the current economic and political trends that see war as the only response to harm or lawlessness.

Another factor is the aging of populations. In developed nations, populations are generally getting older. In less developed nations, populations are getting younger. Another factor is the shifting of populations through immigration and emigration. Consumption levels are of course a problem. Gusman suggests that it is unrealistic to believe that problems such as climate change and habitat loss could be resolved simply with massive family planning programs in poor countries. This is true of course, but what we need to do is solve the suite of problems as a response from total design.

The wealthiest countries account for a large number of new emissions that might contribute to the greenhouse problem. This can be linked to consumption patterns. One factor of aging populations in nations would be the general reduction of emissions, since old older people tend to live in smaller places, travel less and consume less. Not many people argue that cities hold the best chance for a sustainable future. This is what others have been saying for many decades. Large cities, such as arcologies, could reduce the footprint of the population on land.

Traditionally, population growth has been a simple issue of the pressure of numbers against resources. However, there are many other factors that contribute to this, such as lifestyles, energy use, waste, and ecosystem conversion. Population is a complex issue, but many pundits try to simply it by saying that if populations continue grow, the economy will do well. That might be true if resources were infinite and ecosystems were invulnerable, but they are not. Others say that the danger is a confrontation between a pessimism and smugness. Neither is a good approach to addressing the limits on or impacts of populations.

Design of populations through planning has to balance migrations, levels of luxuries, needs, inequities, and many other things. International agreements can balance emigrations and immigrations. Some violence erupts from uncontrolled migrations, but this can be ameliorated with the lessening of institutional inequities and the need to migrate. The United Nations control of common areas, especially the entire atmosphere and hydrosphere, can set limits for the unbridled expansion of economics and populations. Finally, a shift in human consciousness, that results from new images of the planet and human destiny, could make these changes agreeable and desired.

7.8.3. *Global Surveys & Inventories*

Ecological planning and design has to reflect our understanding and use of the planet and its regional and local systems. Each activity needs to be fed back into the process to update it. Implementing the process should result in improvements to it. The process could be applied in stages: Stage 1: Inventory the system; Stage 2: Analyze the system; Stage 3: Establish Zones for Protection and Use; Stage 4: Create Specific Plans and Designs; Stage 5: Put the Design on the Ground; Stage 6: Monitor Activities; and, Stage 7: Evaluate and Refine Manage Plans.

7.8.3.1. *Stage 1: Inventory*

We need to collect knowledge about ecosystems, from local people who know something of the recent history, or from tribal elders, who may have cultural knowledge, or from other sources, such as written reports (from Lewis-Clark or early surveyors), maps, and aerial photographs. This requires research and researchers make narrative reports on findings.

The next part of the inventory is a walk-through, which gives you a rough idea of the state of the system. For example, in the walk-through of a forest, you will look for geological characteristics, wildlife, sensitive plants, number of stems, snags, large downs (or downed woody debris, nurse logs), reproduction, and fire potential. The walk-through may be informal (follow trails) or formal (create and follow a grid, marking distance by chains). If you do not have aerials or maps, this is a good time to make your own map; be sure to establish easy to find reference points. You will record this information on forms.

An ecosystem inventory is the primary source of data for planning. The cost of complete data is considerable, the more complete the more considerable, but you must have data to make any intelligent decision about a system. A partial inventory is better than none.

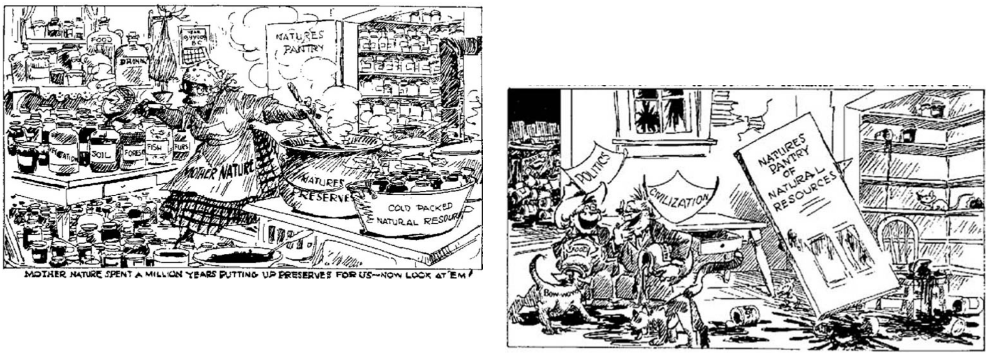

Figure 7831-1. Nature's stocks: Inventorying the Pantry (from J. N. Darling, 1940s). This is reminiscent of a statement by the philosopher, G. W. Leibniz (1683): "man's knowledge of nature seems to me like a shop, well-stocked with goods of all kinds but lacking any order or inventory."

7.8.3.1.1. Techniques for Inventorying (and Monitoring)
One of the roles of a tribal shaman was to sense and know the health of prey animals and plants. If they were too few, then taboos or restrictions were imposed on the people and they had to find other food. This kind of traditional ecological knowledge is still important, although we now have sophisticated techniques for observing systems of plants and animals.

7.8.3.1.1.1. *Remote Sensing.* The first images of the earth from the sky were captured in balloons and airplanes. Aerial photographs are still used for many local property ownership maps. The U. S. Forest Service has used remote sensing since the 1930s to manage diverse and ecologically complex landscapes. High-altitude photography has been used since the 1940s, and satellite data (film and magnetic tape) has been available since the 1960s. As the technology has become more efficient and cost-effective, the amount of data and the uses for the data have increased.

Satellite remote sensing is a preferred tool; satellite data for compiling estimates for area surveys is a less expensive substitute for more expensive aerial photo surveys, which were a less expensive substitute for on-ground surveys. Most of this data comes from a Landsat satellite, from the U. S. space program, since the early 1980s (other recent satellites include SPOT). Landsat provides data from a wide spectrum. The data has to be analyzed and mapped to the landscape using a program such as VICAR/IBIS. Furthermore, the field data must be correlated to the Landsat spectral analysis.

7.8.3.1.1.2. *Geographic Information Systems*. Analysis can be done with a computer-based Geographic Information System (GIS). The objective of this discussion of GIS is to present the technology. Each discipline has its own language. GIS is a composite discipline formed from a combination of geography, cartography, computer science, topology, image processing, information theory, and all of the "content" applications—civil engineering, biology, natural resource management, environmental sciences, and dozens of others in which it is used. What this means, among other things, is that the language of GIS is a composite of terms originating in other fields.

Classification results in a GIS vegetation data plane that contains species, canopy cover, habitat types, and quantitative information such as timber volumes. Vegetation classes are used for many applications, including mapping old-growth timber, mapping wildlife habitat, and designating fire classes. In 1988, the U. S. Forest Service initiated a national strategy for implementing GIS technology to manage resource information. Notice the ever-present assumption, that everything is a resource to be managed—in fact, people's values can distort GIS maps as easily as any maps or word models; furthermore, conclusions drawn from GIS maps can also be inaccurate, regardless of the accuracy of the data.

GIS is an information-processing tool to manipulate resource data to support organizational decision-making. In a sense, any computer system that can incorporate, analyze, and display data is a form of GIS. The system is a combination of human skills (also known jocularly as 'jellyware') with appropriate computer hardware and software (the programs that tell the hardware what to count). Data is fed into a database in layers, which can represent different aspects of the geography, such as topography or vegetation types (these layers strongly resemble the "layer-cake" model that Ian McHarg used in his book, *Design with Nature*); various operations, such as attribute searches or connectivity analyses, can be performed on these layers either singly or in any combination to address specific problems. The results of the operations include tables, graphics, or map-like products.

Before satellite data analyzed by GISs, ecologists did not have tools that could address the scale of landscapes. Regional and global data was hard and expensive to collect. The International Geosphere Biosphere Program (IGBP) coordinated by the U.N. uses GISs for global and regional issues, such as deforestation or desertification. The large images from satellites are exceptional for identifying landscape patterns, especially those related to the scale of species behavior, such as home range or breeding dispersion. Pattern can also be measured at the level of patch size and spatial relationships (that is, inter-patch distance), which is critical for relating the size of a habitat to the species in it—for instance to test or to apply theories, such as the theory of island biogeography.

The data derived from satellite imagery and from field studies can be used to model the landscape at various levels. Some of these tools will be used for specific problems in the classification of forest ecosystems and harvesting schedules.

At some time you, as an informed citizen or consultant, will be exposed to GIS based analyses and decisions. This arises particularly with respect to the plans of public land management agencies, but also with respect to proposals from nongovernmental sources. Neither cartographic beauty in map production nor technical sophistication in spatial analysis bear any necessary relationship to the accuracy of the information or the validity of the conclusions presented. In fact, the conclusions may have preceded the GIS analysis, which was then undertaken for the purpose of supporting them (often the way with science). The mere assertion that the conclusions are supported by the analysis does not prove they are.

7.8.3.1.1.3. *Land Surveying*. Most natural boundaries can be identified by sight. Legal boundaries, however, are composed of imaginary lines through the landscape. In the USA, two major systems for subdividing land are used: (1) the irregular metes and bounds method used by George Washington and throughout the original 13 colonies, and (2) the rectangular surveys attributed to Thomas Jefferson, adopted by Congress in 1785, and applied to most of the public lands in the country.

Metes and bounds survey lines follow ridges, streams, and roads, although they can follow lines of a specified angle *(bearing)* and distance from one established corner to the next corner. The rectangular survey system is laid out into square areas (with specific exceptions due to the curvature of the earth), the largest of which is a *township* of 6 square miles (23,040 acres), containing 36 sections of 1 square mile each (640 acres). Sections are divided into four quarter sections; quarter sections are divided into 40-acre tracts one-fourth of a mile square. Forties were not surveyed out in the early surveys, but their lines have been run out as land became subdivided.

To create a local map, the first step is to obtain base maps for the general area of the property. These maps provide orientation. You can obtain maps of the county showing subdivisions from records in your local county court house. In map making on private or public lands, the primary concern is with sections and forties within sections.

7.8.3.1.1.4. *Cruising*. Once the zones are established, each zone should be refined, in its margins and content, with field data. Using forest characteristics and the principles of ecoforestry, you should be able to set the objectives for each zone (a list or table will do).

Establish permanent plots and cruise them. Field data is collected in an orderly way, along routes in the forest determined from maps and air photos, and adjusted as necessary in the forest. Field data collected includes soil, water, plant, animal, timber, terrain (landforms), and other information that is important to understand and use forests in ways that do not impair their functioning.

At this time, you should establish a series of permanent plots with photograph points. You should take the first series of ground-level photographs.

7.8.3.1.2. Conceptual Tools

(Being edited)

Conceptual tools are necessary to frame, relate and support the physical tools and techniques that we use to inventory and monitor the planet. Two conceptual tools are Gaia Theory and global ecological design.

The Gaia theory advanced by James Lovelock offers testable hypotheses and models, notably Daisy World. This nonlinear model has strong positive and negative feedbacks that link the biosphere to atmospheric composition. It is not an equilibrium model. Thus, even if no extra carbon dioxide were produced for years, the planet would stay in the hot state. Lovelock says stabilization seems only possible at 5 degrees hotter or 7 degrees cooler than it was about 200 years ago. The transition from negative to positive feedback occurs at sensitive points, not just anywhere. The long-term climate history of the earth shows the existence of several stable (but quite different) states. Present day models do not predict their existence. Climate theory is based on atmospheric physics. Lovelock points out that to be complete it should be based on geophysics, biophysics, and ecosystem science as well. The earth seems to have two stable states: greenhouse and icehouse, with metastable states between, like interglacial. The Eocene hothouse was 55 million years ago, the dawn of mammals.

The Gaia Theory can help us relate the special specific characteristics of the global ecosystem with temperature, atmospheric composition, cycling, diversity, and ordered change, that the planet as a system influences. The theory itself is no longer thought of as optimizing Gaia, but more satisficing. It is now less self-regulating and homeostatic, with negative feedback than strongly coevolutionary.

Global Ecological Design is concerned mostly with fitting human activities within the framework of the planet. It can try to minimize the impact of human activities on the global anatomy of the planet, and to minimize the impact of the planet on human constructs. Global ecological design is a human process that considers the emergent and unique factors of the planet. We have to change the framework so that we can shape new approaches. At the biophysical level, global design has to address many more systems as well as the new emergent properties of the globe. (Section 2.6.2.1.) Emergence of a whole system that allows diversity and evolution in frame of place. At the level of ecocultural play, global design considers the sum of cultures and evolution acting on planetary patterns, allowing for failure and development. In terms of ecological economics, global design has to consider economics as the basic exchange of energy and elements at all levels. And, at the level of global design, values are expanded from human and species to those useful for the planet.

This design addresses a global scale. Many global rhythms are influenced by the tilt of the earth and its orbit around the sun, as well as its movements in the plane of the planets and through interstellar dust lanes. Dramatic conversions of forests can create tensions in the mature temperate or tropical forest landscape, as well as with global chemical cycles and rainfall patterns. In global ecological design, many human landscapes can balance wild landscapes in nested levels. Principles of global ecological design either emerge at the planetary level or become more important at that level, such as the Principle of Wholeness, which states that a whole emerges from the interactions of parts and that whole is more than the total number of parts. These principles also result in a further qualification of standards and behaviors, especially limited actions, such as protecting diversity (Section 2.6.7).

7.8.3.2. *Stage 2: Analyze the Landscape*

Once you have determined the pattern, character and condition of the landscape and particular sites, you can indicate them on your map (graphically with patterns or color). The character describes the pattern of habitat types (species of plants and animals), as well as patterns of age and reproduction. The condition indicates how human activities have changed, damaged or improved the state of an ecosystem, as well as the landscape pattern. For instance, the No Name Creek watershed, which is part of the larger Flanagan Creek watershed, which is part of the Palouse River watershed, which drains into the Columbia Basin, much of the forest surrounding Altazor Forest (See Section 4.6.2 in *Redesigning the Planet: Local Systems*) has been cleared for fields; virtually all of the rest of it has been cut using a variety of methods.

7.8.3.3. *Stage 3: Establish Zones for Protection and Use*

The primary concern of an ecological plan is to protect the framework of the ecosystem for all organisms during human use. That means that the habitat of key species has to be preserved. Grandparent trees have to be protected in old-growth areas. Ecologically sensitive areas—steep or broken slopes, shallow soils, xeroscapes (really dry areas)—have to be used lightly, if at all. All riparian ecosystems (rivers, creeks, streams, lakes, ponds, wetlands--all water courses) have to sustain minimal human interference. Animal and plant corridors, especially cross-valley corridors that cross ridges between valleys, need to be maintained for critical movements; remember, many animals, such as bear and deer, require different habitat for eating, mating, and sleeping. The result is an interconnected network of protected ecosystems extending throughout the forest.

Once the protected landscape network is established, the remaining forest areas are zoned for uses to provide for human and ambihuman needs. Forest use zones include culture, recreation-tourism, conservation, fish and wildlife, wilderness, trapping, timber, firewood, and alternative products. None of the uses in these zones should damage the forest.

For regional and global patterns, regional and global zones have to be established and maintained, even if by benign neglect.

7.8.3.4. *Stage 4: Create Specific Plans & Designs*

Field data can either be summarized in one grand ecological plan or in individual plans. If in individual plans, as many of the following as possible should be completed: Landscape plan, Watershed inventory, Soil report, Road plan, Zone plans, Harvesting or Use plans, and a Restoration plan (if necessary). The plan(s) provides an overall picture of the parts of the forest landscape and stands, and how they are functionally interconnected.

If in a grand plan, then more questions have to be asked. Conservation biology recognizes the need for planning at a landscape level. Conservation biology also attempts to answer vital questions about forests.

- Considering that as little as 10% of forests survived in isolated refugia during the ice age, is it reasonable to conclude that today's forests are supersaturated as some industrial foresters claim?
- Given current trends, what rates of forest loss will occur in the next decade? Will the curve be linear or exponential?
- Will the extinction spasm of millions of insects and fungi have a greater effect on forests than other extinctions (such as Pleistocene megavertebrates)?
- Will a major (90-98%) loss of forests in developing countries (especially in the Amazon) be more risky than it was for Europe and North America, considering how relatively slow the changes were in North America and very slow in Europe?
- Can conservation biology provide tested strategies for conserving biodiversity at various scales of space and time?

To answer these questions and others, as well as try to meet its goals, conservation biology must start major taxonomic pushes to classify and inventory species in every kind of ecosystem, using residents, biologists, computers, axial tomography, and nuclear magnetic resonance to collect and scan specimens. It also has to start to plan for future biotas, that may be less beneficial for humanity. Many of these will be restored or assembled from exotics, reintroduced natives, or engineered species. To address problems of inbreeding depression and loss of variability in small populations, molecular markers should be used in a framework of conservation genetics. Biotechnology might also be applied to problems with exotic species that cause damage to the integrity of ecosystems. Cryogenic techniques could be used to suspend material from rare or endangered species. On a large scale, science has to plan for changes in the evolutionary process as a result of massive human technological and social impacts, e.g., slower rates of speciation due to confinement of wild populations. On a national level, people have to build interest in diversity projects, such as salmon or old growth. And, on that level, people have to concentrate on several highly visible successes.

Based on this picture, the protected landscape network and activity zones may be revised. Then, detailed plans for on-the-ground activities are prepared for each zone. Using forest characteristics, the principles of ecoforestry, and objectives, you should be able to set standards for each zone, e.g., number of intrusions, number of snags left or created, or canopy coverage. The standards are established to set limits and provide direction for activities so that the forest is protected at all scales in the short and long terms.

Because the designs take place within a human culture, people also have to analyze the activities to prepare a cultural and financial plan. The whole idea of valuation in ecology is to have enough knowledge (or guesswork about the possible value) about the system to create an intelligent plan that can guide its preservation and use. As Herb Hammond has noted, however, guessing at a value and then requiring a major percentage of it to be exploited has no real basis in an ecological inventory and assessment.

Rather than remeasure the entire forest every year, foresters prefer to measure a number of permanent circular plots, keeping track of ingrowth and cutting. The CFI system does not replace regular inventories. Once you know what you want to do, and where, in the forest, as well as how, you need to find out how much these activities will cost and how much revenue you can expect from the goods and services.

This analysis ensures that your activities will be profitable without degrading the forest. If timber cutting or leasing is determined to be unable to generate adequate revenue to cover costs, then this activity can be abandoned before people are tempted to "cut corners" and degrade the forest in order to achieve short-term economic success. Your economic goals should include covering costs, ensuring that sufficient revenues are generated to cover future costs, such as equipment replacement, improving forest health and aesthetics, and guaranteeing that workers are paid fairly for their services. Many of these activities may not be considered profitable under conventional timber management.

Part of the analysis is investigating markets or places to sell your products or services. A business plan provides a practical blueprint against which you can check your day-to-day, or month-to-month financial picture; it compares the costs of activities with the revenues received from them. Based on the plan, you should also consider borrowing money for short or long term.

7.8.3.5. *Stage 5: Put the Design on the Ground*

The knowledge and planning can now be applied in the ecosystem, region or planet. Within the limits of principles and standards, you can begin laying out the human infrastructure (trails, landings, buildings) and performing the activities that are beneficial or profitable. As you work you should be adding feedback to the plans; for instance if a granite outcropping makes a road in one place prohibitively expensive, we need to reroute or reconsider the road.

7.8.3.6. *Stage 6: Monitor Activities & Edit Design*

In order to understand the effects of your activities, as well as the natural changes in the forest, you must start monitoring a number of vital things. Monitoring ensures that standards of ecoforestry are followed for the duration of the activity. Monitoring also allows the standards for the activities to be revised to increase the protection of forest functioning and to increase your efficiency.

7.8.3.6.1. Establishing a Context for Ecosystem Monitoring (After Richard Hart)
Richard Hart recommends laying the foundation for a new approach to assessment and monitoring, with a scientific approach at its core to account for the act of observing and recording the entire ecosystem. This approach is based on important observations. The actual substance of which the forest environment is made consists of *patterns* rather than things or individual species. The environment is generated by a patterning of an ecological ebb and flow of energy, substances, individuals, and species across a suitable landscape. Successful adaptation to this complex system requires an enormous number of minute local adaptations by a large number of individual organisms from a large number of species. The distinction between growing and declining patterns is not arbitrary, and can be arrived at objectively. And the environment is constituted of a large set of events that are objectively definable by specific outcomes. The procedural consequences of these facts involve practical changes in the relationship:

- Between the planet and its species over space and time
- Between the planet and the collective ability of species to respond flexibly to situations beyond their normal patterning in the processes of adaptation and repair
- In the flow of energy through the environment and its biotic community
- And, in the ecosystem's collective patterning of shared needs and governance which can be defined as its health.

"Taken as a whole, the process of observing patterns in these relationships leads directly to a fundamentally different way of perceiving ecosystem management," according to Hart. We need to review our perception of how species link with one another. We have names for species but we not for their dynamic relationships. We have labels for bundles of relationships, such as aquatic macroinvertebrates, yet, as an example. We do not have a label for the relationship between a caddis fly and dipper. They both have similar needs, but they also have very dissimilar ones when they enter each other's environments. They each follow distinct patterns that overlap to meet their needs, and fulfill the function of their relationship. Traditional labels such as predator/prey need to be expanded upon to more accurately portray the full intricacy of natural relationships. In addition, for each direct species to species relationship, additional bundles or sequences of indirect interconnected relationships spiral outwards logarithmically into the ecosystem and the biosphere as a whole. Indigenous peoples have names for many of these relationships, usually in verb form, such as pollinating, germinating, shading, or camouflaging. They understand and respect the importance and intelligence of species connectedness.

7.8.3.6.2. Relationships are Generated by Rules of Adaptation
It is obvious that relationships are fundamental. What is not obvious is that these relationships are generated by rules of interaction. Each species is ultimately a product of the rules inherent in the gene system; interaction of those rules creates and sustains its life. The generative rules are relatively simple in comparison to the complexity of the end product. This is accepted as a part of bioscience, but for most people it may not be emotionally real. The idea that there can be a set of rules which ultimately generates the environment can be difficult to comprehend, because the rules themselves are not physically apparent. As a result, the idea of systems of rules actually generating structure is not widely shared. The point is that the structure of ecosystems at all levels is not random, but is strictly adaptive, according

to straightforward principles.

In this generative sense, rules actually create the species in an established order during the course of embryonic development. Over the course of many generations adaptation occurs and the generative rules are "revised" by evolutionary processes to fit changing circumstances. Hart emphasizes this, "It is by observing the interaction of the set of rules that one can begin to generate the kinds of monitoring pertinent to the ecosystem's well being." Monitoring the connections is important because it brings the inquiry back to the ultimate intent of ecosystem management—the attempt to discover and describe the structural correspondence between a species and its environment. A healthy species not only fits its environment well but also defines or clarifies the collective life it adapts to. We perceive this clarity to be the richness and wholeness of ecosystem structure. An unhealthy or absent species confuses the collective life, and we perceive this as static, fragmented or degenerating environment. There is a correspondence between the holistic behavior of a species and how it can be seen to relate to other elements of the ecosystem.

The distinction between wholesome and defective structure is a matter of fact, not value. Other species are there, such as pathogens, to take defective structure back down to its basic components, to be reinvested at another level of suitable structure. This process of reinvestment is vulnerable to (unnatural) disturbances when its patterning does not possess adequate information for a balanced response. The ecosystem will proceed to construct and repair according to its established patterns, no matter how disrupted or fragmented it has become. After disturbances to which the ecosystem is not adapted, it may take a considerable amount of time to re-establish the life community, even when there is sufficient resources available. The free functioning of a forest ecosystem (within the bounds of natural disturbance regimes), is not only the key to its current structure, but is also the source of holistic patterning over time and space.

The forest ecosystem is a large-scale pattern of millions of minute events. The environment requires an enormous amount of minuscule local adaptations between the earth and its users. The essential intent of ecosystem management is to initiate and maintain a fabric of events that weave through the common connecting points for all species events within the forest in a 'neutral" or beneficial fashion. The ultimate goal is to collect the information that details the establishment and maintenance of "comfort zones:" Climate, nutrient and mobility suitable for species viability.

Monitoring shows how the ecosystem is changing and at what rates. It shows what areas of the system are critical for its functioning and ecological integrity. It may give an indication of how to rank values in the forest. It shows how use of the forest can be balanced and how the use can be zoned according to degrees of protection and use

7.8.3.6.3. Monitoring

"Monitor" means to observe for a special purpose or to regulate (a machine or process), from *Webster's New Collegiate Dictionary*. I.F. Spellerberg defines monitoring as the "systematic measurement of variables and processes over time for a specific reason," such as ensuring that standards are met. In the last topic we were concerned with measuring the area and content of forests; this week, we will address the measurement of the parameters that define patterns that indicate health or change in a forest.

There are many groups at international and nationals levels measuring the environment in general. The US Geological survey monitors hydrological cycles; the National Oceanic and Atmospheric Organization studies climate. The United Nations, the Environmental Protection Agency, and The Nature Conservancy, among others, have established long-term ecological monitoring programs. The National Science Foundation administers a long-term program with a network of representative ecosystems, including forest ecosystems. Two of the research sites are the Harvard Forest (temperate deciduous forest) and the H. J. Andrews Experimental Forest at Oregon State University, where topics include: Successional processes, forest-stream interactions, population dynamics of stands, effects of nitrogen fixers on soil, disturbance in landscapes, and patterns of log decomposition. Started in 1989, this program collects data on long-term trends in ecosystems, that is, patterns of primary productivity, organic matter accumulation, inorganic inputs and movements through soils and water, disturbances, and populations.

There are different levels of monitoring, including environmental, biological, and ecological. Environmental monitoring is an umbrella for many activities, including climatic variables and geological processes; for example, the systematic recording of soil and air temperatures, humidity, air pressure are measured by meteorological organizations to predict long-term climatic change.

Biological monitoring, according to J. Cairns, is the regular, systematic use of organisms to determine environmental quality; that is, the state of the environment can be analyzed by how individuals react to pollutants,. British Columbia, for instance, uses target species of small mammals to intensively monitor the impacts of herbicides (which are used to try to control early succession) in the Coastal Western Hemlock Biogeoclimatic Zone on Vancouver Island and the mainland; they put live-traps or pellets along transects to get counts of mostly mice and shrews. Biological monitoring has numerous subcategories, such as the biochemical, microbiological, epidemiological, and biotelemetry. Pollution affects the productivity of trees. Lead (from combustion engines) in tissues (which interferes with red blood cell survival in mammal bodies) can slow plant growth. Particulate matter (smoke, ash) impairs stomata in plants. Sulfur dioxide (from blast furnaces) causes tissue degeneration and interferes with enzymes in plants. Lichens are good indicators of sulfur dioxide pollution because different species vary in their tolerance; fruticose lichens are very sensitive, while crustose seem to be most tolerant. Acidification (from evaporation of wastes) comes from many acids, and depresses microbial activity and decomposition.

Ecological monitoring is the observation of communities to understand long-term ecological processes, such as succession and maturity. We will concentrate on environmental monitoring to chart changes in a forest, but we should always be aware of the other two.

Before monitoring can begin the objectives and data collection methods have to be nailed down. The purpose of the monitoring program has to be stated; the objectives have to be identified, e.g., the health of the forest. Health will probably be your first objective, followed by production or aesthetics. Health can be "defined" by a set of indicators of health, such as species, or patterns of health, such as stability or productivity. None of the indices that are measured are really adequate to define the health of the forest because they cannot account for the complexity, richness, and cycling that goes on in the forest. For that reason health indices are data that need to be resolved on the ground in person by someone who knows the history of the forest and has a feel for it.

The basic medical definition of health used to be freedom from disease. Part of a new definition is resilience to stress—of course, there is good stress (eu-stress) as well as bad stress. Ecosystems respond to stresses in different ways, but usually through a decrease in the indices mentioned.

7.8.3.6.4. Goals & Objectives

Monitoring is needed to provide a general characterization of the general "physiology" of the system, including the ecology, biology, and hydrology, and to suggest a set of primary indicators that can be inventoried, understood and monitored over time. Monitoring can provide guidelines for The processes are easy to learn and relatively inexpensive. But we should not be deluded into thinking we are gathering cheap information.

The information needs to be credible, and gathered strategically and carefully. It needs to be entered into a data management system that is both relational and spatial. We are not looking for easy "cures," nor are we presuming to reduce nature into numbers. We are looking for and gauging relationships and their patterns—including our own. Gauging is a way as determining the capacity, volume, or contents of the patterns. This is not for the purpose of making value judgments, an activity common to many forms of life, but for observing how and if the ecosystem is responding to its own needs, and what resources it has available to do so.

What makes something valuable is not in its own properties alone, but also in its relation to the ecosystem as a whole. The "usefulness" of a thing or species does not rest solely in its appearance as an individual entity, but rather in its existence in a web of relationships. How it "is" essentially involves a complex series of relationships between the various events that are going on inside and outside its boundaries over large and small spatial and temporal scales. To understand the physiology of the forest requires that all view-points be considered together (top-down, bottom-up, across the landscape, etc.). The health of forest ecosystems essentially determines our health—physically, socially, economically, and spiritually.

As a result of their monitoring woodlands in Britain, G.F. Peterken and C. Backmeroff propose a set of useful rules for ecosystem monitoring:

1. Any variable or process which can be readily measured and dated may be valuable in detecting changes in ecosystems.
2. Long-term monitoring must be supported by administrative continuity otherwise the program may simply be overlooked or forgotten.
3. Facilities are required to ensure (i) survival of records and duplicate copies or records, (ii) markers locating the transect or quadrat and (iii) that the program is known to exist.
4. Repetitive recording is obviously necessary and although it may not be necessary at regular intervals, further records should be taken after or prior to any formative events.
5. The monitoring locality should be inspected regularly (annually for a woodland) even if information is not collected.
6. Although objectives of the monitoring need to be defined, recording aims should be open-ended. The basic systematic record should be supplemented with casual adjuncts which have a habit of being valuable at a later date. This is because we do not know how the data could be applied in the future.
7. Simple variables and processes well recorded are more valuable than poorly recorded complex variables and processes. It's better to record something rather than nothing.

8. Representative records and replicates should be established if possible but even an unrepresentative sample may be valuable in the future analysis.
9. Regular analysis and preparation of reports, even at early stages in the monitoring help to improve the methods for data collection and help to refine the objective. These reports also serve as a reminder of the program.

Two approaches to monitoring can be distinguished that are vastly different in scale, precision, and cost. The first is relying on scientific apparatus, which is accurate but often requires you to know the problem in advance; physical and chemical analysis are expensive and technology and labor-intensive. Identifying the indicator species may be difficult. The second is mapping biological indicators, which is a quick inexpensive survey in the field. Basically, this means walking or crawling (as Gary Snyder recommended once) through the ecosystem with your senses open.

Each approach has advantages. Scientific instruments are not only capable of detail down to a nuclear level, but, in the case of satellite imagery, great scope at hourly intervals. Infrared detectors (and others at other wavelengths) on satellites can differentiate stress-affected trees from healthy ones.

As you know, the sun produces a unique spectrum (every star does because the composition and size of each star is unique) of electromagnetic radiation, mostly in ultraviolet, visual, and infrared wavelengths, that is intercepted by the earth as it revolves and rotates. Some of this radiation is intercepted by the leaves of trees, which reflect a percentage back to space, where they are detected by special films or scanners on satellites.

Remote sensing can detect some forms of damage immediately over inaccessible stands over large areas. Although not all forms of stress can be detected by remote sensing, there is still a lot of the spectrum (ultraviolet) that has not been investigated. On the other hand, on-the-ground monitoring is probably more labor-intensive and more expensive. The two styles of monitoring forests are supplementary; satellites can pick up dramatic changes, which can then be investigated on the ground. Satellites are not a replacement for ground work, however. Remote sensing and field work are complementary.

7.8.3.6.5. Key Indicators for Monitoring

The following descriptions of each indicator outline the specific attributes which can be measured, as well as an explanation of why they contribute to our understanding of forest health. It is anticipated that as our understanding of ecological processes increases the number and type of indicators may change (See Table 78365 for a summary of indicators presented in the book *RDP: Foundations*).

7.8.3.6.6. Limitations of Monitoring

There are a number of problems or limitations with monitoring that must be addressed. The processes of many forest ecosystems have not been researched, so there is no baseline to compare measurements with (it is difficult to measure change without a baseline). Anthropogenic (human-caused) disturbances have long-term, synergistic, cumulative effects that are hard to trace. Synergistic actions lead to emergent and unpredictable properties of a system. The complexity of the measurements and the limitations of laboratory facilities or labor may lead to additional expense. The costs of monitoring are relatively high, not just the prices of tools or labor, but the cost of investigating over a large area for a long time will be very high. The costs of satellite monitoring are high. For example, coverage of all forested areas on the planet would require 4200 Landsat scenes and cost over $4 million (in 1994 dollars) for current data.

Table 78365-1. Global/local Monitoring Indicators

Categories	*Spheres (General)*	*Key Indicators (Partial)*
Physical/Chemical	Land/soil	Compaction, porosity, recharge potential ...
	Landscape morphology	Change, slope, migration, flow, erosion ...
	Ocean/Stream chemistry	Pollutants, pH, living mass ...
	Atmosphere	Photochemical oxidants, pollutants ...
Biological/Ecological	Habitat	Variability, linkages, fragmentation, organic deposition, canopy cover ...
	Species	Distribution, variability, range ...
	Ecosystems	Diversity, coverage, maturity ...
	Biomes/Regions	Diversity, extents ...
	Global	Connectivity, efficiency ...
Human/Cultural	Health	Mortality rates, disease presence, medical costs ...
	Demographics	Historical patterns, ethnography, land-use ...
	Values	Management factors, community data, time-use ...

7.8.3.7. *Stage 7: Evaluate and Refine Plans*

Inventorying, planning, and designing are only the first actions. How the plan is interpreted and executed is also important. Knowledge of the system and skills at interpreting it determine the success or failure of the principles and standards developed in the plan. Knowledge has to account for the uncertainty of a system. But, this can be done by feeding back information, based on the history and experience of the system, with its changes, disturbances and development, into the plan.

Carl Walters stressed that managers have to live with uncertainty, and then he made the connection that management decisions are essentially gambles. Gambling is a profession that acknowledges the operation of chance and makes conclusions in the absence of facts—few people are successful at it. This are important admissions, that we do not have all the facts to base our actions on, that nature is a stochastic process, and that ecosystems are always changing. Furthermore, we do not know for sure what effects our actions will have on the systems. Successful gambling suggests that the proper attitudes for gambling with nature are awareness, humility and courage, rather than arrogance, fear and maximum use.

Walters suggests that managers should embrace uncertainty by trying to define a set of possible outcomes, e.g., models, consistent with experience, rather than make a single best prediction. Each alternative model would be assigned a probability (Bayes theorem provides the logical machinery for assessments).

Traditional planning asks "what is most likely to happen," where uncertainty planning asks "what has already happened to create the future," in terms of long-term trends and demographics, according to Peter Drucker. Traditional approaches to uncertainty management are probabilistic, focusing on uncertainty as a measure of randomness or of confidence. Uncertainty of course, is reduced by experience and observation.

The plan has to be managed adaptively. C. S. Holling described adaptive management as a response to natural disturbances. The ability to make strong inferences about values and sensitivity to management activities among locations is thus limited. It may not be appropriate to generalize about management impacts unless the interactions of the system are identified and related to the intensity of past activity.

Funding must be identified and allocated as part of the planning process. Funding would provide for monitoring design, field work, data-management (GIS), and evaluation of results over the period dictated by the sampling scheme. The results of monitoring need to be evaluated and fed back into the process of planning and acting.

Involvement with the community, other agencies, research, industry and institutions must be included. Everyone has a stake in the maintenance and enhancement of ecosystem health. Collectively, we can arrive at a greater degree of understanding and effectiveness.

7.8.3.8. *Summary: For the Long Term*

With a focus on exploitation of products from ecosystems, many other measurements are ignored, from shrubs and forbs, and their ratios, to soil dynamics, direction of succession, carbon fluctuation, biomass, biodiversity, long-term biological processes, and the role of ecosystems in global cycles. Beyond products, ecosystems provide food, fuel, and fiber. Many products are consumed locally, but others, such as fruits, medicines, rattan, latex, palm oil, cocoa, vanilla, nuts, spices, gum, and ornamentals, are sold on international markets. We are not measuring these products, and worse we are not using them wisely once we extract them.

Ecosystems should be measured at larger scales: Watershed, landscape, biome, and global. Although we use some of the technical tools, such as satellite imaging and GIS, we have neglected the conceptual tools, e.g., the Gaia Hypothesis or global ecological design. Furthermore, we are measuring over a year or two only to establish a growth rate or productivity. We should be measuring over centuries. An ecosystem is a long-term changing being. We cannot use a short-term industrial approach to measure a few parameters and then pretend we know enough about a forest to cut a large percentage of it. Ecosystems are created by slow processes that take hundreds or thousands of years. In their 36-year study of a 450-year old conifer forest in Washington, Franklin and DeBell (1988) projected that it would take the shade-intolerant Douglas fir 750 years to drop out of the forest. Chris Maser points out how long it takes for coarse woody debris to decay (200-460 years). Soil formation takes millennia; rates can range from 50-100 years per centimeter.

An ecosystem is not a regular annual phenomenon—the kind favored by science. Ecological events may be rare, like a volcanic eruption, or long-term episodic, like windstorms. Many events have not even been observed yet. In marginal habitats, for Ponderosa pine for example, reproductive patterns are highly episodic; in one 37-year period in Arizona, reproduction was abundant in only one year. The importance of insect infestations is overestimated without long-term studies of the forests in which they occur. Many other ecological processes, such as temperature or precipitation, are highly variable.

Litterfall in old-growth Douglas fir forests has high annual variability. Finding a few gross patterns in a forest of complex processes is fairly easy; finding the subtle patterns is difficult without long-term comprehensive studies.

A forest inventory is the primary source of data about the forest for planning. The cost of complete data is considerable, the more complete the more considerable, but whoever has an intelligent say about the use of a forest must have that data. Instead, a partial inventory is often tailored to the expectations of whoever is controlling the forest legally. Our exploitation—and exploitation is okay ecologically (interference is the dangerous interaction)—of a forest is usually limited to a single commodity: wood. And usually one kind of wood, with other kinds left or destroyed in the getting. The fact that forests produce so many things that become products on formal and informal markets means that the forest is more valuable than a single measure can show. We should value everything about the forest and measure everything that has value. So much data is lacking that we should be getting any kind of data we can.

Over 50 percent of the planet was forested at one time—down to about 28 percent now. We could restore at least 20 percent in the next decade, leaving all old-growth untouched and 2 percent for plantations. On the other hand, how much forest cover do we need to keep the atmosphere functioning the way we like it? Carbon dioxide accumulates in the atmosphere at a certain rate annually. Deforestation releases tons of carbon per year (only a third as much as from fossil fuel combustion). Reforestation could remove carbon from the atmosphere. We need about 1.7 billion acres of new forest to store the tons of carbon lost annually (after George Woodwell's estimates).

Estimates of the minimum forested area for the planet are more difficult to arrive at. Houghton et al. (1990) suggest that the minimum should be about what remained in 1990: about 13.1 billion acres, or 40 percent of the land area, although the area remaining that year is not definitely known.

Not enough aspects of a forest are measured. Besides increasing the number of aspects, monitoring needs to address long-term change and human influences. A number of other tools, from topology to metaphor, may prove to be useful in predicting and manipulating forest behavior, if we can figure out how to use them.

7.8.4. *Create Monitoring of Global Properties*

A Global Commission could address real global problems, such as global climatic chaos, which has resulted in grain harvest shortfalls in recent years. The climate in general would receive renewed and detailed examination.

A global system is the sum of localities and may have unique characteristics of its own, that is, the whole planet (or universe) has characteristics that local frames of reference do not have. An ecosystem is directly connected with global cycles and other ecosystems. The system is embedded in larger systems and global cycles. There has to be a good substrate with energy and materials flowing into the system.

The global problems include: Atmospheric heating; ground and ocean heating; ozone depletion (chemical-caused); disruption of global cycles; contaminations (nitrates, mercury etc). These threats cause ecosystem collapse. Ecosystem breakdown happens as a result of stresses, singly or grouped, that relate to interference patterns in the system, most of which are caused by the human species now, although the potential for asteroids or volcanic eruptions remains.

Our actions on the planet are experiments, whether we want them to be or not. Ignorance, denial, or cupidity cannot unmake this experimental course, which may be global and irreversible. This Commission would make the experiment conscious and cautious.

7.8.4.1. Atmosphere Monitoring

The biosphere can exert control on the temperature of the surface and the composition of the atmosphere. On the other hand, soil types and the weather can limit vegetation; invasions of vegetation change soil types. An ecosystem is a topographic unit, a volume of land, occupied by organic beings, extended over an area and through time, with connections to larger mineral, chemical, water and air cycles. This means they are geographical units that intersect with atmospheric units. Ecosystems have a vertical structure, that includes the levels of climate from micro to topoclimate and macroclimate, to soils, water structures, and bedrock, as well as a horizontal structure. An ecosystem is a process, or a set of interlinked, differentially-scaled processes that may be diffuse in space but are easily defined in turnover times.

Processes encounter each other in a functioning web of an ecosystem, with tangible and diffuse surfaces. Lynn Margulis qualifies her definition of an ecosystem: The smallest unit capable of recycling the elements of its membership. For example, organic carbon can be expired, fixed, reacted, or transformed. This is done through the physiological activities of the members of the system, through breathing, enzymes, or some other way. Margulis states that elements recycle faster within ecosystems than between them. Forests, for instance, act as sinks for carbon. The rapid release of sinks can affect other atmospheric or terrestrial cycles. The biota of the planet appear to regulate the surface temperature, atmospheric composition, and ocean chemistry, for a start, perhaps like the human body regulates its temperature, blood chemistry, and other vital signs. As it achieves a new balance, with human inputs, the atmosphere may cause problems with agriculture and other human activities. Atmospheric monitoring is tied with water and terrestrial monitoring. Parts of the atmosphere could be designated as reserves.

7.8.4.2. Ocean Monitoring

Life had once been limited to the oceans. The evolution of living forms expanded those limits. Life, over time, has colonized deep oceanic vents, as well as Antarctic gravel fields. Oceans are not as productive as most land-based ecosystems. Worldwide, oceans could only support about twenty two million people, even though its area is over twenty three times that of grasslands. The ocean bottom acts as a sink for phosphorus. The rapid release of sinks can affect other atmospheric or terrestrial cycles. This Commission would protect the integrity of the oceans. It could designate ocean wilderness or conservation areas. Perhaps eighty percent of the ocean surface could be designated as a reserve.

7.8.4.3. Deep Continents Monitoring

Continents are formed by the movement of tectonic plates. As each continent forms, it develops its own combination of topology and water and climate patterns. Australia for instance has become the driest continent now. As continents rise or subside, in addition to their movement and combination, life has to adapt to the changes. The purpose of such monitoring would be to predict long-term changes as a result of continental change.

7.8.4.4. Bioregions Watersheds & Habitats Monitoring

Monitoring bioregions and watersheds involves a larger spatial scale than ecosystems. Regional goals are appropriate for bioregions. Evaluation of data must occur in an integrated manner that spans biological and physical scales, watersheds, administrative boundaries, as well as functional areas. To understand how ecological processes are connected we need to relate information across disciplines and agencies, and collectively perceive the effect of our actions on the environment. This approach follows ecosystem theory (the hypothesis that cycles in nature integrate the physical, chemical, and biological components of ecosystems), and the hierarchical organization of ecosystem functions throughout the landscape. Hierarchy theory can be described as the development and organization of landscape patterns, e.g., vegetation communities, through time and space.

This can be accomplished by incorporating the three primary attributes of biodiversity, as described by Jerry Franklin—composition, structure and function—into four levels of organization—province, subprovince, watershed, and site. Indicators incorporating composition, structure and function at the appropriate levels of organization have been identified for many ecosystems; they range from landscape morphology to human demographics and cultural influences.

For watersheds and habitats one has to consider the impact of any kind of vegetation removal. What is a minimum, optimum or maximum vegetative cover for various watersheds? Science might identify minima or maxima but philosophy and conservation can aim at optima.

7.8.4.5. Antarctica Moon & Space Monitoring

The moon has been such a constant for the earth, it might be hard to imagine how things would develop or change if the moon changed or were destroyed. The moon is related to stability of earth system. Because of its relatively large size and closeness, the moon forms the other half of a double planet with the earth. The moon revolves around the earth and both orbit the sun, so the entire lunar cycle takes almost 30 days. The moon exerts a gravitational pull on the earth that is stronger on the closer side. This creates a tidal variation in the heights of the oceans; these vary monthly. For many shallow water creatures, amphibians and mammals, it is good to adapt to these tidal variations. Of course, the earth exerts a pull on the moon, also, but it is less dramatic.

Due to its rotation around the sun, and to imperfections in balance, the earth tilts on its axis. This obliquity of the ecliptic creates seasonal variations, to which most animals and plants have adapted. Any changes, even relatively small ones, could be catastrophic for climate—a one-degree change could account for some ice ages. Jacques Laskar and others have documented the importance of the moon on the habitats of the earth. A stable climate needs the influence of the moon; otherwise, there would be immense variations in the solar heating of the earth's surface. The moon provides energy pulses, stabilizes axial tilt, and causes tides and variations.

Space is an equally important part of the system environment. It is not only the source of the sun, but it is the sink for energy from the earth as well. Stars and the sink of space provide many elements and their proportions. Galactic and solar system dust influences long cycles of the earth's climate.

Life is also challenged by energy and gravity, as well as the moon's behavior. The moon provides daily variations in tides, which provide energy to organisms, although the organisms have to adjust for the different levels of water.

7.8.5. *Preparation for Emergencies & Catastrophes*

Any agency that monitors the planet has to also monitor the potential for destructive events and catastrophes. It has to treat them as emergencies when they happen and be prepared to respond to protect human and wild life, as well as their habitats and resources.

The agency has to *Assess Threats (Internal & External).* The Security council is concerned with any kind of threat to the global order and the orders of nations and nature. Many of these threats are internal, as nations enter into conflicts with other nations. These threats can be handled by delegations or police actions. But, many threats are external to the planet. They come from solar or interstellar space and tend to be physical.

With regards to internal (or planetary) threats, international conflicts may cause problems. Widespread poverty may cause catastrophes. Richer countries will need to recognize that the poverty of others is not in their interest, especially as potential markets. Inequity may never be erased. Perhaps some inequity is good and stimulating, but gross inequity needs to be limited.

Conflicts, territorial or symbolic, are symptoms of insecurity. Many of our wasteful conflicts could be more easily resolved through a neutral international power. Conflicts would still occur. Conflicts over prestige or power, as much as for various crusades as for a true state, still lead to human and environmental destruction. The Security Council would be charged with the responsibility to avoid massively destructive forms of conflict, such as biological war or nuclear war.

7.8.5.1. Global Threats

The planet is still a very active planet. Some threats to humanity rise from the normal activities of the planet, such as volcano-building or continental drift.

7.8.5.1.1. Geological Threats

Typical geological threats include earthquakes volcanoes, and mudslides; rare threats may be comets or sunspot activity. While technology may be able to retard some of these threats or counter them early, the best solutions are design. Cities can be moved from floodplains; cities can be required to have quake-resistant buildings.

7.8.5.1.1.1. *Climatic Threats*. Someone said that civilizations exist through the consent of geology; however, the consent of the 'first empire of climate' might also be needed. Climate is a constant and immediate challenge. Many variables affect climate. One variation, with a long cycle of perhaps 100 million years, is continental drift. When Panama closed continents, it forced the gulf stream north. The earth's orbit around the sun, a 100,000 cycle, also changes climate. This is close to the spacing of ice ages. Other smaller cycles, at 10,000 years or 6,100 years are minor harmonics perhaps. Other activities that influence climate are sunspots, comets, and volcanoes. The most stable periods seem to be the coldest or warmest weathers. For instance, 400,000 years ago, a warm period lasted 25,000 years. If we are in a

10,000-year warm period, it may be almost up. This means that predictions are relevant.

Cooling can lead to disease and depopulation, which can lead to cooling. Farmland is abandoned to trees in times of collapse. Because trees take CO_2 out of the atmosphere, the regrowth of forests after the plagues in 1322-1351 in Europe and China, would have allowed drops in CO_2, which would have allowed climate to cool some.

The years 1997 to 2004 broke most heat and storm records, especially as some of the warmest years on record. We experienced 500-year floods, droughts of the century, and other extremes. Some of these events have been related to greenhouse effects.

7.8.5.1.1.2. *Oceanic Threats.* Ocean currents affect not only islands and coasts, but they affect the entire climates of continents. For example, the effects of the Pacific El Nino current can be linked to droughts in India and China in the past 150 years that caused three times the deaths of the Black Death, and more than the 60 million who died in WWII.

There does not seem to be a single trigger for El Nino. One trigger has to do with water overflow and then back flow from the western pacific. Others have to do with sunspots, which would reduce radiation, or volcanic eruptions. Many of these atmospheric, oceanic and geophysical triggers may converge. Nineteenth-century famines may be correlated with ENSO events that influenced China, Indonesia, Brazil, and southeast Africa.

The adherence to political colonialization and 'free market' economics, along with climate changes, made the suffering in famines worse. Millions died within the market system of the golden age of liberal capitalism. Thus, the famines were political and economic failures. Even at the height of the famines in 1877-78 and the 1890, Britain continued to export grain from India to England, which had its own agricultural downturn. The invisible hand did not lift those starving in India or China. There was starvation before the British, especially during El Nino events in 1596 and 1630, but many droughts did not result in such widespread and deep famines. Market economics and politics magnified the effects. The market economy can spread risk, through insurance companies, when crises are local and intermittent, but they may not be able to respond when the crises are global and ubiquitous. As the risks increase everywhere, fewer things can be done.

Other movements of water, such as tsunamis or floods, can be linked to earth movements, such as landslides or earthquakes.

7.8.5.2. Solar System Threats

Solar energy is not quite constant; over millennia it has been increasing; over the next billion years it will start decreasing. Collisions with asteroids or comets will always be a threat due to the nature of the solar system. The passage of the solar system through dust clouds will effect the climate of the planet and the solar output. A global agency could plan to deal with asteroids and comets.

7.8.5.3. Protection against Interference Events or Disasters

Police would be expected to be prepared for natural disasters, including the extraterrestrial. The police would focus on the prevention of man-made disasters, from watersheds that were compromised to chemical spills. Collisions with asteroids will always be a threat due to the nature of the solar system.

Protection is also needed against the many human activities that are creating emergencies, which include: Ecosystem conversion, simplification, collapse, and destruction by agriculture; conversion of agriculture by cities and roads; animal and plant reductions and extinctions; creation of large quantities of waste; disruption of elemental cycles; misuse and overuse of resources,especially minerals and fossil fuels; narrowing if agricultural diversity and species; overuse of energy, pesticides and fertilizers; continued use of exotic and toxic materials and chemicals; fragmentation of wild systems by roads; narrowing of cultural capital and languages and the extinction of many; economic betrayal of trust; global homogenization of products and lifestyles; continuation of slavery, violence and war; gross inequities in wealth between people and nations; and the refusal to consider climate change or respond to it. Unaddressed, these emergencies are converging into one gigantic global catastrophe.

7.8.6. *Designing Regions & Links*
A long-term model might consider that the locations of some cities and cultures should not be renewed if they are destroyed in particularly active zones of rapid geological or climactic change. There are links between climate and disease, between disease and new patterns of poverty. Global climate change, planetary and atmospheric heating, can increase the incidences of some diseases, like malaria in northeastern European states. The drying out of wetlands, which causes smaller stagnant pools, can increase outbreaks of mosquitoes. Ecological models can delineate thee links between ecosystem attributes and stresses. They could suggest standards for design of wild system and human system interfaces.

James Lovelock predicted that the planet is managed by one large bacterial ecosystem that manufactures trigger chemicals. The natural cycles of sulfur and iodine take place through biological production of dimethyl sulfide and methyl iodide. Dimethyl sulfide is linked with algae on the ocean surface, clouds and oceanic climate regulation. Climate regulation on land is coupled with growth of trees in tropical, temperate, and boreal regions. Biodiversity is a necessary part of planetary self-regulation. Ecological design, and global ecological design, could identify these connections and offer designs to keep the larger system healthy and productive.

The design of wild ecosystems is linked to the history and properties of the system. It is also linked to the cultural images of those who want to restore the system. Nature and culture are adaptive systems that change and develop over time. The design has to link the ecological and cultural dimensions to become a self-making and regulating system. These systems are also linked to global biogeochemical cycles that provide elements, air and water to local systems.

The global linking of corporations and economies has resulted in a fragile inter-dependence, which has reduced the functional independence of many nations, which can no longer supply basic food and shelter. Separate regions may want to discontinue or reduce links to financial risks, such as the international commodities market. Economic links can be beneficial in small clusters. Scale-linking is one the principles of ecological design; local banks could be linked to regional and global forms. Small units, with short linkages between groups, are simpler and allow faster feedback. The same ecological design principles work in banks, ecosystems or nations.

7.9. *Redesigning the Solar System*

Science fiction has presented imaginary solar systems in which entire planets have been reengineered into spheres or bands set an optimum distance from the sun, or the entire solar system is surrounded by a shell. Robert Bradbury presented his ambitious ideas in "Under Construction: Redesigning the Solar System." Bradbury suggests that engineering feats, such as converting the solar system into a computer (with matter as software), manufacturing helium stars, or lifting matter from other stars, may enable Matrioshka Brains or MBrains, comprised of swarm-like, concentric, orbiting 'computronium' shells that use solar sail-type materials to funnel and reflect the largest possible quantity of stellar energy. MBrains could interact with one another, perhaps in a KT-III civilization, which according to the Kardashev scale measuring technological ability, and eventually harness the power of and reconfigure the entire galaxy. Bradbury calculates the computational difference between an MBrain and a present-day human brain at ten million billion times greater than the difference between a human and a tiny nematode. With the current billion-fold difference from that worm, and with our current level of technology, some less ambitious projects are possible, now.

7.9.1. *Earth/Moon Orbitals*

The first simple thing to be done is to clean up old satellites and abandoned exploration vehicles. Some of these have already started to collide with each other and the planet. Some of them pose threats to new satellites and even to habitations and land. Given the record with abandoned war machines for the past 120 years, even this seems unlikely. Cleanup is necessary to avoid accidents and recover useful resources.

7.9.2. *Meteors & Planetoids*

We are already aware of the dangers from planetesimals and asteroids to the earth, especially based on large strikes tens of millions of years ago. Several governments and agencies have discussed how to monitor their orbits and prepare to alter or destroy any such threatening small bodies. We have begun cataloging the orbits of large objects in the solar system, especially those that orbit the sun and are potentially dangerous, such as Object 6344 P-L, which as rediscovered in 2007. Modifying the orbits of meteors, asteroids and planetoids would be wise to protect our civilization from objects that could dramatically interfere with the stability of our continents and atmosphere. Asteroids, for instance, could be moved with spacecraft or lasers—Robert Heinlein and others have written science fiction stories about this possibility. This level of intervention is possible with current technologies.

Science fiction writers have imagined moving asteroids and planets for human benefit. Asteroids like Ceres might be used for water to transform Mars; Ceres may have the same volume of water as the Earth. We might also plan to move asteroids and planetoids for minerals and water.

7.9.3. *Mars & Other Planets*

People have dreamed of establishing permanent bases on the Moon and Mars, as well as on other planets such as Venus and Jupiter. One long-term objective of the Chinese Space Program is to create a permanent base on the moon by 2020, for mining and solar energy generation. The United States is also planning a permanent base for 2020, which will serve as a station for reaching Mars. The atmosphere or Mars and the availability of water give that planet the potential to support life originating on earth. Many similarities to our planet, such as day-length and axial tilt, may make terraforming or colonization tempting. Dozens of robotic spacecraft have been launched in the past forty years, although most missions failed. There are economic and political interests in space colonization, besides anthropological ones. Venus has several advantages, including similar surface gravity and shorter launch windows, although the difficulties, such as high temperature and corrosive atmosphere, are more challenging.

7.9.4. *New Planets or Constructs*

Ceres, a planetoid between Mars and Jupiter, might be a possible location for a permanent base. It might be possible to construct a new planet between Mars and Jupiter (raw materials should not be a problem). Eventually, assuming we live beyond the age of a typical species of 1-2 million years, humanity may have to move outwards before the sun expands (and then move back when it contracts). In the billions of years before the sun enters a normal expansion phase for a star of its type, we will have time to consider reshaping Mars or building a new planet between Mars and Jupiter—perhaps even moving to Enceladus, orbiting Saturn. But, the logistics and technologies remain quite distant possibilities at the moment. Perhaps at this level our ideas are more extrapolation and guided dreaming. We might also allow concepts of ethics and interference time for development before considering moving entire ecosystems and species onto other bodies or designed artifacts in the solar system.

7.9.5. *The Entire System & Beyond*

Some thought has been given to reconstructing the entire solar system, either with new planets or a ne system-wide sphere around the sun. When designing a system that large, the first things a designer has to consider are sunlight levels for your area (insolation), gravitational stability, and total power requirement. While it is important to consider the deep future, some of these projects may be beyond the limits of human technology or human psychology.

In a thought experiment, the physicist Freeman Dyson (1959, apparently inspired by a science fiction story by Olaf Stapleton) noted that every human technological civilization has constantly increased its demand for energy. Therefore, if human civilization were to survive long enough, it would demand the total energy output of the sun. Dyson speculated that sufficiently advanced extraterrestrial civilizations would likely follow a similar power consumption pattern and would eventually build their own sphere of collectors. Constructing such a system would make that civilization a Type II Kardashev civilization. He proposed a system of orbiting structures, in a shell or sphere (hence, Dyson Sphere) designed to intercept and collect all energy produced by the sun. Dyson focused only on issues of energy collection, but there were problems with the mechanics of the structure. He responded to criticisms of the concept with qualifications of a "swarm" or "Bubble."

Writer Bob Shaw described a fictional account of the discovery of an inhabited Dyson Sphere in a distant system in his book, "Orbitsville" in 1975. In trying to imagine a more efficient version of a Dyson Sphere, author Larry Niven presented his concept of

“Ringworld,” a spinning band of approximately the same diameter as Earth’s orbit rotating around a star, landscaped on the sun-facing side, with the atmosphere and inhabitants kept in place through centrifugal force and thousand-mile high perimeter wall. When this idea was called dynamically unstable, since the center of rotation could drift away from the sun and eventually let the world come in contact with the sun, Niven used the problem as a plot element in the sequel, *Ringworld Engineers*.

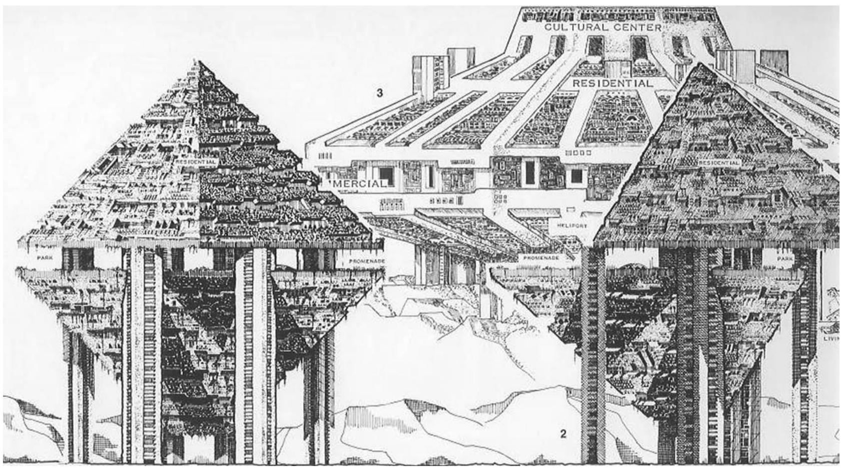

Figure 721-2. Paolo Soleri Arcology BP

8.0. Designing & Making Good Places

Any group can make good places. Cultures have made good places. Often, the making is a slow mutual adjustment among life forms, environmental constraints, and human cultures. But, many need to participate in the making. And certain problems have to be addressed. The levels of intolerance and conflict that are permitted between groups and nations have to be reduced. This change can occur through actions of other design factors, such as recognized global commons. The planet could be set up as a corporation with ownership of all commons, especially those providing ecosystem services for wild and cultural areas.

This could happen as a result of the interrelations of nations. If there were a framework to keep nations small and independent. If there were a framework to allow cultures to develop without unfair competition or dominance. There are big problems that require big frameworks. But, the frameworks can only be viable if they are run on a local level. There has to be a framework to accomplish global designs, especially those related to global things and cycles. The atmosphere for instance. The framework could allow good places to be designed and managed for long periods of time, within the limits of the dynamicism of the planet as well as accidental events in the larger universe.

8.1. *Global Problems: Intolerance Conflict & War*

We tend to think of problems as unwanted 'side-effects' of the wanted main-effects, but all effects are equal, as Buckminster Fuller noted, and must be addressed as equal. Most things identified as problems are embedded in a network. Nothing is simple; there is not one truth, there is not one way, and there is not one goal. Problems could be considered also as challenges that we must respond to continuously, in the process of living, not as puzzles that have to be solved once for all time. It is about consciously choosing to see what can be done, rather than dismissing a conflict as terrible and unsolvable. When challenged by some situation, we react by habit, although this may be disconnected from other habits. Habits protect us from many problems. Addressing a problem often has to do with a power struggle, which becomes part of the problem of the problem. If problems are regarded as challenges that require a social response, then much of the conflict can be avoided.

8.1.1. *Intolerance*

One problem that typifies every culture is intolerance. Intolerance means a lack of toleration or the unwillingness to tolerate or the contrary beliefs of persons of groups. Intolerance seems to be a fact between cultures and between individuals; it can lead to conflict and violence. It used to be understood that intolerance and violence occurred between 'irrational actors,' whether individuals or cultures were involved, so could not be explained rationally.

If cultures or individuals were rational actors, then the irrational actions of conflict and violence would have to be explained in some other way. M.D. Toft suggests that ethnic group settlement patterns, socially constructed identities, charismatic leaders, indivisible issue, and state concern with precedence could lead rational actors to escalate a dispute to violence, even when doing so was likely to leave contending groups much worse off.

The problem of intolerance and conflict can be more easily understood with reference to the cosmology of a culture. A cosmology is basically the complete set of ideas about the nature and composition of the universe used by an individual culture. This idea of the universe provides people with an orientation in their cosmos. It is a collective image. Ezra Pound stated that the image is an emotional and intellectual complex in an instant of time.

All cosmologies cause destruction and waste; all produce the opposite of the good intended. Once cosmological ideas are adopted, they may remain unquestioned and unquestionable, and they can influence a culture over centuries. The principle of otherness, where others are not true humans, is an example. This principle may have made perfect sense when cultures had to protect their territory, especially when the territory was rich but limited, or when there was a large investment in it, as with agriculture. By representing others as nonhuman or subhuman, they did not have to grant them consideration from the ethics of the culture. Many modern political ideologies and economics have been shaped by the principle of otherness. Cosmologies can influence a culture to ignore, accept or fight other cultures. Intolerance justifies inequity, domination and conflict.

8.1.2. *Kinds of Conflict*

Conflict is sometimes perceived as the only response to intolerance or to other problems. However, conflict can be related to various losses or cultural norms. Understanding these conditions may allow us to resolve some kinds of conflict.

8.1.2.1. Conflict as Loss of Fitness

Fitness is the ability to function under normal environmental conditions. Stress, obesity, illness, toxic chemicals, social conflict, and other kinds of dysfunctions, can reduce fitness. A lifestyle dependent on physical and energy slaves, not to mention a diet riddled with addictions to cheap fats and sugars, decreases our fitness. Air pollution, sedentary life styles, exposure to stressful city environments makes things worse, even as we acquire more information about the dangers and options. Conflict is an attempt to correct the problem by capturing more food and energy, or acquiring clean air and water, or conquering new land. The stress of conflict however, can lead to a declining cycle less fitness and more conflict.

8.1.2.2. Conflict from Loss of Equity

Although many resources are distributed unequally over the globe, as a result of different kinds of historical geological processes, trade can allow access to those resources. However, as a result of long-term processes of inequity, from keeping people enslaved to cultural hoarding, many people have far less than others. This has resulted in permanent overclasses and underclasses, which are often maintained by physical force, as well as by the force of economic and religious myths. These myths tell all people that they participate in the "best possible economic system" regardless if it justifies the differences of inequity based on history or on perceived racial abilities. Even low average levels of food and fulfillment can be maintained only through theft from other species and from future human generations, and through the degradation of billions of humans, as well as the ecosystems on which they depend. Conflict is one attempt to bring about more equity, although it can result in greater disparities and losses.

8.1.2.3. Conflict from Loss of Accord

As a result of the unequal distribution of natural resources, including unincorporated waste and pollution, and the unequal distribution of materials and wealth between people, economic conflicts arise, often becoming violent political conflicts. Accord, by definition, means agreement or the concurrence of will or action. As an agreement between the parties in a controversy, by which satisfaction for an injury is stipulated, accord allows people to reconcile their injuries and interests. Because many national boundaries were drawn as a result of colonial expansion and contraction, many cultures are artificially combined in large territories or stretched across several traditional territories. This has created the conditions for continuing cultural and political conflict. In addition to the normal conflict between different cultures with different ways and values, usually resolved by trade or distance, this new conflict resembles small permanent wars over large numbers of territories. This kind of hot conflict not only destroys habitats and resources, but it causes immense human suffering. As the rules change, and conflict includes noncombatants, as well as plants and animals, there is less accord between conflicting groups. Accord requires the ability to trust, which requires self-reliance and confidence.

8.1.2.4. Conflict as a Result of Bigness (Scale)

Leopold Kohr identifies the basic conflict between man and mass, citizen and state, large and small communities, as being the result of bigness. Kohr's theory of size states that the cause of most forms of social misery is bigness. We have always tried to exceed the physical and biological limits of places rather than recognize them and be guided by them. Every advanced country is now over-technologized. Past a certain point the quality of life diminishes, not improves, with each advance. Big science serves big technology, which supports and is supported by big government. And there is no science like big science, and no administration like big administration. But this enthusiasm is misdirected. Scientific advances and technological changes result in unforeseen consequences, good and bad. They cannot be controlled or legislated against before the fact. But the investment seems too big to abandon.

8.1.2.4.1. Personal Conflicts

Individual conflicts often resulted from insults or broken promises. In Mesopotamia, people paid fines for hurting others. For instance, severing the bones of another man with a weapon resulted in a fine of one mina of silver.

When arguments could not be resolved, there was open conflict. Resolution of individual conflicts was usually informal within the confines of the community. For Inupiat and other egalitarian cultures, song duels are a ritual pacific form. The disputants publicly insult one another until the audience laughs down the loser. If individual disputes are not resolved, then they are settled by community consensus.

The predominant value in small cultures, and then many larger cultures, was harmony. This minimized conflict that might have resulted from inequality. Confucian concepts of ritual and etiquette helped to regulate social conduct and made people feel good about their station. For example: "Inequality is the nature of things" and "seek no happiness that does not pertain to your lot in life."

8.1.2.4.2. Group Conflicts

In a Tiwi example, a dispute occurred because the elders of one band reneged on their promise to bestow daughters for marriage to the sons of another band—a violation of the norm of reciprocal marital exchange. Two war parties of fifteen warriors each met in adjoining territory. They wore white paint symbolizing anger. Both sides exchanged insults the first day. Then agreed to meet the next day for socializing and renewing acquaintances. The third day the duel resumed; words escalated into wild spear throwing that wounded a few spectators and warriors. That ended the dispute. Why is warfare limited in band societies? Could it be due to a lack of interpersonal competition for status? Are people taught to be restrained? Are conflicts are resolved by ridicule before getting out of hand?

Population density was controlled by the traditional approaches to resources. In archaic societies, cooperation and consensus, as opposed to competition and individual exaltation, permitted planning to remain informal. Population growth triggered competition and conflict, which lead to positive feedback of the thing that caused the stress.

In Mesopotamia, complex systems were be managed locally by farmers, although there may have been conflict with upstream users. But, cooperation is necessary, especially within villages and between villages. As a result large-scale water systems were first managed by religious leaders, later by secular leaders. Usually irrigation is necessary when the rainfall is unpredictable. Wars started from depressions in food production or storage. Mesopotamian cities had councils of elders to make decisions. They would appoint a leader to lead in war or trade. Agriculture gave a surplus; that and property lead to excitement of war. In China, in the Warring States period, the nature of war changed: From an Aristocratic monopoly of soldiers to one with permanent standing armies, professional leaders and peasant soldiers. Conflict was resolved centrally by a chief or king, who held a monopoly on power.

8.1.3. *War*

Does every society have war? The anthropologist Carol Ember surveyed band societies and found that sixty-four percent waged some kind of war. The reasons for war have gone from insults and personal conflicts having to do with bride exchange, broken rituals and personal honor to group and external reasons, such as territory, resources and patriotism.

The nation states are closely related to large-scale violence, usually having to do with trying to consolidate their power (global war). They then have a monopoly on power(monopoly rents) They specialize on political and economic issues (e.g., the Spanish ransacked the planet for gold). They enlarge and consolidate their territoriality, which gives them increased capacity for marshaling resources (maximum global functions with minimum territorial burden).

Wars, like the recent one in Iraq, are based on weak assumptions: That the war can be waged by blasting away any threats, and that it can be contained by using conventional weapons. But, like most actions, it has affects that can get magnified in the larger system. Furthermore, the war breaks out of the barriers that the participants try to create, destroying properties and civilians—there are no longer any safe buildings or noncombatants, and ruining the social and ecological fabrics.

All wars now are ecological wars that destroy the basis of civilization. There are no nonmonotonic effects with war. There are no side-effects. There are only effects and they can all be measured. Perhaps the next war will be to directly destroy the ecological basis of a nation, an extreme scorched earth policy by the aggressors. These wars would be social wars that destroy entire generations and traditional social structures. Perhaps, future wars will have less to do with honor and territory and more to do with crises, such as famine, population, and environmental collapse. Perhaps, wars will have to do with symbols and religion, again, as they have in the past.

8.1.3.1. Advantages & Disadvantages of War

War has advantages and disadvantages. One of the advantages of war is its long tradition, being simpler to understand than rights, the attendant macroeconomics or the workings of enantiodromia. Another advantage is that war is cheaper than ever before, especially to attack. Of course, war is also stimulating and fun, at least for the victorious survivors, who are bonded by the danger.

It used to be that it cost more to attack than to defend, with preparations and supply lines. Now, It costs more to defend against a bullet than to attack with one. Cheap bullets destabilized the western U.S., but laws and enforcement, also with bullets, restabilized it. Possibly the same thing will happen with cheap cruise missiles. Maybe not, as the cost of attacking will now continue to be less than defending. This means that the world may become more violent and less stable. Can information warfare be cheaper, or less destabilizing? No, because information attacks may be even easier to perform. Unless everyone has the same weapons.

The disadvantages are greater than the sum of all advantages. Ecosystems in disputed and ravaged territories are always disrupted, damaged or destroyed. Human suffering is always made worse than it was before the war. And, war never solves the original problem at all.

8.1.3.2. Style and Scale of War

Politics is the management of people through equitable distribution of resources, and the management of relations with neighbors or trading partners, using negotiation or force, war if necessary. Wars have changed in style and scale. From disagreements, wars have become a centralized state function. From religious reasons, where Gods lived with people, it has gone to the secularization of state concerns.

The essence of war is to defeat or destroy an enemy. Governments are efficient killing machines. On the average in the nineteenth century, states killed 3.7% of their subjects. In the twentieth century they killed 7.3% of the world population.

War as related to growth. Often the same factors that allow unsustainable growth allow unsustainable war. Growth is promoted for its advantages, usually without recognition of its difference from development.

The historical rhythm between war and peace inevitably leads back to peace. When does peace occur, when it is won? Unlike many forms of war, peace is a process with a less rigid beginning. It can never be won or kept permanently. It does not have the prestige or honor of war, and perhaps this is why so much less times and effort is devoted to peace.

Is there a way to limit war, within the context of peace? Is there another way to humiliate or embarrass an enemy, and let some other kind of balance be found? Is there a way to limit violence to heroes or to leaders, as if either would agree to have their individual expertise be responsible for a whole population.

Table 8132-1. Styles of War

Kinds of Wars	*Reason*	*Examples*
Personal Conflicts	Insults, broken promises	Palouse, Aborigines
Leader/Group conflicts	Social insults, food, territory	Uruk
General's wars	Food, Luxuries	Babylon
Psychological wars	Prestige, glory, idealism, patriotism	Greece, Macedonia
Professional Soldiers/army	Food, territory, unification	China, Rome
Religious, Royal, National	Territory / conversion	France, Britain
Economic trade wars	Control of resources in colonies	Britain, France, Spain
Chemists war, with poison gases and explosives	Territory expansion	World War I
Physicists war, with radar and nuclear weapons	Territory expansion	WW II
Mathematician's wars, with computer-guided missiles.	Resources Potential threats	Iraq Gulf War I
Electronic wars, to destroy computers and databases.	Destruction of information or economic structure	Iraq II
Ecological wars	Destruction of land base/Nature	Vietnam, Iraq, Pesticides

Notice the sequence. Competition with other species and groups leads to conflicts, which grow in size and sophistication, gradually including noncombatants, crops, land, other species, and ecosystems, until the war is against large groups of human communities and then against nature in its various aspects from microorganisms to invasive plants or imbalances. The sequence parallels the growth of groups from tribes to Nations and Unions.

8.1.3.3. The Easiness of War

War has become too easy. It seems easier in the immediate or emotional short-term to use institutional violence to solve any dispute. It is exciting, and it allows the combatants to form close bonds, perhaps much closer than those in business or play.

The largest problem with war, however, is its scale. War is waged between nations and groups of nations against other nations or groups of nations. Even on a local scale, it often involves larger complexes of political links.

8.1.4. *Summary: Inseparable Behaviors*

Conflict cannot be separated from other things, such as environmental destruction or inequities. Conflicts have been escalating, regardless of who won a cold war, or whether nuclear disarmament is being achieved. The constant conflict of cultures and the loss of life, human and other, is tragic. But, this kind of tragedy results from a failure of cosmology; humans are responsible ultimately, not fate or chance (See Section 7.2.4.). Humans are equals, not subhuman others. Humans are tragic because they are responsible for their actions. They can choose a tragedy of the commons or of dictatorial control—or they can expand or alter their cosmology.

Militarism, conflict, intolerance, crimes, and health problems are symptoms of the instability of cultures. Confusion and misinformation contribute further to the destruction of cultures. If cultures are lost and new forms cannot fit themselves to the patterns and uncertainty of natural systems, then people may not be able to adapt to the continued development of the planet and its ecosystems.

Conflicts, territorial or symbolic, are symptoms of insecurity. Many of our wasteful conflicts could be more easily resolved through a neutral international power. Conflicts would still occur. Conflicts over prestige or power, as much as for various crusades as for a true state, still lead to human and environmental destruction. The UN needs to take responsibility to avoid massively destructive conflicts, such as biological or nuclear war.

For that reason, the UN Security Council and its force has to consider the broadest meaning of security: It is for people to have the resources and opportunities to provide themselves with their needs. Thus, security has to be addressed on many levels. For example, what do forests have to do with peace? Of the fourteen nations requiring UN peace-keeping operations since 1990, twelve of them have lost over 90 percent of their forests. Perhaps peace-keeping should be abetted by tree-planting. As ecosystems are destabilized, nations become less stable, and must be helped with more than social conflicts.

The UN could propose an adaptive cosmological framework to place human values within a global ecology and to balance human development and the preservation of wild places. The framework could protect the integrity of culturally-based nations and to address global issues. Global and local issues would be differentiated; the myths of global communities and one-world people would be explained and discarded. Pretending to be world people is a mistake based on a misunderstanding of human limits. People are the products of places and cultures, of land and nations.

Each culture develops rules for living together. A common culture provides an ideal framework for public and private decision making. The Sami in northern Scandinavia have institutionalized ways of avoiding conflict, for instance, by shaming those who would impose their will. The Fipa of Tanzania use cooperative exchange rather than competition to keep the peace. The Akawaio of Guyana believe that community disharmony upsets the spirit world, resulting in illness and misfortune, so harmony is worked for.

The individual in a culture is responsible for the style and simplicity of their life and for its effects on nature and society. The individual is responsible for being tolerant of others in the culture, and is free to make many kinds of choices. Individuals could assimilate new knowledge from their experiences without changing if the experiences fit in the framework of their cosmology, that is, if the experiences aligned with their internal representations of the world. This may also allow them to ignore or judge unimportant events that did not fit. Jean Piaget noted that when individual experiences contradicted their internal representations, they had to change their perceptions of the experiences to fit their internal representations. He called this accommodation, the process of reframing personal mental representation of the external world to fit the new experiences.

Accommodation can lead to learning. When the world violates our expectations, we can fail, but by accommodating this new experience and reframing our model of the way the world works, we can learn from the experience of failure. In a scientific view, ethics and cosmology are separate. But in a good mythology, there is a coherence between areas. The individual feeds back into the cosmology in altered form what has been received. It is like a closed loop between cosmology, culture and the individual, even if human cosmologies are limited and contradictory.

8.2. *Global Design Factors: Commons*

Traditionally, a commons was a territory managed by a community so that individuals could share the land for grazing or farming. This form of use characterized many tribal groups for 40,000 years. The commons were only open to the members of the community, and perhaps to a few who asked permission. Community beliefs or a kind of ecological ethics discouraged overuse, in that overusers were shamed with informal sanctions or forbidden to continue using the land. In a sense, any territory not explicitly claimed by one community is a commons. That would include the atmosphere and oceans especially, or rather air and water in any form, since these are global things and can move between systems, and their character is determined by the globe itself. Some global economic or ethical method of management, not just for human use but for nonhuman use, must be devised.

In a traditional English village, inherited bundled rights provided commoners with rights of grazing and gathering fuel wood non-destructively "by hook or by crook," which indicated the way wood was gathered by shepherds. The form "commons" is plural, and refers to the whole group of commons, subject to these effects.

8.2.1. *Tragedy of the Commons*

Garrett Hardin extends the idea of the commons to rest on the idea of a carrying capacity of the territory, which is a very dynamic concept, susceptible to change by the weather, season, food preference, or other things. When the commons is not tempered by rules, then an individual user gains all the advantage and the disadvantage is shared by all users. Ecological degradation is assured and the system collapses, a tragedy due to the "remorseless working of things" in Hardin's words. In a limited system, the self-interest of one person cannot decide the public good, or the ecological good. So, the "invisible hand" does not provide a long-term solution. The hand needs to be visible. Necessity needs to be recognized by freedom, as Hardin restates Hegel.

The misuses of commons, some of which are alluded to by Hardin, include: Uncontrolled human population growth, depletion biodiversity, transformation of fossil fuels, pollution of waterways and the atmosphere, logging of forests, overfishing of the oceans, private vehicles jamming public roadways, tossing of trash out of automobile windows (littering), graffiti, poaching, noise pollution, and email spamming. Each of these misuses places a burden on most of the other users.

Privatization is one possible solution. However, unless individual ownership includes some regional cycles or global resources, then there might not be incentives for sustainability. One problem is that global things cannot be enclosed like land. Regulation is possible, as is payment by the polluter, a form of taxation. Hardin considers these as forms of enclosure also. One solution would be the return of many commons to the cultures that adapted to them and have had cultural rules governing their use. Hardin's suggestion was "mutual coercion, mutually agreed upon."

Many of our less wholesome behaviors, such as rapid technological change or wars, can disrupt tradition and lead to misuse of the commons. If the commons were presented as a prisoner's dilemma for a community, then individuals would have two options, cooperation or defection. Defection, or private mismanagement of common areas, can lead to economic madness, as Paul Shepard indicated. If there are unavoidable costs to defection, then it would be the less likely choice.

The tragedy of the commons is not that the traditional commons system did not work—it did, because it was controlled ethically in a community—it is that other kinds of commons have no such rules governing their use. The tragedy occurs especially when there is a transition from an ethical community use to a free market system that encourages overuse.

In a larger sense the whole planet is the common, and its limits are obvious, between the sun and the greater vacuum of interstellar space. The photograph of the earth made a logical connection between the common earth and the necessity of conservation. So, if the earth is a commons and humans are threatening the health or existence of the commons, then humans need a common ecological ethic, or some set of rules that they can respect.

In another sense, most problems are local not global. So, at the same time, we have to take responsibility for our local environments, and respect the cultural carrying capacity, as a term for the whole integrated concept of capacity that includes human luxury as well as minimal eating and nutrition.

8.2.2. *Actions Profits & Losses*

Modern industrial culture places an emphasis on individualism and competition. Cooperation, with an understanding of rights and responsibilities, is based on cultural understanding. This kind of understanding, once prevalent in many cultures, is the reason why the tragedy of the commons did not always occur with common resources. Cooperation is crucial. B.F. Skinner suggested that a genetically-based "short-term egoism" leads to the environmental Tragedy of the Commons. We can choose between the tragedy of the commons or the tragedy of total control, or we can expand our cosmologies. We are tragic because we have to accept responsibility for our actions.

Every action entails a gain and a cost (or profit and loss). Profits and losses are distributed privately, socially, or environmentally. Unfortunately, the modern system privatizes the gain and externalizes the loss to the "commons," considered as a pool of "unowned resources," where in traditional societies, it was surrounded by rules for use. As long as this is possible, it is profitable to charge the cost to the environment. Externalizing costs works fine in an uncrowded world, where the costs are negligible and can be absorbed by natural processes. Resources were traditionally seen as free for the getting; air and water were seen as free sinks. Modern economies, embracing the notion that "nature is capital," draw on the accumulated "capital" of ecosystems for production. By ignoring the real cost of the capital, as well as the costs of natural services, such as nutrient recycling, soil building, and atmospheric renewal, these economies create a temporary wealth. Decisions regarding resources are made on short-term economic grounds and lead to material shortages and environmental degradation.

Economists try to bronze the economy in its current structure; but it is a changing system. Since it is changing, strategies that are appropriate at one stage are totally inappropriate at another—this is the remorseless working of tragedy, where successful strategies are applied in inappropriate circumstances. Tragedies imply conflicts larger than the individual or even society. The external order of things or the cosmic plan is challenged, even if the cosmos is the size of a city. The source of tragedy for economics is a fatal flaw of the world-view. This is the root of Hardin's tragedy of the commons. The tragedy of the commons occurs only when people are locked into a system of self-interest through economic gain; it could not happen in a culture that understood common holdings. Hardin's definition of tragedy is the working of fate. But economic tragedy results from the failure of a cosmology: humans are responsible, not chance or fate. We can choose between the tragedy of the commons or that of Leviathan, or we can expand the cosmology using ecological knowledge and wisdom and the limit economics to a sustainable place in the cosmology.

8.2.3. *Resolution of Tragedy*

The present causes of the ecological crisis lie in the combined action of technological advance, population increase, and conventional, erroneous ideas of the nature of humanity and the environment. Garrett Hardin asserts that the problems of the ecological crisis are direct results of the tragedy of the commons reproduced on a global scale. In a sense all global resources, are part of a resource commons, due to its mobility or depth in the earth. Therefore, overpopulation, pollution and resource depletion can have no technical solutions; they can only be ameliorated through political reform, which can only result from changes in perception.

Privatism or socialism could work, depending on population size, resource distribution, traditions, or other factors. Privatism works well within a system, with intrinsic responsibility. The problem with the socialism is its contrived responsibility; who shall watch the watchers? Commonism, a systems of cultural commons, or altruism, might not work as large systems. One necessary condition for the preservation of finite resources is sovereign power. To share resources without the discipline of power invites the tragedy of the commons. The limit of sharing has to coincide with the limit of sovereignty; otherwise runaway destruction could result.

Any kind of aid is a distribution from a commons, as Hardin notes. Dealing with a global commons is more effective through laws that end destructive behavior. Furthermore, laws are a second-order altruism; an individual does not risk acting as a lone altruist, in violation of Hardin's Cardinal Rule of Policy, which is to never ask a person to act against his own self-interest. If it can be demonstrated that the long term effects of egoistic actions are harmful, people may be persuaded to forgo short-term gains. To prevent a tragic end to commons, the system must be changed. People will be reluctant to change because of the uncertainty of technological forecasting and political stability.

The Tragedy of the Commons could happen in a mass economy, although not necessarily in an information economy, if people were truly rational actors. Hardin believes that coercion, centrally controlled by majority rule, is required for survival. Self-interest and knowledge of capacity could also avoid tragedy. J. Martino claims that private property can eliminate the tragedy also; self-interest of the owner dictates common sense. In this case, a global socialism would work because it would be responsible to national cultural units, whose interests would be represented. Economic cooperation in world of scarcity will not solve environmental problems.

The UN could create a Commission on the Earth. The Commission would have trusteeship over global commons. Boundary issues need to be resolved first. The Commission would limit national jurisdiction of oceans to 20 miles from the border, rather than 50 or 200 miles, to protect ocean resources. Furthermore, it would have a say on continental shelves and shore fisheries. The other 65-70 percent of the surface of the planet has to be regulated as a common area. The Commission could also charge Use taxes, which would have the effect of limiting the use of nonrenewable resources, such as coal or oil, or the use of slowly-renewable resources, such as forest products or fish, located in global commons, such as the atmosphere or ocean. This would discourage overexploitation of previously 'free' resources.

8.2.4. *Fate & Tragedy*
Humanity can still be a part of nature and still be tragic, however. Even if moral laws are natural. Tragedy is more than an ethical conflict. Tragedy can imply conflicts larger than the individual or even society. Becker claims that the tragedy of evolution is that evolution produced a limited animal with unlimited horizons. For him, tragedy is wanting an earth that is perfect, a heaven abstracted from imperfection. Of course, the swing of the pendulum ensures that humans cannot create a perfect place. In the sense of employing a successful strategy in all circumstances, perhaps natural selection in evolution is tragic (the tragedy of reality)—M. W. Fox and Garrett Hardin hold this view. Modern science is one-sided (or single-visioned), in denying poetic knowledge. The attempt to avoid the pendulum (enantiodromia), without understanding the operation of nature, ends in tragedy.

The definitions of tragedy can be linked to cosmology, the image of the place of humanity in the universe. Tragedy challenges the external order of things (the cosmos), even if the cosmos is only the size of a city. The fatal flaw of the individual is the fatal flaw of the world-view of the individual. This is the root of Hardin's Tragedy of the Commons—people are locked into a system of self-interest through economic gain without being bound by traditional rules for sharing or cooperating. Hardin's own definition of tragedy is "the working of fate." But, this kind of tragedy results from a failure of cosmology; humans are responsible ultimately, not fate or chance. Humans are tragic because they are responsible for their actions. They can choose a tragedy of the commons or of an institutional Leviathan—or they can expand or alter their cosmology.

8.3. *Global Ethics & Rights for the Planet & Its Inhabitants*

In its popular application, ethics is a set of rules governing the conduct of a group of people, based on traditional behavior of that group. An ethics abstracted from historical context, detached from other societies, and alienated from nature is academic, insular, and strange. Such ethics tend to depend entirely on local human utilitarian values. Cultural ethics are usually restricted to some members in a local ecosystem; such ethics are assembled inductively, from experiences from living in specific places. Philosophical systems are little better. The areas of concern of ethics and bioethics are not broad enough; their foundations are not deep enough. Philosophical ethics is the ethics of the human species living alone, without wild animals or plants in modified ecosystems. Albert Schweitzer expanded this ethics to include 'reverence for life,' although not every form of life was equally considered. Ethics can be seen to be a limited case of an ecological ethics in an ecological context.

Human beings have no complete guidelines to interacting with other species in an ecological context. But, an ethics based on ecological knowledge, by comparison, could place human behavior in vital social and biological communities in nature—birth, death, illness, and sex all take place within nature. The frame of reference of ethics would be enlarged, leading to appropriate behaviors in a larger context. Human health could be related to the health of ecosystems. This ethics could address animal rights and wilderness preservation, as well as human concerns.

A new ethics starts from nature itself, not from an extension of the old anthropocentric ethics, with all its limited assumptions. It is based on ecological knowledge, grounded "in the breadth of being," in Hans Jonas' words, and founded on principles discovered in existence. Many ultrahuman cultures have standards (or codes) of behavior to regulate interactions. In birds and simple mammals, these rules may be very rigid and predictable. With increasing brain complexity, however, learning takes a larger role.

Animals are ethical already; they live together by rules; they respond to situations, to other animals. Ultrahuman ethics are rules for living together. The human community is one of many communities that make up ecosystems. Human relationships embrace other beings as well as other humans. Human ethics describes a small part of the rules, perhaps the only self-conscious part.

An ecological view emphasizes human moral responsibility for vulnerable ecosystems and habitats. It recognizes the ends and means of all beings. An ecological ethics can place human ethics in proper perspective, in proper relationship with other living, interacting beings. Understanding ecological relationships permits the toleration of fluctuation, irregularity, uncertainty, diversity, spontaneity, flexibility, looseness, and limits. The basic premise of nature is interrelatedness. The interpenetration of boundaries makes humans less discrete, less alone. A shared biology establishes the fellowship of beings.

8.3.1. *Land Ethics*

Because of the uncertainty of human actions, ethics has to encompass the far past and distant future. No one knew that when DDT killed mosquitoes, it would concentrate in the food chain to kill birds. Values are time dependent, and ecological time can be very long indeed. The futures we invent are viable only if compatible with constraints imposed by evolutionary past. An ethics that requires a long-range responsibility also requires a new humility, since technological power exceeds the ability to foresee its consequences. An ecological ethic recognizes the moral obligation to leave the world habitable for future generations.

Aldo Leopold proposed a land ethic, dealing with human relationships to land, plants and animals. The land ethic Leopold had in mind was a sense of ecological community between humanity and other species. "When we see land as community to which we belong, we will use it with love and respect." Such an ethic would change the human role from master of earth to plain member of it. Predators are members of the community; and no special interest group has the right to exterminate them for the sake of benefit for itself. This attitude is important for habitat protection. Leopold describes the extension of ethics as (emphasis added): "actually a process in ecological evolution. Its sequences may be described in ecological as well as in philosophical terms. *An ethic, ecologically, is a limitation on freedom of action in the struggle for existence.* An ethic, philosophically, is a differentiation of social from anti-social conduct. These are two different definitions of one thing. The thing has its origin in the tendency of interdependent individuals or groups to evolve modes of cooperation."

8.3.2. *Ecological Ethics*

The extension of ethics to animals and land is an ecological necessity with growing human pandomination. This extended ecological ethics defines a social conduct that is a mode of cooperation and, ultimately, symbiosis. Leopold argued that ethics are voluntary limitations of freedom necessary in a complex world of which we remain incredibly ignorant. Extensions of ethics are developed in response to problems that arise from increasing knowledge. Science has phenomenally increased our knowledge of physical and biological processes. It has now become the basis of our moral code, but it cannot very long be a science divorced from feeling and art if that code is to help us survive. To do this science requires aesthetic perception as well as disciplined thinking and feeling. As there is a rational component to ethical judgments, so there is an intuitive and emotional one, also. An ecological ethics suggests that humans avoid tampering with complex evolved systems, not because they are good, but because they are the basis of life at this stage of development. Ecological ethics is situational because ecology is the study of changing systems. It is pluralistic, as Stone notes, because of the variety of entities involved. The morality of the act is determined by the current state of the system. Adaptive modes should conform to ecological patterns. An ecological ethics is based on attributes of ecosystems and human compliance with ecological laws. The aim of an ethic must be harmonious with the whole population of living beings.

Ecological ethics is a series of rules for living together. Most sets of ethics make the rules easy to follow. They emphasize the differences (relativism) or similarities (absolutism) of human beings only; or of the individual or the group; or of good feeling, reason, or desire. But ethics has to confront the individual, embedded in a community, located in a bioregion, on earth. And, the rules really are not as easy as human systems have presented. Schweitzer made them too difficult, with a constant valuing, but neither are they that difficult. An ecological ethics can be detailed only on a local level—even when it uses a global strategy.

An ecological ethics is not distorted by human needs and wants when it argues for the preservation of animals and habitats themselves, because they are as they are. Because of the uncertainty of human actions, ethics has to encompass the far past and distant future. No one knew that when DDT killed mosquitoes, it would concentrate in the food chain to kill birds. Values are time dependent, and ecological time can be very long indeed. The futures we invent are viable only if compatible with constraints imposed by evolutionary past. An ethics that requires a long-range responsibility also requires a new humility, since technological power exceeds the ability to foresee its consequences. An ecological ethics recognizes the moral obligation to leave the world habitable for future generations.

We act by intuition and feelings. Like the inductive creation of cultural ethics, we are building a framework of intuitions, feelings, theories, and principles. The whole is recognized as a valuable end by hunters and actors as well as by scientists and politicians. The framework is supported by principles and theories developed by ecologists and philosophers, by the working rules of conservationists and activists, and by specific instances from cultural traditions as well as from the industrial paradigm (determined to become its own worst enemy eventually). Stone considers that these things are only part of the framework. In *The Laws*, Plato has the Athenian say to a youth that all things are ordered with a view to the preservation of the whole, each portion contributes to the whole, and every other creature is for the sake of the whole. Ethics has expanded in wholes, from the family, to the human community, and to nature, on which everything depends. With Ervin Laszlo, ethics encompasses all systems in the universe.

8.3.3. *Ecological & Planetary Rights*

Rights seem to follow the expansion of the sphere of ethics, as formal statements of intuitive knowledge. But codifying rights is more difficult, especially for philosophers, who tend to limit rights with a series of restrictions. Paul Shepard says the argument is not new, and that its application is ambiguous because “unlimited rights” will conflict with human interest. But, there are two bad assumptions: That human interests are not ambiguous—they are—and that animals will be granted unlimited rights—they will not.

The strongest argument for rights is interrelatedness in communities, which is the basis for assigning rights to nature. Garret Hardin considers interrelatedness, but interprets it narrowly. He considers rights as rules of competition; every right is a ploy in the struggle for existence, and every right implies an obligation to furnish it. This is good, but life is more than competition; it involves cooperation and play. Rights are formal rules for living together. It is foolish not to assign rights to animals, plants, and the earth because of stiff, human contractual formalities. The reverence for all beings is concerned with the right functioning and right numbers in the right places, according to standards of health and quality of life.

Humanity has taken its own opportunities. These opportunities have been codified for centuries as rights. Now, we must allow other beings equal opportunities. The interrelatedness of life dictates the interrelatedness of rights. And these rights are necessary to the integrity of the whole planet. Humanity developed in a community of animals and plants, as part of a clade on the same tree of life. The quality of human life has always depended on the quality of animal life. Animals have sensations and feelings, as important to them as ours are to us.

Furthermore, the extension of rights to animals and plants does not deny any traditional human rights. Animals should be accorded higher moral regard and legal standing to reflect the intrinsic worth afforded by their existence and sentience. Current welfare laws to conserve species and to guarantee humane treatment in research, transportation, and slaughter indicate a growing concern among people. A new ethic can keep animals free from human intervention, prejudice, or overuse. The intrinsic worth of animals is independent of instrumental values imposed by us.

One problem with the current legal system is that all nonhuman beings are given the status of inferior human beings, legal incompetents, thus keeping humans in a guardian role. A new legal category is needed that would respect the existence, competence, and excellence of natural beings. Christopher Stone recognizes that the judicial system has granted rights to a variety of inanimate holders, trusts, corporations, and nations, for instance. The legal system already operates with fictions, so the extension to natural entities should not present an insurmountable problem. Two basic rights for nonhuman beings in their species are: *The Space to Exist & Opportunity to Flourish* and *Freedom from Premature Death Extinction & Suffering*. Every species has to be allowed the opportunity to live, even species that we fear or dislike, such as sharks or viruses. We do not know how these species contribute to the whole process of nature. Giving other species opportunities does not mean sacrificing any human needs, just limiting human influence and interference. In our control of artificial areas, which include many wild species, we can imitate the process of ecosystems by allowing birds, bats, and other animals the opportunity to distribute seeds and energy to other areas or to access their prey, which may be our 'pests.'

To be sure, formal rules should to be altered to account for unconscious, interdependent beings. Current legislation on animal experimentation and protection implicitly recognizes the right to life and to a healthy habitat. Laws are needed to protect entire habitats of animals and plants from human interference.

Human rights have been expanded several times. And, they are relatively easy to identify (See Section 8.4.3.1.3.2 in this book). The rights of nations, for example, to control their own resource or limit immigration or trade connections, have also been presented elsewhere. Of course, one very important right for a nation is the right to basic ecological support provided by the home system.

Rights for individual animals, species and their communities or ecosystems can be more broadly stated. For example, each species, community or ecosystem should have the right to be free from interference (as opposed to exploitation, which can stimulate a species or community), as well as the right to participate in biogeochemical cycles. Each individual should have the right to live in a fitting habitat.

Describing rights for the planet is more problematic. Certainly, the planet has the right to its own metabolism, as exemplified in the biogeochemical cycles that keep the planet relatively stable and suitable for living forms. Certainly, the planet has a right to present its forms in diverse ways, that is, diversity should not be reduced by human actions for short-term economic gain. The planet has the right to exist; human actions, especially with nuclear weapons or generators, should not risk a critical area of the planet. The planet has the right to exist at a suitable pace. That is, humanity should not modify too many landforms in the quest for copper, guano or other slow-moving materials. These and other rights could be codified through an international body.

8.4. *Global Design Factors: Ecological Politics & Panocracy*

For Aristotle, politics was the science of the possible. The city (*polis*, the root for politics) was a human artifact whose structure could be modified by reason; it was potentially a work of art in which only the capability of the artist limited the expression. The city was made for the amateur; and it produced more complete men (women were erroneously considered lesser beings at the time). The city was necessary for politics then, as face to face communication. Now, communities are different, larger and dispersed, so politics can has to change. As a science, politics, or ecocybernics (a neologism meaning governing the house) was concerned with two things basically, a way of distributing power and luxuries internally within society, and a way of surviving contact with others.

Politics is the science of government; it has to do with the regulation and government of a nation or state, the preservation of its safety, peace, and prosperity, the defense of its existence and rights against foreign control or conquest, the augmentation of its strength and resources, and the protection of its citizens in their rights, with the preservation and improvement of their morals. Politics depends on common rights, trust, information, and consciousness.

The function of politics in general is to ensure that decisions are taken at the right level. A state protects individual freedoms, guards national culture (values and identity), and holds groups accountable for use of power. The logic of individualism creates conditions that require constraints. Politics has to make them palatable. Although we realize that nothing in nature is without some limit or cost, we may dislike giving up what we now consider (wrongly) as rights. Humans may have to expect much less than they want, even though many expectations are rising.

Ultimately, politics is about the definition of reality itself. Social reality is created. Different societies have had different realities. The Athenians despised the merely wealthy, for instance, and respected community service. North Americans, on the other hand, revere dollar wealth; community service is romanticized on television but hideously underpaid. Politics is also the art of creating new possibilities for human progress. The current system is defective, however. Although it is admirable to work within the system to prevent further environmental degradation, it might be necessary to produce a change in consciousness that would lead to a new political paradigm.

Besides size and power, there are other things that make governing difficult: Division of labor (are there professional citizens?), centralization, and technology. The interrelation of these things necessitates discussing them at the same time. Political institutions are not givens or timeless. Taking from the strengths of earlier forms, it might be possible to modify government to be more effective.

Archaic nations governed their areas independently. Their political principles were similar: all land is communally owned by the tribe, although household goods may be personally held; all decisions were made by consensus in which everyone participated; chiefs were not coercive rulers, but teachers and leaders with specific duties limited to their realm— medicine, war, or ceremonies for example.

When the Europeans or Chinese settled many areas, they brought their centralized governments. The original goal of the U.S. republic, according to Jefferson, was to make each person a participant in the everyday affairs of government. But the government (state or federal) has become gigantic, managing the area from remote locations of power, and participation has dwindled. Despite a recent emphasis on personal responsibility and international cooperation, our political institutions have not responded.

Central politics overwhelms local politics. It dominates the process of decision-making. Politics deals with words, which are arbitrary symbols for events or things. The wrong relationship of things and symbols can result in misguided politics and violence. Decisions are made on narrow political grounds. Citizenship in industrial cultures is the abandonment of responsibility on the assumption that others know how to manage things; government is the assumption of responsibility, without knowledge, that leads to immense and interrelated problems. Government promises to judge disputes in values and protect its citizens from external attack. Modern government, however, is the abandonment of responsibility on the assumption that others know how to manage things.

Ecological, economic, social, and religious phenomena are part of the broad definition of politics. The basic goal of politics is the "survival of the community" as William Ophuls identifies it. Politics is the interactive means of providing the basic necessities of a community. As survival is survival within nature, politics rests on an ecological foundation. The organization of a community must be in accord with natural laws. Political participation depends on information, much of which is provided by ecologists.

Politics occurs, it is now recognized, in an ecological context. There can be no separation of politics and ecology. Every political act has ecological consequences and every ecological decision is a political demand for control over use of the environment. Ecological consciousness must be identified with political consciousness. Politicians need to think about the hunger and squalor of billions of human beings and the destruction of habitats with billions of ambihuman lives, before concentrating on missiles and private fortunes.

An ecosystem, if not a watershed, is a good candidate to be an independent political unit. It is a governable size. It has relatively clearly defined boundaries, as an ecosystem, that is the ecological community including humans, and not a state or county whose boundaries have been determined by rectangular grids at human whim. The first step would be to form an independent government for each ecosystem or watershed. This kind of government, more clearly defined, might look different.

8.4.1. *Political Actions of Individuals*

There are only a limited number of behaviors that people can take to interact with others in their culture or nation: They can ignore the others, as too different, or because of internal conflicts of their own. They can trade with them. They can fight them, or, they can cooperate with them.

8.4.2. *Forms of Governing & Leading*

There are many ways of leading people. Some ways offer models to follow; others represent people in group decision making; and, a few make all decisions themselves. There are formal and informal ways. Almost every way, however, involves more prestige or status for the leader. Sometimes that translates into more meat, more goods or more wealth.

Leadership is the process of leading, that is, providing direction to others. Political leadership, the sense used here, is often formal and refers to a person in a position of authority, as a result of possessing skills at directing. The number and kinds of leaders are compared in Table 842-1.

Leaders, or headmen, help others by choice. Big men distribute the products of their own activities. Chiefs redistribute the fruits of other's labor. Kings take a percentage of resources from the peasants and give it to retainers or use it for public or religious displays. Emperors often represent on a larger scale by far.

Dictatorships needs great leaders, or at least powerful ones, to be successful. A dictator may be self-appointed or popularly backed or appointed by a military force. Idi Amin in Uganda, was an example of the latter. In some states, the dictator is described as a president; Fidel Castro in Cuba was also the head of the Communist party. Kim Jong-il in North Korea seemed to have complete power and referred to himself with numerous titles.

Rome once had a ruling triumvirate. Bosnia and Herzegovina has a three-member Presidency, each of which are elected by a different constituent nation. The position of the President of the Presidency rotates between the members. Modern Switzerland invests leadership collectively in a seven-member Swiss Federal Council. The President is a member of the Federal Council elected by the Swiss Federal Assembly for a year and is merely *primus inter pares* (first among equals).

Some states have a Parliamentary system of government, in which the President is the head of state, sometimes with only ceremonial duties, depending on the constitution, and the Prime Minister is the head of government. Countries with this system include Germany, India, Ireland, Italy, and Singapore.

In nations with a Presidential system of government, the President is the head of government and the head of state. The United States and Venezuela have this system, where the President is more powerful. Democracies need effective and educated citizens. Democracy is the work of the people (remember the Negro spiritual: "We are the ones we've been waiting for").

Table 842-1. Political Systems (after Aristotle)

Number of Rulers	*Kind of Ruler*	*Ruling in Interest of*	*Chosen by*
One	Leader (headman)	Band	Consensus
	Big man	Tribe	Consensus
	Chief	Chief Nobles	Ancestry Gods
	King Emperor Dictator	Monarchy City-State Tyranny of Few Self/Power structure	Self Parent Self Military
Few Collective	Triumvirate Co-ruler	Aristocracy Oligarchy	Citizens of State Few (Rich)
Many	Prime Minister President	Polity Voters Democracy Ochlocracy	Voters People or College Poor People
All	People Anarchy	Self-All Community anarchy Direct democracy	All People

Leaders themselves may be influenced by choosers or controllers. Controlling groups such as the military, political parties, ruling elites, or religious elites sometimes place higher expectations on the leader, such as transformational change. The leaders may encourage their followers and believers to worship leadership. The followers may be uncritically obedient.

In the United States, a President is elected by the Electoral College, which is made up of electors chosen by voters in the presidential election. Each elector is committed to voting for a specified candidate determined by the popular vote in each state. However, due to skewed representation, it is possible for the candidate with fewer national votes to win the electoral votes in the Electoral College and get the presidency, as happened in 1888 (and again in 2000).

Leaders, with choosers and controllers, are part of the governing process. The forms of government range from tribal leaders and chiefs to anarchy and direct democracy. These forms work best with small populations where everyone is known, even if they do not share the same culture. Other forms of government, such as authoritarian dictatorships, monarchies, and republics, have worked with larger populations. At the largest sizes, the bureaucracies and infrastructures have more in common, regardless if the government is socialist, communist, parliamentary, or representative democratic.

Larger nations require larger governments, to make laws to accommodate differences in cultures. Specialists are required to resolve conflicts. The specialists often have a monopoly on weapons and the spectrum of information. A bureaucracy is needed to run the government more effectively.

Table 842-2. Governments

Leadership / **Decisions**	*Egalitarian Leader*	*"Big man"*	*Chief / Hereditary*	*King / Hereditary*	*Representative*
Bureaucracy	None	None	None Crony level	Many levels	More levels
Monopoly on Force & Info.	No	No	Yes	Yes	Immense
Resolution Of conflict	Informal	Informal	Central	Laws, judges	Laws, judges, specialists

At the largest sizes, the bureaucracies and infrastructures have more in common, regardless if the government is socialist, communist, parliamentary, or representative democratic.

8.4.2.1. Traditional Small-scale (Elders, Chiefs, Kings)

The Coeur d'Alene people had strong leaders. Each village had a council with male and female members. A large village had a headman or woman who regulated economic and religious affairs. Their only real power was their persuasive abilities and the public esteem they built up. Chiefs were elected or deposed by the council. The band chief regulated basic resources. Next in authority were a war leader, hunting leader, and shaman, chosen for their respective skills

Marvin Harris shows how headmen are associated with hunting societies, big men with horticultural societies that are larger, and chiefs, still larger, and starting to accumulate goods. Headmen are more informal, in bands of 50 or villages of 150. Every one knows and understands others; reciprocity is the bank. Headmen are leaders without power. Big men give away extra wealth. Chiefs accumulate it.

Chiefs have proven ways to keep the underlings happy or at least resigned. They arm the elite and disarm the public, that is, monopolize force. They use the monopoly of force to maintain order and reduce violence. They redistribute some of the wealth in public displays and games, a kind of informal tax refunds. Chiefdoms were successful in Rome, the Pacific Northwest and Hawaii.

Kings enlisted ideology or religion to justify the transfer of wealth to the king and rich retainers. The shared religion also makes strangers act more peacefully without kinship. It gives people a reason to sacrifice their lives for an institution, nongenetic. The king was the central human representative of power. The Mayan king gave blood, with other nobles and prisoners. Blood is the home of the soul; it is valuable and the most powerful gift.

Mesopotamian cities had councils of elders to make decisions. They would appoint a leader to lead in war or trade. The word for this leader, 'Lugal,' eventually came to mean king; after 4800 YBP, gods changed from natural forces to war gods. Agriculture gave a surplus; that and property lead to excitement of war. In China, in the Warring States period, the nature of war changed: from an Aristocratic monopoly of soldiers to one with standing armies, professional leaders and peasant soldiers. China. New towns were planned and built by ranked lords at the edges of the state. The king gave land, title, ritual things, and a clan name. The King served as his own priest because he could contact his ancestors.

8.4.2.2. Modern Large-scale Government

As leaders had more followers or constituents, they needed help addressing problems of income and payout. They needed a large bureaucracy to maintain records and make local decisions. For example, large-scale irrigation appears in Egypt first in 7100 YBP. In Mesopotamia, large-scale water systems were first managed by religious leaders, then later by secular leaders. As problems developed, temporary military leaders became permanent hereditary kings. Palaces were built and staffs numbered thousands.

Power became centralized in the king. As the populations became larger, the king had to have representatives. Centralization and representation became necessary properties of large-scale government.

8.4.2.3. The Importance of Leadership

Leadership can refer both to the process of leading, and to those entities that do the leading. Leadership can have a formal aspect, as in most political or business leadership, or an informal one, as in most friendships. A leader is assumed to have special skills or competencies. Leaders of bands or tribes were often specialized in specific activities such as hunting or social integration. Although leadership can be exhibited by an individual, either a group of people or a heroic character can show leadership.

Leadership is often confused with transformational change, although usually leaders are the last to change. Leadership may also be associated with respect, obedience, or worship of the leader. National leaders may be presidents or queens who make the decisions for their countries. Global leaders, however, will have to address a wider spectrum of needs, and balance them.

Even in representative systems, leaders may have ceremonial or reserved powers. Leaders need to have idea people (like F.D. Roosevelt had), but they also need to have jesters and clowns to mock their mistakes and pride. In most every nation, leaders have too much power, as well as too little information, humility or wisdom.

8.4.2.3.1. The Importance of Having an Idealist

Leaders need to be exposed to as many ideas as possible, without the wrappings of ideologies or the distortions of lobbying. The ideas need to be presented objectively and and as comprehensively as possible. Ideas need to be presented for their utility or beauty, more than for their coinage or party flavor. Ideas can then be considered for their fitness in the larger political system. The idealist (or imagicist, eutopian or 'imagineer') needs to be neutral to be effective, therefore this might be a paid professional position in, for instance, the President's Cabinet of the US.

8.4.2.3.2. The Importance of Having a Jester

Traditionally, the jester had the lowest status in courts; anything he said was accepted, in a limited way, because they all, kings, royalty and pretenders, acted as if the jester was moronic and mad, and he couldn't help it. The jester was exempt from the normal rules and social expectations. Jesters had to be amusing, but were expected to be honest in observing and commenting on the behavior of their betters. They had the power to mock and revile the most prominent, until they were removed or killed sometimes, for being too accurate or insistent.

We need to institute that office again, but maybe without the possible death penalty. In the comedy of politics, the jesters would present common sense and truth. A new Office of Jester is crucial to the continuity of modern government, only now it is the little elected kings who are moronic and mad. Politicians have learned that nothing is too dumb or extreme, regardless of how ridiculous or socially destructive it is, as long as a few of their constituents, probably family members under 18, love their idiocy, cute greed and smiling shrewdness, they continue it.

Since politicians likely do not see the Comedy Channel or read the comics, it might help if they had a personal Fool to remind them of their intellectual and moral errors, not only to protect us from losing our health and paltry wealth, but to protect them from pangs of conscience or moral meltdown. But, are they smart enough, humble enough, to act on such a reminder? The Supreme Court certainly needs a court jester. Where is the Irony Board to address the wrinkles, from the crooked crush of greed and stupidity, in the fabric of social cohesion? This government by 'make-believe' is creating a thin cloud too far from the ground—dare one say 'Cloudcuckooland'? With apologies to Aristophanes.

It is urgent that we create a formal position of Jester to attend every high political position and ground it. Let's not just fool around. It might cost something, but it would employ many unemployed comedians or funny philosophers. They could lightly amuse the 'Decisioners' or procrastinators and then deliver the really bad news: Shrinking economies, social upheaval over massive inequities, dangerous armaments not for warfare, and runaway environmental destruction and looming catastrophes. Basically the message is: Stop pretending all is right and business as usual can save the day—It's an emergency! We all need to act. Won't someone considered important and alert, or entertaining and honest, or at least famous, or maybe a professional 'honest' speaker, please tell our political leaders that the planet is burning!

8.4.2.4. Forms of Governments

People have chosen, or allowed, or suffered, many kinds of governments and institutions, including rule by king or co-consuls, presidents or oligarchs, communism or democracy, aristocrats or anarchy. Societies are constituted by people and their ideas about government and justice, among other things. Ideas and behavior continue to evolve in a natural and then cultural contexts. The individual human being is a result of a family and local community, but law evolves in a larger culture. Law is now an important part of social structure.

Humans consider themselves to be self-creating and self-ordering. But, that is because they are part of a context of self-ordering processes. Government is part of that self-ordering process, wherein specialists make decisions based on their expertise. Specialization is built on trust. We trust that others will produce enough grain for them if we make a plow for them. Government has to balance giving and receiving of things and services. It preserves the balance of society.

But, governments do not always balance giving and receiving very well. Since they are run by people, and people tend to put their own interests first, governments can be tyrannical about refusing to distribute power and goods. Which tyrannies are acceptable? The abuse of power by kings, or abuse of power by corporations? Unjust executions, or cancer from toxic wastes? Government mismanagement, or the abandonment of communities by capital? Governments are accountable to the laws that they make. Enforcing the law may keep governments more balanced.

8.4.2.4.1. Excellence & Law

What is government? Tribal government was based on customs and who was best at certain things, from hunting to resolving conflict. In tribes and empires laws were formed to overcome differences in customs. Government now is based on laws. But, it also needs to be based on information as well as on general common human values (and shared rights).

8.4.2.4.2. Separation of Powers & Functions

Aristotle, the Greek philosopher of about 2350 years ago, recognized the importance of a “rule of law” for states, as well as a central government with a separation of powers.

The framers of the U.S. Constitution wanted to form a government that did not allow one person to have too much authority or control. While under the rule of the British king they learned that this could be a bad system. Yet government under the Articles of Confederation taught them that there was a need for a strong centralized government.

With this in mind the framers wrote the Constitution to provide for a separation of powers, or three separate branches of government, a legislature, executive, and judicial. Each has its own responsibilities and at the same time they work together to make the country run smoothly and to assure that the rights of citizens are not ignored or disallowed. This is done through checks and balances. A branch may use its powers to check the powers of the other two in order to maintain a balance of power among the three branches of government. The checks and balances, combined with a separation of powers, gives responsibility to each branch to oversee the others, but the branches must be equal. Partly this is done by having overlapping responsibilities.

8.4.2.4.2.1. *Legislative Branch.* The legislative branch of government is made up of the Congress and government agencies, such as the Government Printing Office and Library of

Congress, that provide assistance to and support services for the Congress. Article I of the Constitution established this branch and gave Congress the power to make laws. Congress has two parts, the House of Representatives and the Senate. The functions of the legislature are: To make laws, and To check the executive branch by confirming appointments, and investigating executive branch activities.

8.4.2.4.2.2. *Executive Branch.* The executive branch of Government makes sure that the laws of the United States are obeyed. The President of the United States is the head of the executive branch of government. This branch is very large so the President gets help from the Vice President, department heads (Cabinet members), and heads of independent agencies. Typically, the President is the Leader of the country and commands the military. The Vice President is President of the Senate and becomes President if the President can no longer do the job. The Department heads advise the President on issues and help carry out policies. Independent Agencies help carry out policy or provide special services to that branch.

The executives could include monarch, prime minister or a cabinet. The functions are: To execute laws; To execute policies; To Control policies; To appoint officials; To Command the military; and, to Veto legislation.

The executive branch could be headed by an Executive Council of seven, with these specialties: Internal Coordination, External coordination, Ecological affairs, Cultural Affairs, Religious affairs, Economic Affairs, and Communication (Press). This Council would elect a President for Internal affairs and a Prime Minister for external affairs.

8.4.2.4.2.3. *Judicial Branch.* The judicial branch of government is made up of the court system. The Supreme Court is the highest court in the land. Article III of the Constitution established this Court and all other Federal courts were created by Congress. Courts decide arguments about the meaning of laws, how they are applied, and whether they break the rules of the Constitution.

The functions of the judicial branch are: To maintain the integrity of the Constitution; to interpret laws; and finally to check the executive branch by questioning enforcement of those laws?

8.4.2.4.2.4. *Other Branches.* Are three enough? Or too many? All three deal with the rule of law, to make, execute, and interpret laws. There is no reason there cannot be a fourth or fifth branch. People have suggested the “people” or the press as a fourth branch. The Philippines have three branches plus three regulatory commissions, on for civil service, one on elections, and one for auditing all accounts. The Netherlands have a Water Authority Board. Iran has an equal religious leader and Board of Guardians, although they may have more power than the traditional three branches. Some countries in Africa recognize the role of tribal leaders in government.

Is the rule of law enough for nations? Should there be rule of information or rule of religious beliefs? The formal power of beliefs might be separated into knowing, expressing and wise application. Are those enough to be separate? Informational power supports law, but it might also be more important than law under some circumstances, and law should be allowed to support information. An informational power might be separated as well, into research, applications for planning and wise assessments.

8.4.3. *Functions of Politics*
The functions of politics are internal and external. Internal functions are characterized by activities like the fair distribution of food and rewards. External functions are: To coordinate interaction with other nations; and To decide matters of exchange of people through emigration and immigration.

8.4.3.1. Internal Functions of Politics
Internal functions are: To promote the survival of the nation and communities; To preserve the balance of society; To maintain the affairs of the nation and communities; To guarantee fair distribution of food, goods, and necessities; To manage the distribution of power; To preserve the safety of the nation with laws and defense; To represent the citizens, to educate them, protect their rights, and remind them of their morals; To resolve conflicts between citizens; To regulate the activities of citizens regarding safety of the environment; To encourage conversation and communication; and To moderate the forces of change (internal and external).

8.4.3.1.1. To Promote Survival of Communities & Nation
Politics has to be successful enough for a new generation to take over ruling the culture and nation. If rulers promote the wrong images, that do not fit the environment, eventually a nation will collapse.

8.4.3.1.1.1. *To Preserve the Operation of the Environment.* Nations are embedded in places. If the place itself, the environment, fails, then no political assurances will be able to feed hungry people. So, political decisions should not interfere with the operation of global cycles or local renewal.

8.4.3.1.1.2. *To Preserve the Balance of Society.* Place sustains government. Land sustains government. Land produces food and resources, but the land is not equal or consistent. Poor land does not produce as much as rich land. Agriculture in general does not seem to produce as much wealth as business. Business does not seem to produce as much wealth as artists (symbols and abstractions have fewer limits on productivity). So, government needs to preserve some balance and equality by giving and taking. Individuals are produced by a community. So, the community in place seems to be the source of most of the wealth. Restoring balance in a small community can dislocate people. Leon MacLaren states that balance can be restored by depression, war, or revolution, and it can be painful. Of course, planning and conscious adjustment might be less painful and less risky.

To Encourage Conversation & Communication. We can best understand the social aspect of culture by realizing that the central function of human symbolization is communication and requires adherence to understood conventions. Constant communication allows a culture to be coherent. Lack of communication can lead to unhappiness or violence.

To Manage Individual Civic Relations & Conflicts. Many cultures have built-in limits to local kinds of conflict, but conflict between cultures requires some laws or understandings. Behavior has to be understood in a context as meaningful. Sometimes conflicts are the result of language, behavior patterns or simple geography. There has to a path to resolve conflicts, either consensus, mediation or neutral judgment.

To Decide Limits to Growth Development or Movement. Keynesian economic theory, the predominant theory in industrial countries, holds that the full utilization of resources is necessary to ensure full employment and the maximum social good. This economics depends on economic growth to avoid crisis. The major premises assume that: Population will grow, that social good is related to the equitable distribution of material products, and that if resources are limited, technology can erase the limits. The economist Kenneth Boulding referred to this as a cowboy economy, an economy that has yet to even recognize the possibility of limits of wealth.

Growth is rarely an unlimited process in nature. Unlimited growth is only an economic characteristic if the economy refuses to recognize physical and biological limits. Because people seem to have unlimited wants, some political rules need to be in place to allow equal distribution before some can amass vast fortunes.

One solution is to work within limits of sustainability. Population could be stabilized. Consumption could be stabilized, especially with a shift to recycling and solar energy generation. The technology exists, but educational and political problems are more difficult.

8.4.3.1.2. To Manage the Affairs of the Communities & Nation

Hutterite communities were able to manage their community as long as it was less than about 150 people, Garrett Hardin noted. With more than that, distribution of goods failed, due to some doing less than their share or getting more. So, the Hutterites split communities into two, when they got too large. The scale of community can make some things work better. The force that keeps individuals from laziness or greed seems to be shame, which seems to work as a force only in smaller communities. In a small community, a person can be shamed into working harder or into being less greedy, but in larger communities shame does not work as well. Maladaptive behavior may be less visible or the malcontents may form a subgroup that justifies their behavior. Hardin suggests that most utopias do not consider such a change in scale while describing sizable communities.

Many archaic cultures mismanaged their natural resources, but got away with it because their impact was relatively small. Some cultures were not as lucky, the people of Ur, for instance. Luck, as well as size, has a lot to do with the success of some human cultures. Many other cultures mismanaged the affairs of communities, but they were able to survive because of brute control.

The industrial cultures are mismanaging their resources and affairs, but may not be able to control or organize—or luck—their way out of their problems. Modern society has benefited from modern means of management. In fact, management has made industrial operations, from science to agriculture, possible. But, to continue without disaster, it needs to re-empower local voices, especially indigenous peoples, poor, displaced, and women. It needs to encourage unique local management solutions, such as the water management on Bali. It needs to adjust to optimum scales that are more efficient and just.

8.4.3.1.2.1. *To Guarantee Fair Distribution of Food & Necessities*. With the complexities of civilization, with various levels of responsibility and duty, politics has to make sure that necessities are distributed in a timely manner. The infrastructure, that is the bureaucracy, the coordination, storage areas, trucks, and other things, have to be in place and functioning.

Resources (Managing Commons & Private Properties). Traditionally, a commons was a territory managed by a community so that individuals could share the land for grazing or farming. This form of use characterized many tribal groups for 40,000 years. The commons were only open to the members of the community, and perhaps to a few who asked permission. Community beliefs or a kind of ecoethics discouraged overuse, in that overusers were shamed with informal sanctions or forbidden to continue using the land. In a sense, any territory not explicitly claimed by one community is a commons. That would include the atmosphere and oceans especially, or rather air and water in any form, since these are global things and can move between systems, and their character is determined by the globe itself. Some global economic or ethical method of management, not just for human use but for nonhuman use, must be devised.

Hardin extends the idea of the commons to rest on the idea of a carrying capacity of the territory, which is a very dynamic concept, susceptible to change by the weather, season, food preference, or other things. When the commons is not tempered by rules, then an individual user gains all the advantage and the disadvantage is shared by all users. Ecological degradation is assured and the system collapses, a tragedy due to the "remorseless working of things" in Hardin's words. In a limited system, the self-interest of one person cannot decide the public good, or the ecological good. So, the "invisible hand" does not provide a long-term solution. The hand needs to be visible.

The misuses of commons, some of which are alluded to by Hardin, include: Uncontrolled human population growth, depletion biodiversity, transformation of fossil fuels, pollution of waterways and the atmosphere, logging of forests, overfishing of the oceans, private vehicles jamming public roadways, tossing of trash out of automobile windows (littering), graffiti, poaching, noise pollution, and email spamming. Each of these misuses places a burden on most of the other users.

Privatization is one possible solution. However, unless individual ownership includes some regional cycles or global resources, then there might not be incentives for sustainability. One problem is that global things cannot be enclosed like land. Regulation is possible, as is payment by the polluter, a form of taxation. Hardin considers these as forms of enclosure also. One solution would be the return of many commons to the cultures that adapted to them and have had cultural rules governing their use. Hardin's suggestion was "mutual coercion, mutually agreed upon."

Many of our less wholesome behaviors, such as rapid technological change or wars, can disrupt tradition and lead to misuse of the commons. If the commons were presented as a prisoner's dilemma for a community, then individuals would have two options, cooperation or defection. Defection, or private mismanagement of common areas, can lead to economic madness, as Paul Shepard indicated. If there are unavoidable costs to defection, then it would be the less likely choice.

The tragedy of the commons is not that the traditional commons system did not work—it did, because it was controlled ethically in a community—it is that other kinds of commons, e.g., global, have no such rules governing their use. The tragedy occurs especially when there is a transition from an ethical community use to a free market system that encourages overuse.

In a larger sense the whole planet is the commons, and its limits are obvious, between the sun and the greater vacuum of interstellar space. The photograph of the earth made a logical connection between the common earth and the necessity of conservation. So, if the earth is a commons and humans are threatening the health or existence of the commons, then humans need a common ecological ethic, or some set of rules that they can respect.

In another sense, most problems are local not global. So, at the same time, we have to take responsibility for our local environments, and respect the cultural carrying capacity, as a term for the whole integrated concept of capacity that includes human luxury as well as minimal eating and nutrition.

Goods. People made their own goods in foraging societies. For the Desana, goods from the gardens support people, although small numbers of extra goods are traded for clothing, machetes, soap, salt, aluminum pots, fish hooks, and rarely a gun. With farming came specialization, and more goods that could be made and accumulated. Goods became a form of wealth, especially in groups like the Kwakiutl. In Crete, written records show how goods were directed to the palaces and redistributed from there. The demand for goods between Europe and China resulted in the introduction of the camel in the Trans-Saharan trade and boosted the amount of goods that could be transported. Donkey caravans from the Mediterranean brought obsidian and other goods to Mesopotamia, and ivory combs from the Indus river. The value of goods was determined by supply and demand.

Industrial farming depended on a new kind of market, a large market for cheap goods. The English encouraged trade to increase the number of goods. The industrial revolution decreased contact with the natural world and objectified what was left. As a result of drastic changes in the production of economic goods, other political, social and even psychological changes occurred. Other kinds of order were de-emphasized. Human relationships became based on economic allegiances instead of kinship, and were formed in societies, not communities. Money became a symbolic representation for the value of labor and land. Land and labor became commodities.

Economics has become more and more global. Where peoples used to trade material goods, fish for roots or feathers for leather for instance, now all things have a common symbolic value, most often expressed in yen or dollars. This means that whoever works cheapest, and with the lowest cost of living, sells the most.

As the automated production of goods became more efficient, goods-producing jobs declined. The goal of production moved from the production of goods to efficiency. Needs are almost completely defined in terms of commodities. Even relation needs a commodity, travel, to be fulfilled. Once the need is defined and partly satisfied, it becomes a right. From walking to the right for passenger miles at high speed in a mere fifty years.

The material goods of human societies has been increasing. How many of us can carry everything we own on a bicycle or horse? Goods are privately owned more often. Items that used to be shared in neighborhoods or communities, such as lawnmowers or radios, have many separate individual owners. While this is good for the modern economic system and for the ideal of convenience, it weakens socials bonds, dependencies, and trust. Private goods, like gardens, are also public goods, especially in a city, where they contribute to renewing air. Private good, like a loaf of bread, can be owned and not shared. Public goods are those that can be enjoyed in common, since one consumption does not subtract the possibility of another consumption. Air is a good example, although there might be a time when air is rare.

Stung by the suffering of people with new unsatisfiable needs, modern governments have offered to produce more, safer goods, instead of ecologically analyzing the relationships of needs to satisfactions. People have to imagine and construct new frameworks so that they can develop satisfactions that are not dependent on commodities.

Surprisingly, once basic needs are met, for food shelter, respect, and confidence, according to Abraham Maslow, then happiness is not increased much by additional material goods or money. The things that make people unhappy are when their higher needs, such as self-esteem, are not met. Lack of love or security, or lack of communication or appreciation, lead to unhappiness. People try to balance their lacks by acquiring more money or things. The culture has to be meaningful, as well as secure and equitable, with lower extremes between wealth or status.

8.4.3.1.2.2. *To Guarantee Fair Distribution of Power & Rewards*. Power in physics is the capacity to move. Socially it is the capacity to act. Power is the capability of making things move or happen. Power is not only making things happen, it is a way of controlling which things happen. Having power determines who gets to decide. Power allows dominance. If power is concentrated in one or few people, then there are fewer opportunities to challenge or limit it. Concentrated power can lock or gridlock patterns of movement; this is not always healthy, since many problems need many different solutions. Absolute power is no longer accountable to lesser power.

In archaic societies everyone has some power. Power is given to those who have better abilities, at hunting, healing or coercing. The real power there is the ability to persuade others. First persuasion yielded power, then strength, then knowledge. Power can come from strength or a connection to another form of power, ancestral or holy. Power can be derived from the permission or weakness of others.

The creation of large dense communities required new forms of power, due to size and organizational problems. No matter how big the bureaucracy, for a while it only controlled human muscle power. That limited their reach, regarding armies or builders (of pyramids). Traditional states had trouble controlling regional potentates or their armies completely. New forms of energy expanded human power and control.

Scale of governments or corporations gives them more power. Management techniques, or technology, can augment power. Power allows more waste. But, power diminishes the ability to see or feel, or suffer, the consequences. Power often reduces the perceptions of those who have it, such that they use power to simplify ecosystems rather than imagine working inside the systems. Having rewards gives people more power. Such power can be expressed in buying patterns as well as bribes.

Corporations increase their power temporarily because of our failure to grasp their nature. Misunderstanding of power or nature can allow a temporary expression of power. The competitive way of life, as it dominates, distorts the meaning of power and demand, and causes imbalances of power and demands.

Governments with concentrated power can be tyrannical about redistributing power or rewards. Inequality in rewards is maintained by the concentration of power. Rewards and power are treated as primary needs, which results in imbalances. Power can lead to detachment from primary needs and natural wealth. Rewards give more power, so that the two form a positive feedback loop that sometimes cannot be controlled, by the user or the less powerful. The cycle becomes self-reinforcing.

If power is spread more evenly, through many leaders and many kinds of leaders, then they can check each other and power is balanced. Under many constitutions power is dispersed by dividing into separate branches. Humans are momentarily powerless to replace or transcend the circuitry of natural or cultural systems. People often have the power to deny using the power, especially for activities that can destroy place or human values.

8.4.3.1.2.3. *To Promote Safety & Security*. Without safety and security of the primary needs of food, clothing, and shelter, there will not be a cultivation of secondary needs that promote higher culture. Ultimately security is the availability of food, materials and energy. There are levels of security, starting with a healthy ecosystem, and the ability to use it, protect it, and restore it. Security also requires that resources be available to be used, conserved and substituted. Socioeconomic security requires a healthy culture that can distribute basic needs equitably and efficiently. For people to be secure in their own skins, all of their needs, such as self-actualization, have to be encouraged.

Safety is a basic human need, physiological and psychological. Safety is increased when people accept limits on their social behavior, when natural disasters are anticipated, and when technological extremes, such as nuclear accidents and wastes, are safeguarded. Safety does not mean wiping out large predators, such as alligators or sharks, to ensure than no one ever gets bitten or eaten; it means reducing exposure to wild animals, by reducing the overlap or reduction of territories. Animals have to balance their own safety with migration and food-getting. Safety does not mean killing every form of bacteria or virus; it means limiting exposure, being healthy, and preventing the spread of pandemics through accelerated travel and sharing. Ecologically, safety means leaving functioning ecosystems outside the circle of human domination.

Safety is increased with higher standards for sanitation as well as for technology. It means minimizing the potential for harm in a work or play situation. This occurs when governments and corporations take higher risks than the communities and cultures, accept a burden of proof for new developments, and accept higher margins of error and certainty. Safety is increased with laws, such as those concerned with cheating, thieving or killing. Laws that limit dangerous things, such as alcohol or guns, expand safety.

8.4.3.1.2.4. *To Adapt to Internal Forces of Change.* The principle of change indicates that nature is in flux, culture is in flux. Politics is concerned not only with how power and authority are exercised but with how these relationships get transformed. We are interested in the forces that sustain consensus as well as in the forces that bring about change. Intensive change is the development of consciousness or social sophistication; it is characterized by consciousness, connection, and communication. This should apply to cultures also. Extensive change results in the development of cities and technology; it is characterized by conquest, colonialization and consumption.

As humans stay in place, they tried to extract more resources from the same area. This requires new ideas and technology. Which resulted in denser settlements, which resulted in new technology and new social organization. This is extensification. Innovation is influenced by the growth and intensity of population, by the expanding and intensified activities of states or cities, and increasing trade and commercialization. The ease of communication also increases rates of innovation. Perhaps that is why it went east-west in Europe and Asia and north-south in the Americas. Accidental innovation became a culture of innovation, that is, a part of the culture that was encouraged and used.

Civilization is shaped by extensification and intensification, and complication and complexification, although on a local level there were booms and busts of individual civilizations. Why do countries lag behind in industrialization? Why do they need to join the race? Economists argue that their policies or attitudes are at fault, that their environment might be poor. That they are unorganized. That they are fearful of change or exploration. That does not seem likely though. Often the problem can be resources or domination, but sometimes, it is the social predisposition to change, as a result of historical or cultural factors.

8.4.3.1.3. To Represent Citizens

The early Sumerian temple tower, with a hieratically organized city surrounding it, became the model for the Hindu world mountain Sumeru. The king was the central human representative of power. First there were cities and then empires of cities, with kings to represent citizens. Leaders always try to represent members of a group.

In archaic cultures, when people could not present themselves at every meeting, it was useful for someone to represent them. Some degree of household autonomy is sacrificed to some larger order group in return for greater security against attacks by enemies or from starvation. A government promises to judge disputes in values and to protect its citizens from external attack.

The people of a nation-state were first given full sovereignty officially in 1648, with the Peace of Westphalia. Representative governments still use that sovereignty to claim responsibility for their actions, without recognition of any international body. They also represent citizens in matters of economic opportunities and trade, to attempt to guarantee access and fairness.

8.4.3.1.3.1. *To Educate Citizens Scientifically & Morally.* Thomas Huxley thought that people in nature were Hobbesian, unfit for civilization unless culture educated them. The same essential belief was held by Sigmund Freud. But, the contexts were, and are different. The thought of Huxley was dominated by ideas of competition and fitness, and that of Freud by individuals in society, from hysterical women and conflicted children to selfish businessmen and power-blinded leaders. The context now is drones in an industrial flatscape.

The modern state has an educated bureaucracy to manage information. It requires compulsory education, resulting in mass education and mass literacy. Mass literacy disenchants the cosmos by undermining traditional and magical ways of thinking. Testing traditional knowledge became a habit. Difficulties of dealing with a half-hearted half-educated public, of dealing with a hard-hearted, hard-headed professional elite, only add to the problems of a culture.

Education may be a necessity, but it has to be a freely offered broad education, based on rich philosophies and sciences. It has to be adaptive. Tribes in the Brazilian Amazon, for instance, have stopped using chainsaws and tobacco, to live more traditionally. They also set up educational centers to show others how it is done.

8.4.3.1.3.2. *To Protect the Rights of Citizens.* In a traditional English village, inherited bundled rights provided commoners with rights of grazing and gathering fuel wood non-destructively “by hook or by crook,” which indicated the way wood was gathered by shepherds. The form “commons” is plural, and refers to the whole group of commons, subject to these effects.

Human rights refer to the concept of human beings as having universal rights, regardless of legal jurisdiction or other localizing factors, such as ethnicity, religion and nationality. Sometimes the rights are considered to be inherent, universal, indivisible and inalienable. Legally, human rights are defined in international law and covenants, and in some domestic laws. Human rights can also be based on the moral order described by religious writings. Religious societies can justify human rights through religious arguments, e.g., liberal Islamic movements have tried to use the Qur'an to support human rights in a Muslim context.

In his January 1944 State of the Union Address, Franklin D. Roosevelt, then President of the United States, suggested that it was time for the nation to recognize and implement a second Bill of Rights. He argued that the political rights addressed in the constitution and the first Bill of Rights was inadequate to assure us equality in the pursuit of happiness. Therefore, he felt it was necessary to declare an economic Bill of Rights that would guarantee each individual: Employment, with a living wage for food, clothing and entertainment; freedom from unfair competition and from monopolies (and now oligarchies since the 1980s); decent housing; adequate medical care and the opportunity to enjoy good health; adequate protection from the threats of sickness, accident and unemployment; a good, well-rounded, useful education; and social security, when it was no longer possible to work.

Roosevelt said that these rights would contribute to the security of the country, and security would ensure our place among nations. He warned that true individual freedom cannot exist without economic security and independence, which is ultimately related to equality. He stated: "We cannot be content, no matter how high that general standard of living may be, if some fraction of our people—whether it be one-third or one-fifth or one-tenth—is ill-fed, ill-clothed, ill-housed, and insecure."

He traced the weakness of the first Bill of Rights to the rapid expansion of industrial and corporate power. The Bill was not adequate protection against concerted greed. These economic truths are now self-evident. Despite the lofty and reasonable goals, this second Bill of Rights was never implemented. Americans can see faint echoes of it in the concern for Social Security. They are slowly advancing with the first Clinton proposal and now Barack Obama's compromise health care plan. Perhaps, the entire second Bill could be part of the government of every nation, in the interest of peace.

Other nations, some European ones and South American, have been giving their people more economic rights. Some are even talking about social, cultural and environmental rights, as well. As rights have expanded, they have also been made more explicit in laws and codes. There is a form of an International Bill of Rights, covering human and ambihuman. This would cover workers rights. Residents expect to have equal rights and opportunities.

8.4.3.1.3.3. *To Outline the Duties of Citizens.* In addition to having rights, citizens also have responsibilities to participate in government and to live as wisely as possible, to make good places. Often, duties have to be made known through education and communication from the government. In a panocracy humans must represent other species, who have a say in the rule (humans already successfully represent the young, mentally handicapped and corporations, who cannot represent themselves).

8.4.3.2. External Functions of Politics
External functions are those outside the boundaries of the nation. But, those functions may have dramatic influences on the shape and course of a nation.

8.4.3.2.1. To Coordinate Interactions with Other Nations and Cultures
The possible kinds of interactions of groups or cultures are: To ignore each other; to exist separately with trade or contact; to compete for resources and people; to cooperate with each other; to fight for dominance or territory; or to destroy the other.

For interactions leading to violence, a number of trends that can be seen. These are feedback loops that loop around to the beginning, also. For instance, the failure of neighboring economies can lead to the failure of trade, or the failure of negotiation. The failure of defense, the failure of contextual system, and the failure of a structure for individual participation can lead to the collapse in the meaning of participating. The fragmentation of social responsibility can led to an isolated self-image (unrelated to the external), to lack of self-confidence, and to a decline in participation. Conspiracies for societal control can lead to government intervention, guerrilla warfare, and massacres.

On the other hand, alienation can lead to selfishness, gangs, and anarchy, then neighborhood control by criminals, psychological stress of urban environment, substance abuse, family breakdown, lack of control, and violence. Prejudice can lead to segregation, discrimination against indigenous populations, destruction of cultural heritage, ethnic disintegration, an inadequate sense of identity, psychological alienation, and violence.

Conflict starts with people, but extends to animals, natural events, and nations, leading to the unfortunate metaphor of war. What is a definition of war? Does it have to do with the number of battles or dead? Or with having a professional army? Does it have to have a beginning and an end? Does it have to be a certain scale? Does it have to be agreed on by both sides or all parties? The whole process and its effects are complex. As violence and conflict occurred on larger scales, they were called wars.

8.4.3.2.2. To Decide Matters of Emigration & Immigration
National governments have the right to determine their own immigration policies, even though the policies are influenced by many other factors, from disasters to invasions, outside the control of governments. Governments need to balance emigration and immigration in a context of a satisfactory population suited for its environment.

8.4.3.2.3. To Adapt to External Forces of Change
Extensive evolution is the horizontal spread of species. Extensive change is the spread of cultures through many ecosystems. Human migration was a form of extensification. That is, when the size of foraging communities made hunting and living problematical, some humans moved away. Only when they could not or would not move, did it become intensification, which required different strategies to live, such as intensive food-gathering strategies. Exploitation of new areas shows the ecological power of the species. Intensive development of a place shows the creativity of the species.

Politics has to adapt a culture to external forces, from climate change to invasions of exotic plants and animals. A culture cannot escape the rhythms of nature. Some events, such as earthquakes or floods can be anticipated with plans and architectural designs.

8.4.4. *Ecological Politics & New Functions of Politics*

Ecological, economic, social, and religious phenomena are part of the broad definition of politics. The basic goal of such a politics is the "survival of the community" as William Ophuls identifies it. Politics is the interactive means of providing the basic food and necessities of a community. As survival is survival in nature, politics rests on an ecological foundation. The organization of a community must be in accord with natural laws and limits. Political participation depends on information, much of which can be provided by observers and scientists.

There can be no separation of politics and ecology. Every political act has ecological consequences and every ecological decision is a political demand for control over use of the environment. Ecological consciousness can complement political consciousness. The ecological, social, and political problems of today do not have simple disciplinary solutions. The problems are cosmological and must be solved on that level. But a single cosmology cannot solve all problems in all places. Where human understanding is still underdeveloped, humanity cannot afford to suppress the diversity of thought necessary for adaptation to the diversity of environments, or to eliminate ecosystems and the societies adapted to them, which explains why archaic cultures are valuable.

Practicing a holistic, or metapolitics, is the recognition that humans are part of a larger community, a larger whole that includes all humanity and all the earth, with its species, habitats and resources.

8.4.4.1. Deciding Goals for Ecological Politics

The government of a community is a framework to maintain the lives of people. For the original archaic peoples, tribal teachers were adequate for this maintenance function. In our representational republic, representatives are relatively uneducated, except in law, and less capable of institutional change.

The functions of government are to support the functions of politics with specific actions, such as: To make laws; to decide the meaning of laws, how they are applied and related to a Constitution; to lead the country and to make sure laws are obeyed. These action specifically include: To protect the nation; to command the military; to manage internal affairs; to coordinate national activities; to manage external affairs; to represent the nation to others; to coordinate trade; to coordinate information; and, to coordinate education.

8.4.4.1.1. Expressing the Purpose of Government

Central government has lost sight of its own purpose, which is not the sum of special interests or its own desire for perpetuation. Government has always had other reasons for existing. Some of these reasons are to:

1. Hold a vision of the common good, where 'common' means common to all beings in the ecological community as well. Make goals conscious, with some flexibility to enhance the vision over time. Balance public and private interests.
2. Coordinate the means to satisfy the long-term needs of the community, balancing freedom and regulation. Tie rates of consumption to the limits of the system—this means controlling resources and land use, in essence determining the physical shape of the community.
3. Regulate the community. Link it to cultural values. Determine the closure and

openness of the community; rates of increase or decrease, through births, deaths, or immigration. Encourage or discourage some forms of technology or trade. Provide work opportunities to members.

4. Protect the community from internal and external threats: natural disasters, criminal elements, and other communities. Most of these threats are unavoidable. Some are long-term and rare; others are constant and of low intensity. Some are part of the human condition; others the result of historical balances that cannot be restored easily or quickly. We need to be aware of them and minimize the damage.

8.4.4.1.2. Increasing Participation

John Dewey believed that personal face-to-face communities were necessary to a free and open government. The local communities need not be isolated as they have been in the past; they are more open and active, connected to other larger communities. Government requires trust and goodwill; these arise more easily in communities of acquaintances.

Citizenship is too complex for television or even electronic global villages; it must exist in the community, in person, in place, where individuals can learn about each other in context. Government by local meeting assumes the common sense and wisdom of the common person in an open exchange of belief and need.

Often this kind of involvement takes more time than just voting annually or having one person decide for many. The effect of presenting a problem before a traditional American Indian council was to slow down response by passing it to the entire constituency and getting a consensus. This ensured due consideration.

To encourage the participation necessary for effective democracy, or communism or socialism for that matter, government should solicit public opinion. Land-use agencies do so. Government should offer real power to people—power should devolve to lowest level—by changing the local political institutions to start. Montana or Vermont in the U.S. offer examples of how to change local participation.

8.4.4.1.3. Taking & Yielding Powers

Central government must shrink in order for local government can expand. Some things must be done at a national level, such as the protection of watersheds, rivers, and the atmosphere, to make sure of minimal protection. Some protection must be enforced at the international level, also.

Following the federal model, delegated powers go to the highest level, and reserved powers to the community. So, a renewed national government would coordinate internal and external defense and security; maintain law and order; and, set ground rules on economic exchange to ensure fairness. The most important responsibility of government is to set standards for itself and its institutions. The constitution would instruct the courts to interpret clauses as narrowly as possible.

The new government would have an administrative department to handle taxation, budgeting, and purchasing. It may coin local money, perhaps on the model of the Local Employment and Trade System—LETS—on Vancouver Island in Canada, which records credits and debits on a computer, which can then only be used locally. There may be departments to protect the civil rights and liberties of the people and a department to protect the environment. Environmental disputes could be resolved by mediation, as was developed in Seattle in the U.S. in 1980s. The nation would also conduct foreign policy, provide technical services to communities, and maintain regulatory offices.

To avoid insularity, being set against the rest of the world, each nation could create an office of global communication, which could set up connections similar to sister cities program. It might be beneficial to join confederations of other similar areas, especially those that could offer complementary crops, or a larger union, such as the United States, for preferred trading.

Spending on education, roads, welfare would be done at local level. There is some risk, especially with education or wilderness restoration, but the breakdowns and errors will not be devastating as with centralized planning. Citizens will need to do some of the work of government as well as make the decisions. They should have total control over some things. The judgments of the people are more important than the efficiency of those judgments. It may not be necessary to have many separate authorities or committees; it might be better to integrate policy-making bodies so they are not too specialized.

With centralization of functions, money has become the primary source of security for most people. Welfare, as giving money to those who do not have it, may reduce homelessness or disease, but it cannot restore family. Family needs a supporting community context—institutions. Decentralization, and the power it would return to local communities, may also help the family as a source of security. Money is an enormous simplifier, but many things cannot be simplified. Decentralizing would make government and economics enough of a small scale to be understandable and manageable.

Decentralized communities fitted to their ecological location are more suitable and livable than urban spreads. Some cities may still be fairly large and dense like those envisioned by Paolo Soleri. Some may be smaller and rural like those suggested by Murray Bookchin. Their relation to support areas would be more explicit and include large amounts of natural and domestic vegetation. As much as possible, cycles of materials would be closed.

As cities become more sustainable, their forms may change. They may become more compact, with more multiple-use streets, as a focus for human activity, and less involved with cars; buildings could use solar power, efficient heating, perhaps integrate roof-top crops; integrate older buildings into new groupings to integrate services, play, and work, with living; local public spaces and services; recycle waste into cycle; regenerating derelict land, either as green area or new construction.

Preconditions to a sustainable, steady state, economy include pollution control and the redistribution of resources more equally. The redistribution of resources and improvement of environmental quality are more important than increased production by sophisticated technology. This strategy calls for social and educational organization more than technological style. Styles of technology must be determined by culture and context. Such development requires a local authority working with suitable economic and ecological conditions. No authority can be effective without the participation of the people.

8.4.4.1.4. Prescribing an Optimum Size

To restore participation, we have to consider the limits of participation. The current large populations of many places may seem to be too large for direct democracy, as does any of the projected optimal populations.

Twenty five thousand people is large for direct democracy. Many of the cities and towns in an area are approaching this size; thousands have already exceeded it. The size has to be small enough for people to meet and "exercise government" in James Madison's words. Kirkpatrick Sale concludes that the optimum size for direct meeting is five hundred. Participation becomes more difficult as the size increases. Bryan and McClaughry suggest 2,500 as a maximum, since in larger groups people cannot all know one another and the assemblies tend to become a debating forum for a few.

Putting these figures together, we could design neighborhood sizes to be from 500 to 2,500; these neighborhoods would make up communities of 5,000-25,000; and the communities would bring a regional or even national population to 400,000-500,000. Differences in size seem to be close to powers of 10. Each Community legislature would be 40-60 people. Perhaps these sizes are close to the optimum; and, these numbers are similar to those in Christopher Alexander's *A Pattern Language*. About 3,000-4,000 people are needed to support an elementary school. The Swiss are a good model for government levels—with a national government equivalent to the Swiss national, communities equivalent to Swiss cantons, and neighborhoods to Swiss communes.

There is a point in critical mass reaction where the mood of the mass becomes indifferent. As long as the size is small enough for recognized identity, people will behave with concern. At a larger size the ideology, which is capable of anything through indifference, can takes over, according to Leopold Kohr.

Small communities are essential to the democratic ideal and other ideals. The uniqueness of place gives belonging and identity. The whole community gives meaning and richness to life. The population density of some places may cause some difficulty, however. People will not be within walking distance, but may have to travel 20-30 miles to meetings or communicate remotely through telephone, computer, paper, or friends.

8.4.4.1.5. Protecting Ways of Life

Zonagraphy (or compartmentalization) avoids the need to compromise every ecosystem for human use. Multiple use systems should only be part of the picture. First, the government could ensure a protected environment of mature ecosystems, then productive systems, and then multiple use, and urban areas. This could be done through function (not activity) zoning. The landscape needs to be zoned (compartmentalized) to provide a safe balance between protected ecosystems and used ones. Restrictions on land and water are one means of avoiding overpopulation or overexploitation.

Long before the limits of food or space are reached, or the ecological balance is lost, or a vital minimum is exhausted, phosphorus, for example, the quality of life will sink lower. Regardless of how much protein or energy can be provided to support human life, human happiness will be problematic in large, insecure populations. The question is not how many people agriculture and technology can support in one place at once, but what kind of life is possible for those who have no choice but to live in that place. The limiting factor is that condition in the environment that approaches the limits of tolerance of individuals. The population density may be the limiting factor. It may be living space. It may be wilderness. It may be beauty—aesthetic space.

At a limit, the cost of change accelerates. We seem to understand technological limits, to sailing ships and computer chips for instance, but not to individuals or groups, not environmental or ecological. Calculating these kind of limits is difficult—too much data, too much uncertainty.

Peter Drucker points out that economists from Adam Smith to the conservative F. A. Hayek argued that it is impossible for governments to control or manage the economy, especially in an information age. Recognizing, on the basis of mathematical models of complexity, that detailed management of the biosphere is beyond human capacity, a government should minimize its management, to coordination of communities or larger alliances. The biosphere is dominated by natural communities of which we are largely still ignorant. Detailed planning of complex open systems is not necessary. Planners are not in a position to attempt detailed models of future situations because many relevant parameters remain unidentified, and many of those known cannot be quantified. Plans can be made within the limits of variables, although it is not safe to be limited by lethal variables, as Gregory Bateson recognized. Closeness to limits reduces flexibility, that is, uncommitted potential for change. Vagueness and lack of detail are acceptable in planning, because people will fill in the details. Furthermore, it is almost impossible to plan every detail of a dynamic chaotic system. That does not mean stagnation, that a rice field must always remain a rice field or a town a town. What the government should preserve is the pattern, not the details, is limits, not directions. The limits are to be applied to scale not development.

Therefore, we must limit human intrusion in every system. Government should zone some segments to be free from human activity, and tailor human-made systems to approximate the form of the natural systems replaced. Interference is a broad term for the negative side of human activities. There are numerous forms of human interference: Overexploitation, introduction of exotic species, pollution of air and water, and the subsumption of habitats, in shape and size. Interference is caused by large human population growth, with its requirements of poverty, inadequate metaphors and images, which are too anthropocentric or short-term, uncontrolled change or transformations, as a result of colonialization or revolution, and political or economic failures, from wars or market internationalization.

8.4.4.1.6. Paying Costs & Leveling Extremes

Relative to European communities, many nations have less funding for public services, such as parks and public transportation. Some nations have traded public support for higher levels of private affluence, which has not made people any happier. In fact, they are more insecure; and they can become far poorer, and then second-class and neglected.

Many cultures should try, like Sweden, England and Japan have tried, to weaken the connection of material reward for achievement. Income distribution is too unequal. Full internationalization through trade would bring only greater extremes, which most populations can least afford.

The communities could levy taxes on property. But, there is a discrepancy in the wealth of communities. The nation could collect income taxes, and communities could claim a percentage of taxes collected. The community and nation could both tax the same bases: Income, sales, meals, property, and fuel, as many nations are now. The nation would set a ceiling on each tax; the community rate could be zero on some. Or the communities could do all taxes and give the national government a percentage, although differences in wealth might be maintained; then the state could return a percentage to make up equality in education and environmental protection. The important thing is that taxes are used to direct development and reflect the true costs of the society that people want.

Government could change taxation procedures to reduce growth instead of stimulating it. Talcott Parkinson suggests that taxation beyond a certain point yields declining marginal returns. Government could use a single flat rate tax at some percentage, perhaps from 10 to 25; and pay everyone a fixed amount of income for basic needs, from 3,000-10,000 USD.

Similarly, property taxes could be appropriately scaled to use. One way to keep farms as farms is to tax land by use. The more important the use, farming for instance, the lower the taxes. Buying farmland for shopping centers would result in discouragingly high taxes.

It is difficult to persuade people to pay more in taxes, to vote to keep less of their income. But, through education or understanding, a culture could expand the understanding of the self and expand self-interest in that way. Some catastrophe might work towards equality, but that might have other high costs to society.

Of course, most of these taxes could be eliminated entirely, if only environmental uses and losses were taxed. Some taxes, such as luxuries or heroic income, might be maintained temporarily until the extremes of ownership and wealth are leveled.

8.4.4.1.7. Meeting Limits of Government

When a place has a reputation for being small and livable, it attracts more people, until it is no longer small and livable. But, imposing the limits and stopping growth are problematic. Government could impose limits on birth through licenses, perhaps risking rebellion, through limits on housing and public services, possibly causing shantytowns, or through peer pressure, which could contribute to social disorder. Nature is self-organizing, and, society is self-organizing, but we need to recognize some limits and define others, and take responsibility for keeping to those limits in order that the self-organizing process not break down. Limits are fundamental to understanding nature and life.

8.4.4.2. Limits of Ecological Politics

The basic goal of politics is the 'survival of the community' as William Ophuls identifies it. Politics is the interactive means of providing the basic food and necessities of a community. As survival is survival within nature, politics rests on an ecological foundation. The organization of a community must be in accord with natural laws. Political participation depends on information, much of which can be provided by ecologists. Politics is the interactive means of providing the basic food and necessities of a community. Misguided politics arises from the wrong relationship of worlds and symbols. Things are regarded as symbols for words in totalitarian states, which have the advantage of reducing individuals to stereotypes, which can be tortured or disposed of without involvement. Such semantic prisons confine and warp thought. People become prisoners of an order that rejects new knowledge and solutions.

As survival is survival in nature, politics rests on an ecological foundation. The organization of a community must be in accord with natural laws. Political participation depends on information, much of which can be provided by ecologists. There can be no separation of politics and ecology. Every political act has ecological consequences and every ecological decision is a political demand for control over use of the environment. Ecological consciousness must be identified with political consciousness. The ecological, social, and political problems of today do not have simple disciplinary solutions. The problems are cosmological and must be solved on that level. But a single cosmology cannot solve all problems in all places.

Ecological politics may not be enough to contribute to redesigning or 'managing' the planet. Our genetic make-up predisposes us to some things and pushes us in other directions. It makes limits on our plasticity. It could promote behaviors that damage the environment, and hence our long-term interests. If we are limited by genes, then some behaviors may be ineffective, and others effective. For example, maybe we must have contact with the natural environments where we evolved—or suffer psychological and physical harm.

There may be fundamental human limitations that could derail it. What if humans have genetically-based urges for sex and reproduction that cannot be limited and cause overpopulation (as Paul Ehrlich expected)? Politics might be successful after a certain density has been reached; the Chinese experiment might furnish some enlightenment, both on the sort of density and on the time lapse for reduction. Or, what if humans have a genetically-based "short-term egoism" that leads to environmental Tragedy of the Commons (as B.F. Skinner considered)? What is human egoism is tempered by genetic tendency to live in groups and to behave altruistically towards kin, but only the kin, and not others (as E.O. Wilson wondered)? That limit might guarantee unending conflict. What if a genetically-based denial caused us to always underestimate the probability and severity of environmental threats (as Garrett Hardin expected)? That might mean we would be caught regularly by catastrophes. What if our old brain is not adaptive and does not perceive or respond to gradual environmental deterioration (as Robert Ornstein worried)? That would mean that we would be surprised by slow, invisible or long-term catastrophes. Have we been surprised? And, finally, what if the human brain cannot comprehend current complexity of our own social systems, even ecological politics, which might act in counter-intuitive ways (as Jay Forrester suggested)? What should we do then?

Ecological politics could be derived from our ecological identity, but that identity may not be comprehensive enough to be effective in politics. Maybe our perceived dominance over nature will be a problem that politics cannot solve. Certainly ecological politics is going to be more complex than traditional politics, which was after all designed for the human city. Perhaps we could create an open, self-conscious ecological politics.

For this politics to be global, it would have to address all cultures and all interests (nonhuman and human). A panocracy, a 'rule' of all beings, like a democracy, could result from a formal legal system, where humans represent all interests. A global ecological politics would have far more restraints on it, and limits to it, from the complexity of the emergent global connections and structures. Global ecological design could offer advantages through designing good societies based on healthy ecological places.

8.4.5. *Designing a Good Society*

As the basic goal of politics is the survival of the community, politics has to strive for a good society—that is, a society that is based on the properties of a good culture in a good place. These basic properties develop into the properties of a good society (Table 845-1; the discussion is extended in the book *RDP: Foundations*). We need to design for limits for conflict; maybe that means a limited arena for conflict or maybe a form of competition that would resolve conflict.

Table 845-1. Contrasted Properties of Different Levels of Patterns

— **Nature** —		— **Culture** —		— **Design** —	
Field	*Ecosystems*	*Place*	*Culture*	*Good Places*	*Good Society*
Process	Course	Dynamicism	Conduct	Action	*Method*
Autopoesis	Self-making	Identity	Wholeness	Individuality	*Extension*
Differentiation	Diversity	Uniqueness	Flexibility	Richness	*Variety*
Integration	Construction	Investment	Adaptation	Conviviality	*Cooperation*
Constancy	Stability	Regularity	Endurance	Consistency	*Loyalty*
Development	Productivity	Renewal	Vitality	Health	*Harmony*

8.4.5.1. Method

Method is a way of considering process, course, dynamic change, conduct, and action. More than just courses or actions, ecological designs are methods to create good societies in good places. A science like ecology may be limited by its method, but in ecological design, method is a way of addressing limits to create the conditions for a good society. Play is the method of learning for most juvenile animals, but in ecological design, play is a way of creating imaginative experiences that can describe and test experiences scientifically and aesthetically.

8.4.5.2. Extension

Design combines the self-making of a place with the wholeness of a culture, in context of the identity of an ecosystem, to create good places and extend those properties into a good society. Humans identify with places. Identity becomes an extension of the self to a place. This identity is a form of rootedness in place. The extension of identity creates an ecological democracy that fits the self to the larger Self that extends through local animals and plants and supporting ecosystems. All people have to represented according to minimum standards. People do have shared common interests, including a healthy environment, meaningful employment, education, security, and health standards, but they also have personal interests, such as roads or factories, that may not be shared by a or majority.

8.4.5.3. Variety

Variety is based on differentiation, diversity, uniqueness, flexibility, and richness. Diversity at the ecosystem level and uniqueness of a place promote flexibility at the cultural level and richness in good places. Animation and ecological value change the differentiation of the field to the diversity of the ecosystem. The addition of communication and cultural values to the characteristic of the ecosystem results in the richness of place. And, the addition of social values and awareness of the uniqueness of a place leads to variety in a good society. The design of a good society requires the property of variety. How do we incorporate this variety of interactions into design? Should we ban interference activities entirely? What do we design for? Wild animals in place, good domestic or industrial systems? In ecological design, because the operation of the universe tends to change systems, the design of a good place and good society should be open to the types of processes that could destroy the design. Design has to participate in the political actions of a society. Every political act has ecological consequences and every ecological decision is a political demand for control over use of the environment. If we wish to advance through design, to harmonize on higher levels of development, we must preserve and promote variety in nature.

8.4.5.4. Cooperation

The construction of an ecosystem contributes to investment in place, which encourages the adaptation of a culture to place. A culture uses conviviality to design a good place and cooperation to design a good society. The culture and the ecosystem (environment) co-adapt. If our old human brain is not adaptive and does not perceive or respond to gradual environmental deterioration—as Robert Ornstein worried—then that may explain why we are surprised by slow, invisible or long-term catastrophes. Cooperation, which can be enhanced through design, can increase conviviality so that we start to shape a good society that diversify in response to catastrophes that are regular and disruptive.

8.4.5.5. Loyalty

The stability of an ecosystem contributes to the regularity of a place, which sets the opportunity for the endurance of a culture to place. A culture uses consistency to design a good place and loyalty to design a good society. If a place is regular and displays structural constancy, design can increase stability by creating intermediate structures in a series of levels in an order of complexity—what Arthur Koestler calls holons. Designs for a good society have to be based on the regularity of a place and the endurance of a culture in the context of ecosystem stability. Design takes the consistency of a good place and lets loyalty emerge from the process. Dissent occurs within the context of loyalty. Freedom is expressed within a context of law that limits it and protects it. This avoids runaway feedback.

8.4.5.6. Harmony

Harmony is related to wholeness—indeed, health can be defined as harmony in a whole context. The flowing movement of the implicate order (David Bohm's word) is harmony. But, since the flow and order of the holomovement are imprecise and uncertain, perfect health or perfect harmony is not possible. We recognize breaks in harmony as disease or disorder. The productivity of an ecosystem contributes to the renewal of a place, which promotes the vitality of a culture in that place. A culture uses the health of the system as a basis to design a good place and the harmony of the system to design a good society. To survive, an ecosystem depends on the interactions and balance of many variables, most of which are not well understood. In agriculture or forestry, we try to maximize one of those variables. When that happens, the balance or harmony is altered, and although it may take decades or centuries for the consequences to be known, the system is affected. This means we need to consider long-term balance to have any kind of sustainable pattern. In natural design, natural processes are concerned with long-term harmony building as a fundamental property of that design at the level of value. In ecological design, harmony is good fitness with the environment that results in a meaningful and flexible order on the time frame and scale of living processes. Harmony constrains a system within limits. The wisdom of harmony, harmosophy, requires respecting the limits of control and certainty, and striving for the most satisfactory balance possible.

8.4.5.7. Harmosophy: Imperfect Design in Incomplete Harmony

Cultural system health is a measure of the harmony of the overall physical and ecological degenerative and regenerative processes, which may recycle thousands of human dwelling places, especially those badly sited in earthquake or tsunami zones. Harmony cannot be complete; completeness would make it fragile, like some glass instrument. Harmony has to be dynamic and changeable. An ecological designer should take care to create good places, but on the global level especially, be aware of short or long-term destructive processes at work. At the global level, harmony has to include the whole order and geological time.

Ecological design is the creative modification of ecosystems, including human as well as wild, to repair or enhance their ability at self-organization and maintenance of their complexity and diversity. The pattern has to be small cells under a unit larger than the largest cell. That would allow harmony and management by ensuring a physical and numerical balance. Then, central authority can be relatively weak, rather than trying to be omniscient and dictatorial. The relative anarchy of cultural cells and actions would have an ecological harmony at the level of the planet.

Human survival is not guaranteed by the planet, by evolution or by human virtue. The perfection of a place or society is not possible. The properties of a good society—method, extension, variety, cooperation, loyalty, and harmony—are indefinite and incomplete. Although the properties can inform ecological design, which can improve our situation on a developing planet, they cannot be used to create ideal, permanent utopias. The properties of a good society need to be considered with the properties, principles, standards, and practices of a culture, so that the properties and principles can guide specific actions (See Section 5.9.7.). On the level of the cosmology, that is, world-image, of a culture that means the use of appropriate images of the culture in its place; it may mean pruning and grafting different images that can improve understanding. At the level of economic and social justice it means creating rules to limit and share wealth, so that some cannot have thousands or millions more than others; it may also mean setting limits of wants and demands until basic needs are met for everyone. These practices can be refined over years of implementation, as this design is imperfect, yet flexible and changeable.

8.4.6. *Rebuilding Failed Nations*

Many tribal groups federated into national units, many in relative isolation. A nation, by definition, has a single, central government representing people who occupy contingent lands and are consciousness of a common identity. The professional ruling class is divorced from kinship bonds; structure is stratified and internally diversified. Almost the whole land surface of the globe is divided into centrally governed states. Human affairs are managed within the framework of these autonomous units.

Cultures have been self sufficient for thousands of years. Although some of them fail, others last for quite a long time. The Desana, for example, have existed in the Amazon for over four thousand years by maintaining an equilibrium with the environment. Ecosystems are local, not global. Although we regard communities as being tied together globally, each community is alone. Each culture has to be responsible for its own welfare.

History records the debris of some civilizations that tried to manage their resources and failed; they existed in the Americas, the Middle East, Africa, Asia, the Pacific, and Europe. Success as a nation can lead to hyperadaptivity and overshoot, to traps and failure. Hyperadaptivity is a serious condition that allows humans to adapt to poverty, bad diets, crowding, stress, suffering and immense natural loss.

The nature of failure for nations is puzzling. Many were very successful before they failed. Failure from success is tragic. For the Greeks, the operation of tragedy resulted from success taken to great lengths, that is, where successful behavior in one context is applied to all contexts, with the result that the opposite action occurs from the one desired. For example, humans in moderate numbers were able to take what they needed, such as wood, from natural ecosystems without interfering with the processes. Our dominance, once so successful because of our big brains and tool-using hands, has now become self-destructive. When human cultures adapted to ecosystems over long periods of time, the ecosystems also adapted to human cultures; when the human impact has been rapid and intense, as it has been in North America recently, the ecosystems collapsed or stabilized at a simpler state. The historical origin of the ecological crisis is in the failure of people to use their intelligence to anticipate the long-range consequences of their activities; this is a perennial human problem.

Failure often follows tremendous successes. The failure of nations may be traced to the failures of cultures, communities and individuals. Failure of nations can be related to their connectivity. Too little connectivity and species die (no food or prey). Too much connectivity and each species has to compete with all species. So it seems that connectivity must have regions of operation. Overconnection can be compared to power grid connections and failures. If overconnected, all can fail; if underconnected, many local areas fail; at a mid-range there can be power transfers.

The cultures of industrial nations are based on unethical accumulations of materials. The success of large nations may be due to accumulations of power, the wrong kinds of power. Power is capacity to carry out reasoned intentions, even if the reasons are irrational. Power is centrifugal, as people have more influence over future. Power becomes interference.

Whenever there are too many replicating units competing for space and resources, whether genes, organelles, individuals, families, cultures, or species, some persist and some fail. Reasons for failures, such as poverty or pollution, include failure of imagination or will. Many people believe that energy and food increase automatically as people multiply, and that simplifying ecosystems can increase their productivity. This exemplifies the failure of imagination. We should not confuse the limits of our mind with the limits of the world, as the philosopher Schopenhauer warned. Failure to recognize limits is a failure of perception.

The failures in our character or group or national character, can be seen to be responsible for the problems identified by Konrad Lorenz as the seven deadly sins of civilized humanity, from destruction of nature to the loss of civility. These failures can be described as a series of failures, from perception to intelligence, imagination, integrity, will, and charity.

Nations are being linked in a partial global economy. It is important to rebuild failed nations. For instance, the failure of neighboring economies can lead to the failure of trade, or the failure of negotiation. The failure of defense, the failure of contextual system, and the failure of a structure for individual participation can lead to the collapse in the meaning of participating. The fragmentation of social responsibility can led to an isolated self-image (unrelated to the external), to lack of self-confidence, and to a decline in participation. Conspiracies for societal control can lead to international conflict, government intervention, guerrilla warfare, and massacres.

8.4.6.1. Reasons Why Nations Fail

The failure of a nation is a large political event, although its impact on the citizens of the nation may be minimal if they are self-sufficient. Nations can fail from single internal or external causes or from a combination of causes.

8.4.6.1.1. Weak Cosmology
If the image is incomplete or does not fit environmental conditions, it may fail. People who constructed their worlds from preconceived notions sometimes did not survive. The Aztecs, for example, based their cosmology on the belief that the sun needed human blood to survive, and so they sacrificed great numbers of lives to ensure the sun's life. Their political policy was based on raids for victims, and this policy contributed to their overthrow and decline with the arrival of the Spanish. This inability to imagine the differences in situations and the consequences of our actions leads eventually to tragedy, which is the failure of a guiding image of the world, i.e., cosmology. In a theatrical play, the failure to give up a chosen role or pattern of behavior leads to great loss later. The play reflects our actions in the environmental play. The real-world tragedies result from the failure of our working images, the products of our imagination: Humans are responsible for the consequences of actions based on certain images, not on chance or fate. We can choose between the tragedy of the commons or the tragedy of total control—or we can expand our cosmologies.

8.4.6.1.2. Poor Knowledge
Much of the environmental crisis is caused by the failure to understand patterns of cycling. This is especially true with industrial agriculture, which tends to break up cycles. Like most human endeavors, agriculture ignores cycles, as well as physiology, metabolism, and diversity. We fail to see the incredible interdependence of humanity and nature, of diversity and success. We do not seem to be able to see others as feeling human beings, or animals and plants as feeling beings, or rocks as experiencing beings. One frightening aspect of government is the total failure of our leaders, in political and economic spheres, to learn or understand the simplest facts of science or technology, much less ecology and evolution.

8.4.6.1.3. Internal Conflict & Loss of Integrity
Integrity can be related to the general character of a human being, having to do with the integration of the self, into an identity that represents things beyond it, but also referring to a way of acting morally. Acting with integrity on a particularly important occasion could best be explained by the general presentation of that character and life. The failure of integrity leads to both the breakdown of tradition, as we pretend that ubiquitous behavior forms a global culture, and to the destruction of natural habitats, as we take key elements from the ecosystems. We must acknowledge the failure of our remedial efforts, our failure even to address the flaws of our ideologies. The failure to value those things necessary for life, of a person or a habitat, is a failure of integrity.

8.4.6.1.4. Economic Collapse
The metaphor for the economy used to be a simple mechanical model for turning resources into products. To be successful, the economy had to grow and turn a profit continually. Unfortunately, the assumptions of the model were also simple and failed to consider human needs and natural cycles, causing great suffering and great disruption.

Bad economic myths led to bad assumptions, which led to false beliefs, thus serious problems with many economies, such as economic overgrowth and ecological destruction.

Economies collapse for the silliest and saddest of reasons, using traceable to greed and dishonesty on a heroic scale, as with the collapse of real estate and stocks in the US in the fall of 2008. Considering a fictitious human nature under imaginary circumstances and thinking it is real is the fallacy of "misplaced concreteness" according to Whitehead. Daly and Cobb suggest that the classic instance of the fallacy in economics is "money fetishism," where the characteristics of an abstract symbol, such as limitless growth, are applied to real commodities and values. Daly and Cobb point out that modern economics might better be called chrematistics, after the distinction made by Aristotle between chrematistics and economics; the former related to the manipulation of property and wealth to maximize the short-term abstract money value to the owner, whereas economics was the management of the household (community) to increase the concrete value for everyone over the long-term.

8.4.6.1.5. External Conflict & War

Many human societies advanced by fighting and expanding. Fighting is a common form of human behavior, occurring in children, as a ritual limited by pain, and in adults, as failure of communication or understanding. The growth of the brain and its capacity for abstract thought seems to have bypassed the ritualization of social conflicts common to other mammals. Human fighting is not as formalized; and, this is what permits humans to slaughter one another. Most tribes followed two standards of morality: One for insiders and one for outsiders. Most aggression was directed outwards; losers were often exterminated.

8.4.6.2. What is Needed for National Success

Market economies have begun exploiting the resources, such as the forests of Siberia, of failed economies, while at the same time trying to rehabilitate other resources, such as the forests of East Germany and Poland. This contradictory behavior is due to a combination of economic myths and practices.

Obviously, the will of other cultures and nations is needed for help. If we cannot imagine extremes, it is hard for us to have the will to sacrifice things to avert it or ameliorate it. For all our cleverness, we still emulate flies and grasshoppers, when it comes to acting always in short-term self-interest. During the good weather and the good crops, we expand to or past the limits of water and food.

We lack the political will for sacrifice or planning. The failure of will leads to susceptibility to indoctrination by governments and even by advertising schemes. Policies are not implemented, due to social differences, corruption or war. What does this failure mean? Living in fear? Fear is not necessarily bad. Fear serves a purpose in human affairs. It is a warning system against unknown or overwhelming facts. But, fear can get out of control. Fear builds barriers. It also can lead to the hatred of ideas and languages. Too much fear can lead to the failure of will. Afraid of failure or of being unpopular, many politicians, perhaps all politicians, exercise too much caution. They refuse to stray from their opinion polls and say what they believe. They refuse to initiate actions that they know are correct.

8.4.6.2.1. Hopeful Ideas

Disarmament, for instance, is a simple rational idea. Our failure to disarm, especially nuclear weapons, is a failure of will. Perhaps will is undermined by comfort and security. Perhaps the lack of security has allowed fear to dominate our decisions.

The failure to change, to choose real equality and real peace seems to be another unique kind of human failure, the failure of will.

We must have courage. We cannot be doomed by our present failures. We have to imagine better and strive for it. On the other hand, we must display intense effort, discipline, patience, and a tolerance for failure.

Perhaps we need an empowered United Nations as a central mechanism to help countries emerge from conflict; it would meet the agreement that the international community has the right to step in when national governments fail to fulfill their responsibility to protect their own citizens from atrocity crimes.

8.4.6.2.2. Practical Ideas

Many practical things can be done. Most are matters of removal or restoration, according to an overall design for the nation. These things may start with remove weapons, bombs, and land mines. Then, we could remove obstacles to long-term success. Obstacles such as inequity, racial violence, and opportunities to work and thrive for all citizens.

Restoration projects have the potential to save entire ecosystems. Restoration is a necessary part of reforestation and improvement of ecosystem health. Maintenance of remnant populations may not be enough to prevent loss of key species on a landscape level. The restoration of forests from abandoned fields, anthropogenic deserts, and ruined ecosystems can be begun by something as simple as planting trees. Of course, more complex actions, such as restoring the soil and reworking the landforms, might ensure that the restorations are more successful. Restoration areas are experimentally restored ecosystems that had been disturbed by human activities or natural events, for example, Shagawa Lake in Minnesota. Another example is the Tall Grass Prairie in central North America, covering parts of the states of Kansas, Illinois, Missouri, Iowa, Oklahoma, and the Dakotas. There is always some risk with restoration projects, but it almost always less than letting the systems degrade. Furthermore, the projects would stimulate interest and pride as well as participation and employment.

We can apply similar ideas to domesticated landscapes. The coupling of agricultural productivity to a solar budget, and the conscious restoration of degraded systems, would contribute to the health of ecosystems. Sufficient wilderness would allow the self-maintenance of global cycles. With the increase in security, wealth, and self-esteem, human populations could be dependent on ecosystem productivities and still be diverse and unique.

We can restore and conserve the entire matrix of landscapes. Most ecosystem designs will not be restorations, because of the uncertainty about the kinds and associations of native vegetation. Furthermore, humans are now an large part, although not yet a very integral part, of the system; therefore it could not be restored to a premodern or prehuman state, even if we knew the proper or historical state. These design are not meant to be biotechnological designs of new ecosystems, either; we cannot accurately control and predict ecological events in most ecosystems. However, we can steer some of the events in a known direction—known because we have historical records of the system, even when not complete. We can also reduce those human activities that we know alter the conditions of ecosystems, such as overcutting and pesticide use.

8.4.6.3. How Can We Rebuild?

With money? We have tried money, sometimes too much money. Most humans do not experience cognitive dissonance when gifts are too small or too large, as is the gift of millions of dollars in aid. The money is rarely spent wisely; we need only witness the Bush administration's gifts of uncountable and untraceable billions to Iraq.

We could show some nations how to build an infrastructure, such as schools and manufacturing plants, roads even regenerative agricultural systems, and then help them do it, through international networks of volunteers. The transition to an emergency foooting and then a new framework of nations will require much more labor and many more jobs. Governments need merely to redirect military budgets to job budgets to build and rebuild a better infrastructure.

8.4.6.3.1. Promise of Trade

Difference allows continued difference and concentration. The results of differentiation drive trade between people and groups. There are patterns of interactions of cultures, which arise out of several possibilities: Indifference, trade, competition, cooperation, conquest, or respect. Some archaic cultures seemed to be limited to indifference, that is, they ignored one another, and to trade. Competition and conquest may have accelerated with the acquisition of territory for agriculture. Cooperation and respect seem to have occurred under some circumstances of trade or unification. Trade has a long tradition. People would have traded seeds or animal products for metals or gems. Obsidian from eastern Turkey was found in caves in Zagros. Natural asphalt was traded to western regions. Emmer wheat was traded to groups further east in Iran and south. These commodities were traded regularly in a pattern of exchange east and west. Edible grasses would have been transferred to areas where they were not native, such as southern Iraq, which was too dry for the plants to grow without assistance. Some cities were offshoots of trade. Other cities intensified trade. In the past, trade led to development of agricultural and horticultural knowledge, as well as new technological knowledge. And to specialized occupations dealing with trade. Furthermore, other social things developed such as complex division of labor, with castes and slave labor. Trade increased and competition increased. This may have had to do with resources that were abundant and could be stored, and transformed into political prestige and power.

In eastern Africa, depending on livestock, but not eating it, people come to depend on trade. By 1800 there was regular trade between the Bantu and Masai. The Kikuyu supply food, spears, swords, tobacco, gourds, red ochre to the Masai, in exchange for sheep. The English encouraged trade to increase wealth. This led to government regulation of the economy to ensure growth by granting monopolies, or mercantilism, an early example of regional trade going to global trade. Mercantilism allowed the accumulation of capital. And, capital required more energy and new technologies. This led to the separation of people from the land and resources, at least in England in 1650, during capital production, or capitalism.

With the globalization of trade and the domination of national languages, smaller cultures are being absorbed into larger ones. Although people retain some of their traditions, the loss of their language means that the whole perspective of their culture, related to the uniqueness of place and human adaptation to place, is being lost. Knowledge of plants, animals, and processes is being lost at a time when modern science is half-heartedly trying to catalog knowledge of every place.

Although many resources are distributed unequally over the globe, as a result of different kinds of historical geological processes, trade can allow access to those resources. However, as a result of long-term processes of inequity, from keeping people enslaved to cultural hoarding, many people have far less than others. This has resulted in permanent overclasses and underclasses, which are maintained by physical force, as well as by the force of economic and religious myths. Trade usually declines with impoverishment and collapse. Trade is one of the important activities for connecting nations.

Innovation is influenced by the growth and intensity of population, by the expanding and intensified activities of states or cities, and by increasing trade and commercialization. The ease of communication also increases rates of innovation. Geography encourages some paths of innovation (east-west in Asia and Europe, but north-south in the Americas).

Historically, trade has had the effect of destroying many traditional cultures, especially in North and South America, not just from exotic plants and livestock but also diseases. Other trade undermined regional livelihoods. Many of the modern trade agreements are causing suffering and violence. The gross domestic product of the world increases, but what is produced? Trade needs to be regulated better for fairness. Trade needs to be limited so that nations will not fail to be self-sufficient first. The function of economics is to provide needs.

In the past, specialization has allowed human groups to successfully fit the requirements of their environment. Successful cultivation, for instance, intensified the trading of cultivars and resources between groups and permitted further specialization. Village specialization may have been a great adaptation. As a result of surplus food and larger population, specialized people can create a flow of specialized objects.

Complex societies depend on production from resources. Increased complexity requires more information processing and more integration of disparate parts. The costs of communication increase. Complex societies need control and specialization. Yet, investment in complexity yields declining marginal returns because of the increasing size of bureaucracies, increasing taxation, and costs of internal control.

Overspecialization reduces flexibility and ability to change, but underspecialization reduces efficiency. Specialization is a way of limiting problems. If the numbers of specialties were reduced, there would be less overhead and higher returns. According to economist David Ricardo, the patchy distribution of resources is not the only reason trade is profitable—trading allows peoples to produce limited items more efficiently, allowing a better payback on their efforts.

Through specialization, now, each nation could become an expert in one area and could reduce taxes in that area. In a global economy, economies of scale are not as important nationally (and therefore, nations do not have to be large at all to have scale advantages, and therefore ethnic groups could form their own nations without giving up some economic advantage). The higher standards of living can be gotten by clever trade and specialization, after self-reliance is achieved.

Some international group must keep track of ghost acreage globally. Ghost acreage is the additional land, from sources outside a nation through trade, theft or conquest, which a nation needs to supply the total amount of food and fuel. Eventually, it must be a limiting factor for population, needs, and trade.

8.4.6.3.2. Treat Nations (& Cultures & People) as Equals

Other myths, such as the "market is free" or "growth is beneficial to all," suggest to people not to try other economic forms. But, the market is not free; it is orchestrated to benefit the rich. Continued growth is amoral and pathological, benefiting the elite of authoritarian regimes as much as the oligarchs of democratic ones. It refuses to recognize, much less to pay, all of its costs, such as depletion, loss of security—which may be most important—or extinction. The entire system perpetuates mass poverty and justifies it by blaming individuals, but the system itself fails to reduce inequity or poverty.

8.4.6.3.3. Cooperate with All Nations

Cooperation and respect seem to have occurred under some circumstances of trade or unification. Climate may affect nonhuman behavior. Cooperation is fostered by difficult climates, more than competition. Cooperation has advantages over competition or compulsion.

Cooperation can allow different nations to decide the criteria for trade and political relations. Maybe if nations are equals they will respect and cooperate with each other. Maybe the cooperation can come first. Complex systems, especially global ones, can only be managed through cooperation (something the farmers in Mesopotamia learned while trying to irrigate crops with canals). A larger ethics may come from the tendency of interdependent groups to evolve forms of cooperation.

Cooperation is necessary. For patients, partnership. For communities, the interaction of patients and professionals. A cooperative framework for healing within the depths of communities and ecosystems. Reconciliation (equality of opportunity for treatment) is necessary. Conviviality, basically living together in harmony, according to Ivan Illich, is a necessary strategy. These ecological principles, and many more nor presented here, can guide our actions to make good, healthy places.

The characteristic of cooperation, and its corollary ideas, awareness, complexity, intensity, and patterning, emerges from the characteristics of good human places, ecosystems, and the field: Conviviality, Adaptation, Awareness, Intensity, Development, Complexity, Participation, Integration, Connection, and Infolding. It is modified by ethics. Cooperation implies convivial or appropriate technology. The word convivial means social, from the Latin word "convivium," meaning living together. Ivan Illich, in *Tools for Conviviality*, sketches a meaningful community where workers have control of their tools and their lives.

Economics would become characterized by friendship and cooperation. The root problem is how to live with technology in a mature manner. We need an ecological awareness at all levels; a human, existential ecology, where humanity is part of system, with an awareness of awareness. Cooperation, with an understanding of rights and responsibilities, is based on cultural understanding. This kind of understanding, once prevalent in many cultures, is the reason why the tragedy of the commons (Hardin) did not always occur with common resources. Cooperation is crucial.

8.4.6.4. Summary: Success through Harmony

Success through harmony? Harmony is the agreement of method, extension, variety, cooperation, and loyalty in a social and ecological context of good societies in good places. Harmony in a society is the agreement of actions, feelings, ideas, and interests that results in peaceable relations. Harmony in society can be reduced or destroyed by cheaters, 'free-riders,' or anti-social individuals. But, society itself may select for traits of reciprocal altruism or altruistic punishment in other individuals.

Harmony is mutual constraint plus a shared adaptive history. It is constraint that limits the scale of a society. Harmony requires understanding and then planning for adjustments. Harmony requires adequate ecological information and the infusion of its significance in human affairs. And, it requires the time to do this, with caution and reverence.

For the individual, success is measure by leaving progeny. In a nation, success should be measured by the health of the nation, by the continuity of its people, as a result of their needs and dreams being met. We need to relate the success of a nation with the success of nonhuman beings, with the interdependence of all beings in the territory. Selfishness is not enough to succeed. Intelligence by itself is obviously not enough to guarantee our success. Success needs humility, curiosity, and tolerance. Success may be more important than wealth or power.

Traditional ways and social forms have operated successfully for thousands of years, despite sometimes serious problems, but the change in scale to the global has made success more difficult to achieve (it is almost like one big pool, with many more competitors and many fewer winners). Perhaps nations could create special ceremonies to celebrate the bringing back of a failing nation.

The tao has an interesting standard of success. Because there are more commoners than aristocrats, there is a net gain to the success of a nation. Society has to weave a course between its successful competition to support and renew itself and its tendency to overdevelop and destroy its habitat and place.

Human modifications of earth can be lastingly successful only if their effects are adapted to the invariants of human and physical nature. Ecological management can be effective only if it takes into consideration the visceral and spiritual values that link us to the earth. Although some of nature can be regarded as a garden to be cultivated, large areas should be preserved as untouched reserves or necessary systems for global balance.

The goal of global planning and design is the success of nations and communities, as well as the health of environments and personal happiness, based on self-reliance in food and shelter, self-sufficiency in food, and self-limitation in size and desires. If human patterns were based on mature ecosystems, civilization would be far more complex. Human values could allow for the welfare of humans, animals, plants, and land. The inhabitants have to be wise enough to be disciplined, to leave wilderness for other beings, and yet to make good places for ourselves in the very long term.

8.5. *Global Design Factors: Legal Protections for the Planet*

Political systems are impotent to stop the massive interference in ecosystems by international corporations. The simplest and most direct way to give the earth a voice in the development of the earth by humanity is to incorporate the earth following international law. The entire planet, with its biochemical cycles and nonhuman communities, would become one legal body. Since corporations are human constructs, however, humans would have to represent ecosystems and their wealth of living organisms.

8.5.1. *Incorporating the Earth: A Thought Experiment*

In early civilizations, the advancement of the state was expected to contribute to the welfare of its people. Corporations are recent devices created by states for public purposes. Most early American corporations, for example, were concerned with travel (turnpikes and inland waterways) or safety (fire insurance)—they resembled public agencies more than profit-seeking associations. In fact, the exclusive privileges and political power granted to corporations were based on the implicit promise of social services.

The association of economic development with national wealth allowed incorporation laws to be broadened. The corporation was given the constitutional rights of an individual. A corporation is a legal entity, independent from its founders, with its own rights, privileges, and liabilities. It is, however, required to obey laws and pay taxes; and it is accountable for its deeds in courts of law.

Unfortunately, as private good became identified with public good, corporations became larger, more acquisitive, and less concerned with social services. The quest for profit now has the effect of violating social amenities, such as clean air and clean water, instead of ensuring them. No responsibility is taken for environmental degradation since no right of contract or fair use of property has been breached.

Changes in societies, from rural to urban, from sparsely to densely populated, from culturally diverse to monotone, have transformed corporations and the societies themselves. Business corporations now provide the bulk of goods and services in many states. The scale of these corporations, the processes of production, and the size and needs of human populations, have altered and degraded many ecosystems and biogeochemical cycles.

Successful modern corporations create an identity based on their purpose in providing goods or services; they define their business in terms of profitability, growth rate, cash flow, and competitive position; they develop a corporate vision, with specific objectives and strategies, including long-term vision, collection of ideas and creative implementation, aggressive manufacturing, and reliable finance.

The purpose of a corporation often transcends simple financial gain—the corporation seeks to maintain its own existence, before profit. Financial objectives (sales, assets, profits) exist to sustain its existence. The goals that most motivate corporate managers are survival, independence, self-sufficiency, and self-fulfillment. Yet, these motives are consistent with the financial objectives of the corporation: to maximize corporate wealth. The responsibility of managers is to maximize the value of the company. Furthermore, because corporations are long-lived, that value should last a long time—a good reason for looking beyond the ten-year monetary horizon and the lives of its managers.

Although current wisdom (Milton Friedman et al.) holds that a corporation's only responsibility is to its stockholders, corporations are being pushed to include social purpose in their strategies, again. Alas, they are doing poorly at it. They do not know how much responsibility to take, or where to put limits, or whether to pursue policies that diminish their profits. Corporations have proved spotty in doing social and environmental good. It would be more appropriate to have them deal with the environment as a corporate entity concerned with maximizing its own values. Of course, that would mean no more "free" resources or environmental services.

The important advantages to incorporating the earth are the same as for incorporating a business.

1. Managerial flexibility: the stockholders are separate from managers; responsibilities are assigned by needs of the corporation.
2. Limited liability: the corporation borrows and repays. It shields its members from hazards to which they would otherwise be exposed.
3. Financial advantage: the ownership of assets can benefit stockholders and the corporation.
4. Tax advantage: investments in the good of the corporation may not be taxed by nations.
5. Estate planning and longevity: the corporation exists indefinitely beyond the lives of its participants.
6. Central management and representation: a large and complex business needs operational and managerial efficiency. Many of the participants have no direct voice in the operation—they must be represented.

The earth incorporated would focus on a core business: to ensure the integrity and continuity of life and all its connections and to secure the opportunity for development free from undue interference. It would operate to optimize values, like any good corporation, but the values would be ecosystem values (fungus values and earthworm values, as well as human values).

A temporary Board of Directors (the undersigned) would adopt bylaws, elect working officers, approve stock certificates, open accounts, and arrange a stockholders meeting. The stockholders would elect new directors, possibly from United Nations representatives or directly from elections, and decide on dividend declarations.

Stockholders, as citizens of independent nations, would turn over common and national property to the Earth Corporation, which would issue stock certificates to the stockholders. The corporation would allocate the purchase price of stock to capital at par value. Most of the shares—the percentage to be determined by the board as necessary to the operation of ecosystems—would be treasury shares. Anything more than par value would go to capital surplus, and only capital surplus could be distributed as dividends. Stockholders have the right to receive these dividends equitably, without resort to traditional distributions of wealth.

Stock certificates denote ownership of the corporation. Although the stockholders own the corporation, they do not own the property of the corporation, the earth, which is owned by the corporation itself. Stockholders, as individuals, groups, or nations, could make agreements about how business would be conducted, about what resources would be used or traded.

The elected board of directors would make decisions of distribution and limitation. Percentages would be deducted from the interest for the operation of the corporation and for equitable distribution to nations less favored by chance with biological or geological wealth. Furthermore, since the dividends would be distributed among people according to net ecosystem productivity and resource availability, no advantage would be gained by nations having large populations.

The basic functioning system would be considered capital, thus limiting the amount of human use of resources and probably the size of human populations. Interest would accrue in the form of net ecosystem productivity and diverted percentages of materials, such as gold or water.

The earth incorporated would solve the problem of having to value ecosystems in monetary or quantifiable terms; its systems would be untouchable capital. The human value of resources like copper, air, or water would be equated to the technological cost of recycling or producing them.

Raw material and energy are only two facets of the capital of a corporation — another is human ingenuity. Thus, human wealth would not be limited by restrictions on the availability of resources, but rather by a shortage of ingenuity.

An incorporated earth would be instrumental in conditioning international corporations to their social responsibility and in internalizing all costs. This corporation and governments could use traditional means, such as credit access, low interest rates, and setting priorities on equity issues, to evoke public interest in smaller and healthier human endeavors. The suggested articles of incorporation are:

FIRST: The name of the corporation shall be The Earth, Incorporated.

SECOND: The purposes for which the corporation is formed shall include: The protection of functioning ecosystems and their living beings from destructive interference. The conduct of inquiry into the operation of such systems and the role of humanity therein for scientific and educational purposes. The taking of appropriate legal steps to carry out these purposes. The maintenance of all real common property, including all lands, seas, and atmosphere, subject to the restrictions and limitations hereinafter set forth, to use only the interest from income therein, reserving the principal thereof exclusively for the aforesaid purposes, it being intended that the corporation be organized and operated for preservational purposes and not for pecuniary profit.

The corporation is organized as a voice for nonhuman beings and systems. No part of the income of the corporation, if any, shall inure to the benefit of any trustee or officer of the corporation or to any private individual having an interest in the corporation (except for reasonable compensation) and no trustee or officer of the corporation or any private individual shall be entitled to share in the distribution of any of the assets of the corporation.

The corporation shall not be authorized to carry on propaganda, influence legislation, participate in any political campaigns, or discriminate against human cultures.

In furtherance of the foregoing purposes, the corporation shall have the following powers:

To accept and hold by gift or judicial order any real or personal property of whatever kind, nature, or description, wherever situated.

To sell, transfer, or dispose of the interest from any such property, but not the principal or any part thereof.

To make, accept, endorse, execute, and issue bonds, promissory notes, bills of exchange, and other obligations of the corporation for moneys borrowed for the purposes of the corporation.

To invest and reinvest its funds in stock, bonds, or in such other securities and property as its trustees shall deem advisable, subject to the limitations and conditions contained in any grant or gift.

In general, and subject to such limitations and conditions as are or may be subscribed by international law, to exercise such other powers which now are or hereafter may be conferred by international law upon a corporation organized for the purposes herein above set forth.

THIRD: The operations of the corporation are to be conducted on the surface of the earth but the operations of the corporation shall not be limited to such territory.

FOURTH: The principal office of the corporation is to be located in the United Nations, currently in the City of New York, State of New York, United States of America.

FIFTH: The number of directors, who shall be known as trustees, of the corporation shall be not less than 30 (a minimum number associated with major ecosystems), nor more than 3,300 (the number of independent cultures associated with biogeographical provinces and subprovinces).

SIXTH: The names and residences of the persons who shall be trustees until the first annual meeting of the corporation, are: C. J. Hagen, Seattle, Washington; L. G. Nieman, Viola, Idaho; V. L. Reason, Wilmington, Delaware; A. E. Wittbecker, Nashua, New Hampshire; and, M. H. Wolfe, Cambridge, Massachusetts.

SEVENTH: All of the subscribers of this certificate are of full age; all of them are residents of settled places on the Earth.

(signed on original, July 4, 1988, Cambridge, MA)

8.5.2. *Trusting Earth*

Perhaps the form of a nonprofit corporation is not the proper approach to protect the planet. Perhaps, the planet could be represented well by some sort of legal trust. This might solve the dilemma of ambihuman species as well as future human generations, which require a much longer time frame than most plans.

8.5.2.1. Local & Regional Commons

Bali's water-sharing temple system for rice farmers is a good example of commons management. And, there are other examples of this kind of management of limited resources. The Spanish Huerta was also a system for distributing water and resolving disputes.

Garret Hardin, after criticism of his article on the "Tragedy of the Commons," pointed out that the problem was not common ownership as much so open access without the limits of social structures or rules. Ocean fisheries and the planetary atmosphere are two examples of modern commons with limited restrictions. Tragedy occurs especially when social structure breaks down, as in the Mayan case after 900 CE, or when the scale increases beyond the control of any local organizations, as with atmospheres and oceans. New technologies, of course, need new rules. Overpopulation can put pressure on the commons. External corporations can put more pressure on a commons.

The commons can be productive where there is a common culture with rules and laws. Switzerland and its alpine pastures, or the rice fields of the Philippines, are examples. The commons of the ocean and atmosphere are too large for local control, however. These real global commons have to be ruled by a global institution. This is possible because the management can be scaled up to an international body. Individual people and cultures have to recognize that the commons provides for all equally and have to have rules.

8.5.2.2. Global Commons

The local social structures that are so productive seem to be local and community. So, how can global institutions match that? Can they even attempt it? Are other societies too large, too diffuse? Are some of the commons, like the atmosphere too large for that kind of management? Scaling up communities might lose some vital ingredient. Scaling up corporations or trusts might not work with benefits and equity over long periods of time. Both corporations and national governments are vulnerable to short horizons, as well as to short-term political needs, rather than long-term community or system needs. Jonathan Rowe suggests that the trust is the best institution to protect the functions of commons. We have local land trusts to protect local land; it might be possible to expand a trust to have all global land not claimed by nations. Peter Barnes suggests a global Sky Trust, which would serve as a trustee for the atmosphere, but allow auctions for available dump space, which would have real limits. It would reward commons owners, the public, with high standards, which would encourage less pollution using supply and demand (that is, higher prices when less is available. There are several possible approaches: A market-based approach to selling air space; or government regulatory limits to polluting air space.

8.5.2.3. Local & Regional Trusts

In common law legal systems, a trust is an arrangement whereby property, including real, tangible and intangible property, is managed by one person, or persons or organizations, for the benefit of another. A trust is created by a settler (or trustor, grantor, donor, or creator), who entrusts some or all of his or her property to people of his choice, the trustees. The trustees hold legal title to the trust property (or trust corpus), but they are obliged to hold the property for the benefit of one or more individuals or organizations as the beneficiary (a.k.a. *cestui que use* or *cestui que* trust), usually specified by the settler. The trustees owe a fiduciary duty to the beneficiaries, who are the "beneficial" owners of the trust property.

The definition of a trust allows it to maintain an asset for future beneficiaries. For example, the Pacific Forest Trust protects private forests from clearcutting and development, through conservation easements that limit the kind of use that might harm the ecosystem. Private landowners can harvest some trees sustainably. Marin Agricultural Land Trust buys development rights to farmlands. Oregon Water Trust restores water flow to endangered streams by acquiring water rights. Could it apply to oceans? In each of these cases the owners hold the land and can benefit, within limits, from it. Would this work with nonhuman owners like the planet? Can local commons management be applied to global commons to address global problems, such as ocean and atmosphere?

8.5.2.4. A Global Trust

The trust is governed by the terms of the trust document, which is usually written and in deed form. It is also governed by local law, although it could be governed by some new global law. There are a few basic principles for a trust: Property of any sort can be held on trust; the uses of trusts are many and varied.

Trusts can be created by written document (express trusts) or they can be created by implication (implied trusts). On a global scale, the trust would be created by one of the following: (1) a written trust document created by the settler and signed by both the settler and the trustees, and this is often referred to as an *inter vivos* or "living trust;" (2) a court order (for example in family proceedings if it were a local trust). Due to the legal limitations of the ability of nonhuman species to communicate legally, a court order would be the best way to set up a global trust.

There are formalities for establishing a trust. Generally, a trust requires three certainties: (1) Intention. There must be a clear intention to create a trust; (2) The property subject to the trust must be clearly identified. Trust property can be any form of specific property, real, personal, tangible, or intangible. In local trusts, for example, it may be real estate, shares or cash; and (3) The beneficiaries of the trust must be clearly identified, or at least be ascertainable. In the case of discretionary trusts, where the trustees have power to decide who the beneficiaries will be, the settler must have described a clear class of beneficiaries. For the global trust, beneficiaries could include any living beings alive or not born at the date of the trust. Alternatively, the object of a trust could be a charitable purpose to be held by the United nations or organization rather than specific beneficiaries.

A Trustee can be either a person or a legal entity such as a company. There can be multiple trustees (there must be a minimum of two for a trust, usually in relation to land. A trustee can have many rights and responsibilities, which could vary from trust to trust depending on the type of the trust. A trust generally would not fail necessarily solely for want of a trustee; if there is no trustee, whoever has title to the trust property will be considered the trustee—in this case a global governing body. Otherwise, a court may appoint a trustee. Trustees are nearly always appointed in the instrument that creates the trust.

The Trustee, especially for a global Trust, has a huge responsibility. He may be held personally liable for any issues that arise with the trust. However, due to the differences between the value of the Trustee and the value of the planet, the Trustee has to be overseen by a global governing committee. There are two main types of trustees, professional and non-professional. Liability is different for the two types.

The trustees are the legal owners of the trust's property. The trustees administer all of the affairs attendant to the trust. This includes investing the assets of the trust, insuring trust property is preserved and productive for the beneficiaries, accounting for and reporting periodically to the beneficiaries concerning all transactions associated with trust property, filing any required legal documents on behalf of the trust, and many other administrative duties. In some cases, the trustees must make decisions as to whether beneficiaries should receive trust assets for their benefit. The circumstances in which this discretionary authority is exercised by trustees is usually provided for under the terms of the trust instrument. It is then the trustees' duty to determine in the specific instance of a beneficiary request whether to provide any funds and in what manner.

By default, being a trustee is an unpaid job. However, in modern times trustees are often lawyers or other professionals who unwilling to work for free. Therefore, often a trust document would state specifically that trustees are entitled to reasonable payment for their work—perhaps an amount equal to the average income of a mid-range position.

The beneficiaries would be the equitable owners of the trust property. Either immediately or eventually, they would receive income from the trust. The extent of an individual beneficiary's interest depends on the wording of the trust document. The settler has much discretion when creating the trust, subject to limitations imposed by law.

Many of the common purposes for trusts are not applicable to a planetary trust. For instance, privacy, wills, tax evasion, and money laundering, would have no meaning in such a trust. It would not be a protective trust, since there would be no inheritance or debts. The idea of charities might not apply well to the planet, since every being is endowed with life and some skills. Although asset protection sounds like it might be useful, there is no possibility of divorce between owners or gifts to creditors. On the other hand, some Common purposes for trusts may be of interest, and these would include:

- Co-ownership. Ownership of property by more than one person is facilitated by a trust. In particular, ownership of a matrimonial home is commonly effected by a trust with both partners as beneficiaries and one, or both, owning the legal title as trustee.
- Constructive trust. Unlike an express or implied trust, a constructive trust is not created by an agreement between a settler and the trustee. A constructive trust is imposed by the law as an "equitable remedy." This generally occurs due to some wrongdoing, where the wrongdoer has acquired legal title to some property and cannot in good conscience be allowed to benefit from it. A constructive trust is, essentially, a legal fiction. For example, a court of equity recognizing a plaintiff's request for the equitable remedy of a constructive trust may decide that a constructive trust has been "raised" and simply order the person holding the assets to the person who rightfully should have them. The constructive trustee is not necessarily the person who is guilty of the wrongdoing, and in practice it is often a bank or similar organization.
- Hybrid trust. A hybrid trust combines elements of both fixed and discretionary trusts. In a hybrid trust, the trustee must pay a certain amount of the trust property to each beneficiary fixed by the settler. But the trustee has discretion as to how any remaining trust property, once these fixed amounts have been paid out, is to be paid to the beneficiaries.
- Incentive trust. A trust that uses distributions from income or principal as an incentive to encourage or discourage certain behaviors on the part of the beneficiary. The term "incentive trust" is sometimes used to distinguish trusts that provide fixed conditions for access to trust funds from discretionary trusts that leave such decisions up to the trustee.
- Irrevocable trust. In contrast to a revocable trust, an irrevocable trust is one in which the terms of the trust cannot be amended or revised until the terms or purposes of the trust have been completed. Although in rare cases, a court may change the terms of the trust due to unexpected changes in circumstances that make the trust uneconomical or unwieldy to administer, under normal circumstances an irrevocable trust cannot be changed by the trustee or the beneficiaries of the trust.
- Private and public trusts. A private trust has one or more particular individuals as its

beneficiary. By contrast, a public trust (also called a charitable trust) has some charitable end as its beneficiary. In order to qualify as a charitable trust, the trust must have as its object certain purposes such as alleviating poverty, providing education, carrying out some religious purpose, etc. The permissible objects are generally set out in legislation, but objects not explicitly set out may also be an object of a charitable trust, by analogy. Charitable trusts are entitled to special treatment under the law of trusts and also the law of taxation.

- A Spendthrift trust is a trust put into place for the benefit of a person who is unable to control their spending or handle money. It gives the trustee the power to decide how the trust funds may be spent for the benefit of the beneficiary. These are especially attractive for spendthrifts. In many cases a family member or friend has prevailed upon the spendthrift/settler to enter into such a relationship.
- Unit trust. A unit trust is a trust where the beneficiaries (called unit holders) each possess a certain share (called units) and can direct the trustee to pay money to them out of the trust property according to the number of units they possess. A unit trust is a vehicle for collective investment, rather than disposition, as the person who gives the property to the trustee is also the beneficiary.

The planet trust could have elements of a constructive trust, since it would be imposed by law as an "equitable remedy" against those holding the assets as a matter of luck or discrimination. It would have elements of a spendthrift trust, since humanity is unable to control its spending of natural capital; the trustee, perhaps an agency of the United nations, would have the power to spend only ecological interest. It would resemble a unit trust, in the sense that all human beings would possess a certain share of the interest of the planet—of course, nations would control a percentage, determined by the ecological carrying capacity, which would be divided equally among the population; this would encourage nations to normalize their populations. It might resemble a public trust, in the sense that it would have the object of protecting the planet and keeping it healthy, as the source of most capital.

Co-ownership, as a trust, could be divided between species first—that is, the ownership of the home, earth, is shared by all living beings, and all living beings should have some legal representation. If it were a hybrid trust, the amounts of the trust interest could be paid out at the discretion of the trustee; this might be used to settle long-standing grievances and inequities It could resemble an incentive trust, in part, because it would encourage some behaviors, such as inventiveness and frugality, and discourage others, such as waste or inequity.

8.5.2.5. Summary: Benefits of Trust

Obviously, there would be many benefits to setting the planet up as a trust. The greatest benefit would be legal protection of many areas for ambihuman species. In fact that would be a major purpose of a trust. A second major purpose would be to equalize the income from global interest so that it would be divided equally among nations.

8.6. ***Global Problems: Innocently Wicked Gaia***

James Lovelock is deservedly respected for developing the idea of Gaia, the dynamic physiological system that has fit the planet for life for over three billion years. The theory states that all living beings, from algae to massive fungi (the largest organisms on earth), are locked in self-regulating cycles of behavior and reproduction that optimize conditions for the continuity of life. In his early work, Lovelock implied that Gaia was 'indifferent' and not motherly to humanity.

8.6.1. *The Prodigal Child Retreats in Fear from a Fevered, Elderly Mother*

In his book, *The Revenge of Gaia*, James Lovelock extends the theory into a warning that Gaia is under serious stress, due to human activities, that could be catastrophic for human civilization. We humans are not good with global scales and evolutionary times—so many catastrophes seem unimportant to us, because they are invisible, slow, immense, and unexpected. Lovelock's book is a warning for immediate action to avoid a catastrophe of extreme climate change due to human interference with natural cycles and processes. Although the planet seems to be very much self-regulating, changes in the atmosphere as a result of human transformations of ecosystems and wastes could trigger a new equilibrium that would be devastating to human civilization. The problems have much to due with global scale and global time lags compared to the two-year horizons of human business.

Despite any small disagreements in details, regarding the quantity of nuclear energy or fires, this book is correct. We *need* to acquire an emergency attitude and make changes fast. We *need* a massive program of changes, larger in size and scope than any previous military campaign or political plan. If anything, Lovelock does not go far enough in describing the implications of a global atmospheric fever or socioeconomic recommendations. Nevertheless, the book raises many intriguing questions.

8.6.1.1. Blues for an Elderly Planet

What are the connotations of calling the planet Gaia? Remember that in mythology Gaia rose from Chaos. Should we call the solar system Chaos? Gaia formed Ouranos, the atmosphere, and with him had children, who killed their father at her inducement. Is humanity a Titan that is killing its mother, the atmosphere? Or just a hundred-armed giant Hekatoncheire? Does history repeat mythology? Does Gaia die after her son dies? Did William Golding suspect this when he made the suggestion to call the theory Gaia?

Lovelock implies the earth is aged and later calls her elderly. Gaia is well over 3 billion years old. The sun will continue to increase its output slowly for another 4-10 billion years. Of course, the planet will most likely live another 4-5 billion years, as a rocky planet, but maybe only another 2-4 billion years as a self-regulated, living planet. Or, Lovelock might be right, that soon it will not be able to adjust to increased solar output or changes in the atmosphere. Michael Whitfield and Lovelock calculated in their model that in less than 100 million years the sun's heat will overwhelm the earth's regulation, and the atmosphere will move to a new hot state with a different biosphere. However, that's not the same as dying, even if the biosphere is not as comfortable for human purposes. Later, Lovelock states that any catastrophe that causes the Gaian regulation system to fail could lead to a hot dead earth, and human actions could precipitate that. This is a frightening possibility! Is it likely? Is Gaia that close to dying?

Lovelock repeats that if Gaia is elderly, and heats up again, then heat-loving plants and bacteria may not have a critical mass of living things to regulate the environment. There is a critical mass of life implied, and that may be related to a critical area inhabited—Lovelock mentions 70-80 percent of the surface. What would happen if carbon dioxide (CO_2) went over 1 percent as a result? Would the earth transition to a Venusian state, clouded and cooked?

On the other hand, the planet would not age the same as a living cell (there is no planetary genetic code to limit development and aging). It is also more complex. We might regard the planet as a healthy middle-aged goddess, although in urban humans middle age can be beset by heart attacks, strokes, and obesity, as a result of transforming the human body into a stress-ridden, torpid consumer. Perhaps we are forcing Gaia to consume more energy and exotic materials.

Whitfield and Lovelock also point out that self-regulating systems tend to overshoot a goal and stay on the opposite side of the forcing. If too much heat comes from the sun, the system regulates on the cold side of the optimum. In the past the planet developed this way through a complex web of feedback. For humans to keep the planet cooler, for our comfortable civilization, we will have to manipulate what we perceive as controls or triggers. We might enter another ice age, which might be healthier for the planet, but might be equally disruptive to civilization.

Lovelock states that all of life is urged by its selfish genes to reproduce—his quotes, which may or may not reveal contradictory, reductionistic assumptions, seem out of place at times. Life also may also try to expand out of bounds or limits. Perhaps life always tries to exceed limits, and then is stopped when the limits are exceeded by systematic feedback. Perhaps it is all that selfish nitrogen in the selfish genes. Ecosystems tend to be dynamically stable, yet ecosystems evolve differently than the genes of its inhabitants. The environment and feedback are constraints, such as temperature and water.

8.6.1.2. The Prodigal Child as Victim

Apparently, our cultural aim is still growth and profit at any human or natural cost. We convert forests to agricultural fields, and animal and plant flesh to human flesh. We use too much energy in cities, just to light up everything, because we are afraid of the dark. We kill everything inedible with pesticides because we are afraid of competing animals.

Lovelock recognizes the equal kinds of devastation to the countryside from legal decision, development and conversion, especially the social losses that seem invisible to most media. Lovelock and many others recognize that our error lies in thinking that unlimited growth is possible and desirable. Lovelock actually states that the error is thinking that "development" is possible, but Lovelock is ambiguous about growth, development, sustainable growth, and sustainable development. Each is different.

There is no necessary association between development and growth, as Herman Daly and others have shown. Growth is an increase in size. Further growth can result in destruction or disruption of the system itself and its environment. Growth is good for immature beings or systems. Development means the introduction of an innovation. Development is related to maturity, which is what we need. It can be sustainable, and it may include modifying sizes and changing our ways of using energy. Economic development requires technology. Ecologically sound technologies can minimize stress to the environment. Production could be stabilized in a "steady state economy," a mature economy like a climax system, where processes and cycles are constant.

There are real problems with the use of terms like sustainable development (from Gro Bruntland) and renewable energy. Of course, no energy is really renewable, only easier to capture or not. And, of course, our current size and momentum are not sustainable, but that does not mean that we cannot reach a sustainable level, or should not try. Maybe we should call it dedevelopment to make it obvious. It could include going backwards, being simpler and smaller when necessary. For instance, we could easily go back to energy use of 1960. Perhaps that is what Lovelock means when he refers to sustainable retreat. Elsewhere, Lovelock approves George Ballard's suggestion to keep a national stockpile of hydrogen in individual vehicles. It would be used in vehicular fuels cells, but be available as a national store in a hydrogen economy. But, isn't this a sustainable development that is earlier dismissed wholesale by Lovelock?

8.6.1.3. Paralyzed with Fear

We perceive risk irrationally. We fear too many trivial things. We fear too many unavoidable things, like pain, cancer, and death (and it seems that cancer is unavoidable in an oxygenating atmosphere). Perhaps fearing too much is a human weakness, a failure of courage, one of the several failures that seem to plague us. It may be a weakness, but it may be wise, and that is the contradiction, and that is what we have to learn to live with, also. We rarely fear the big things.

As Lovelock notes, food contains toxic substances, as well as mutagens and radiation. And, as Paracelsus said, "The poison is in the dose" not the substance, whether food or radiation. Too much water can kill, as well as food additives or natural toxins. Yes, organic food is now another form of agribusiness, now, although it is strange for Lovelock to blame its lower productivity—in the long-range, it is not lower, but more akin to what we should be taking from natural systems without converting them to impoverished temperate or desert grasslands. There are many neglected and visionary alternatives to industrial agriculture, for instance, the Land Institute (Wes Jackson), Natural Farming (Masanobu Fukuoka), Tree Crops (J. Russell Smith), or Permaculture (Bill Mollison), that promote ways to change modern agriculture. Organic growing would not be a problem with lowered demands by smaller populations. Lovelock suggests that we can improve efficiency at farming by using a proportion of straw, manure and wood chips as fuel. This is probably a weak solution, considering that the conversion to farmland reduces diversity and impoverishes soil as it is.

Cognitive dissonance is mentioned as a problem. This is an effect of scale, also. Before dissonance can be resolved, the scale has to be right. Too big and it is ignored; too small and it is ignored. It has to be a proper human scale, a proper gift exchange, or just what is understood personally. Otherwise, self-deception is the result.

8.6.1.4. No Places or Good Places: (O)utopias or (E)utopias

Lovelock mentions the possibility of synthesizing all food needed. This would allow the reduction or abandonment of agriculture, but with over 6 billion people, the scale of that enterprise would produce many new dangers and problems. What would it look like if every household had its own synthesizer? The scale might be reminiscent of the first home breweries in Mesopotamia; every household could make its own ale. Lovelock asks if synthetic food would lead to utopias. Synthetic food could reduce the impact of agriculture, much as the creation of arcologies could reduce the footprint of cities. Perhaps, however, we should strive instead for Eutopias, not perfect nonexistent no-places like utopias, but satisfactory good places.

Lovelock notes that a collapse of human civilization would probably allow the continuation of humans as a species. The extinction of humanity is unlikely, and the collapse of civilization may not be inevitable. Lovelock comments on the scale of wind power, but he seems to ignore the scale of nuclear development, and not just scale, but development time. If all these proposals, from wind and solar power to chemical and nuclear power, were integrated into city buildings (or arcologies), there would be fewer problems with massive landscape changes. Lovelock suggests strategies, especially the rapid expansion of nuclear energy programs, which offer a carbon-free type of power generation, although it would have to be large-scale, perhaps 7000-9000 new plants. That much concrete would produce a massive amount of CO_2. And, that scale would increase the number of accidents and effects. Many of our actions, from higher-mileage cars to international agreements, he rates as half-hearted appeasements to avoid hurting the feelings of polluters. Perhaps our species is a “plague of people” and mad, greedy, stupid people at that. But, now we are more tightly connected. A Mayan collapse today, or more likely a US, Chinese or Russian collapse, could rapidly become a global collapse, due to extensive connections of trade in energy and food.

Lovelock suggests, at least for his nation, zoning the country into equal thirds, of nature, agriculture and cities. *Eutopias* recommends zoning the planet into half wild nature, 35 percent domesticated land areas, and 15 percent cities and artificial areas. And, others, such as Paul Shepard and Dave Foreman, have suggested 70 or 75% nature and far less area for agriculture and cities. Maybe that would be better, but a third or half would be a great beginning. Although cities have the potential to be compact, efficient and ecological, according to Paolo Soleri and others, they are the largest wasters of energy at the moment.

Lovelock concludes that the biosphere of the Earth will soon be distorted by unanticipated complications. His solution is an ultra-high-tech, low-energy civilization. But, as we know, much well designed low-tech is faster and more benign, according to Victor Papanek and others. However, as humans try to take over control of the planet, through high technology, such as orbiting mirrors or doping the atmosphere or oceans, further complications will certainly increase the wobble further. We only need to refer to our difficulties with space stations or Biosphere II, where biological controls failed quite dramatically, between pests and loss of oxygen. Fortunately these experiments were extensions supported by the planet; if we try to control the planet, there is no support planet to save us. We can manage ourselves, maybe, if we tried. Managing the earth, however, would be a form of slavery and a trap, since the earth is self-regulating now.

The root of environmental problems is population and its needs. Lovelock states that there is no single right number for a hunter/gatherer world or for an urban world. On the other hand, we can calculate several satisfactory numbers that allow the diversity of many coexisting human worlds. Part of the solution is adapting human numbers to human lifestyles. We have to do this with rational constraints, based on what kind of planet we want and what kind may best survive the increase of the sun.

Lovelock mentions using an oath to foster constraint, like the Hippocratic oath that Physicians take or the formal oath that professional Ecoforesters take: "First, do no harm" (for the full oath, and its meaning, refer to the Ecoforestry Institute). Lovelock states that our primary obligation is to the planetary system, before it is to humanity. This is a lesson that greens, blues, reds, humanists, scientists, and consumers need to learn. Such an oath would help redirect consciousness.

8.6.1.5. Retreat or Daydream

Our first role as humans on Gaia was simply to recycle carbon and other elements. Now, it is to communicate for Gaia or perhaps to assist with the controls. We sometimes err to think that humans are superior because of our fascinating technology. Lovelock is right to try to communicate the situation.

Despite his genius at global dynamics, Lovelock does not seem have an understanding of cultural dynamics, anthropology or history. Lovelock predicts that the future society will be tribal, and hence divided between privileged and poor. He should understand that tribal societies are much more reciprocal economically and much less divided into status and classes than are chiefdoms or empires. Furthermore, Lovelock uses the Australian aborigines as an example of the misuse of fire to destroy forests, and as a metaphor for our biggest evolutionary mistake, fire. It is more likely, according to Tim Flannery and others, that aboriginal fires only mimicked the larger fires that resulted from the droughts during harsher ENSO events, and that these small grass fires were a healthy form of controlled burns.

Evolution makes mistakes and eliminates many errors. Is Gaia cruel, like fellow gods Kali or Nemesis? Or, is that a problem with personalization? Earlier, Lovelock suggested that metaphors were crude ways of knowing; later he emphasizes that they are needed to comprehend the earth. Darwin had described evolution as wasteful, blundering and cruel. But, cruelty requires consciousness. And, we consciously drive plants and animals extinct in a cruel way. Gaia only filters.

Lovelock uses war metaphors, such as we "declare war on Gaia." But, we are not at war; Gaia does not fight. No, we are just thoughtlessly converted Gaia to agriculture and urbiculture. Lovelock points out several ways that we are at war with the planet, but wonders if democracies can act fast enough to order changes. Other forms of government could act faster, although they may not have the knowledge or desire to act in that way. We certainly will need restrictions, rationing and service, just as we did in times of war. Although he does not specifically mention this, perhaps it is time to give more power to the United Nations, the power to own continents, disarm countries, and dictate emergency measures for survival.

Lovelock uses Napoleon's Russian campaign as an example of how survival could have been salvaged by a military retreat. Lovelock likens our retreat from unsustainable living as this kind of strategy that can let us regroup and remain intact to fight later. Economists and politicians have to recognize that the shutdown of emissions from power plants is imperative. Our growth is addictive, and addiction is in fact a trap, and we have to withdraw from the addiction. We have to minimize our interference with earth's cycles and feedback.

Would it be sustainable retreat? Perhaps a radical reformation would be better. We never think of it as a retreat to lose weight. Why should we think of it as a retreat to use less energy or have fewer people? Is it a retreat to become smarter and to act accordingly? Sometimes even benign technology can enslave us.

Even with a retreat, parts of the human sphere may become disorderly, ruled by brutal warlords—not like now, of course. And, this is another reason to have a stronger UN, one that might own and manage the planet, or the resources set aside for development. We are unprepared for large-scale danger—or even small-scale problems like crop losses or storms.

Lovelock suggests that some believe the precautionary principle regarding burning fossil fuel. We cannot see all the problems, but Lovelock recognizes that we must try to understand the current state of nature, which we can do scientifically (and culturally) by monitoring and measuring.

Lovelock refers to the interglacial state as a fever. For life, a cooler earth may be a safer response to solar increase, but there is not a lot of evidence that it was more productive during ice ages, even having a greater land area with vegetation and fewer deserts (or rather a large area of ice instead). Lovelock argues that, because of solar increase, Gaia has greater control during glacial epochs, which has a lower CO_2 concentration in the atmosphere, which he interprets as indicating that the biosphere was healthier and more productive, because cold ocean water is more biologically productive. The argument needs to be filled out, since some data of the carbon composition in the deep ocean indicates that there was less organic carbon being fixed. Was the CO_2 too low for plant productivity, even with a larger land surface available near the equator? He notes that the rainforest is an adaptation to recycle water in a warmer environment. And, it is relatively fragile. And now it is important for carbon sequestration as well. The ocean deposition of CO_2 is important of course, as a physical process of the dissolution of silicate rocks, and as the biological flow towards a sink.

Think about this: Ice caps cool the atmosphere and lower the sea level. More land is exposed in the equatorial belt, which absorbs more heat. Do trees make the difference, creating more clouds? Are cool ocean currents less cool in glacial conditions? Do they bring up more sediments or less? Is there less sea life than before? Is productivity the same?

8.6.1.6. Reducing the Fever by Retreating with Nuclear Energy?

After the last glaciation, the CO_2 rose from 180 parts-per-million to 280 ppm. It is 380 now and may get to 500 within another human generation. Perhaps planetary maturity will parallel human maturity and the earth will have a second childhood with high CO_2 in the atmosphere (28%?). Perhaps things will get disorderly and dependent and require oversight.

There have been recent hot spells; 55 million years ago, the increase may have been 8 degrees Centigrade in temperate areas and 5 degrees C in tropics. At the beginning of the Eocene there may have been a massive release of methane from clathrates in the ocean (frozen ice-crystal deposits of natural gas heated by a subterranean volcano). If Gaia got that hot so recently, then she was elderly then and recovered, or not elderly and recovered, and so not elderly now. Why should change be less possible now? Of course, humans were not alive then, or their civilization might have evaporated. The lesson should be that the earth is dynamic and full of surprises, and humanity needs to adapt to that.

The problem is not burning wood or coal, the problem is doing it 420 times faster per year than is naturally available. As Lovelock says, this is the sin of quantity. Civilization is bloated and energy-intensive. The largest problem is the excess CO_2. Lovelock concludes that our aim should be to give up fossil fuel and to aim for the least hot world.

Klaus Lackner proposes equipment to extract CO_2 from the air and react it with powder from serpentine alkaline igneous rock. The magnesium carbonate would be a stable solid that could be used in building materials. A good possibility, but if it were applied at serpentine rock sources, many of which are in forested areas more fragile than other areas, it might destabilize forests.

An important part of Lovelock's argument is a plea for nuclear power. And, he is correct that it should be an essential part, maybe even the dominant part, of a portfolio of energy sources. But, he neglects the other emergency actions that we need to emphasize: The dramatic reduction in use that could be as simple as returning to 1960 levels of energy use—and so what if it means not illuminating every inch of empty buildings or highways; a natural reduction of population that could be done over 20-40 years; and increased power to the UN as a global management and ownership agency.

Much of the evidence that Lovelock gives for nuclear safety is true, especially as regards its safety record on accidents and fatalities. Of course, that may be related to tighter regulation and smaller scale—as the scale increased, we would expect more deaths from nuclear, much like the number of deaths from coal went up as it was expanded. And, he is wise to point out the ubiquity of natural radiation and plant toxins.

In his praise for things nuclear, Lovelock goes wild: "One of the striking things about places contaminated by radioactive nuclides is the richness of their wildlife." He says that the preference of wildlife for nuclear waste sites suggests that the tropics might be the best sites for nuclear waste disposal, which would then be deterrents for human development or "guardians" against destruction. I suspect that wildlife is not choosing nuclear waste as much as fleeing human interference or choosing places that are less inhabited by humans, such as deserts or mountains. I agree wild animals and plants may not perceive radiation as dangerous—and neither do we, if we are ignorant of it—but that does not make it safe or a good idea. Wildlife might also be unaware of rates of mutation.

Lovelock glosses over the problems of waste, although he does mention our schizophrenia and delays about storing it. In terms of a human lifetime, nuclear wastes can stay around a long time and harm organisms. In terms of disposal, we are still tentative and sloppy. Perhaps we should let France and Britain take up Lovelock on his offer to store their waste of one year in his backyard. That might be a good, small-scale experiment.

8.6.1.7. Certainty & Action

We could educate our young so that Gaia was an instinctive belief, or rather an unconsciously learned lesson, certainly as we inculcate the young into sports teams and religious beliefs. An important part of mythology is providing a meaningful order. Even with mythology and science, we are too ignorant to be stewards or developers of the earth. We have a self-regulating earth, but so much is unexplainable and unknowable. We need the participation of the whole mind, conscious and still.

We have to be prepared to react to the surprises and catastrophes (literally downturnings) that any action can provoke. Lovelock could have spelled out what kinds of catastrophes will happen if the atmosphere settles at a much warmer level. Will domestic plants become more toxic or tougher? If so, will we have to develop new domesticates or grow more coverage to survive? Will bacteria be more threatening and destructive? Describing likely possibilities would make the argument more effective.

Securing safe energy for the lights of civilization, and securing foolproof ways of educating others, are two things we must do. Lovelock repeats the adage: We cannot go back to 1800, to the beauty of the world then. But, we should not neglect the beauty now or stop from increasing it.

Now that climate change has been affected by human activities, anything we can do to reduce the population, to reduce our levels of consumption, and reduce our conversion of wild ecosystems into fields or deserts, will make a difference on the atmosphere. Of course, as Lovelock recognizes that one real problem is scale of events and lag between them.

Lovelock recommends a complete abandonment of technologies that burn carbon, as well as of "renewable" forms such as wind energy, and a radical switch to nuclear technologies. Abandonment of carbon burning technologies is a good idea, given the scale of other carbon use for concrete (for nuclear plants?) and firewood (of course, solar cookers and battery heating could replace much wood-burning). But, his recommendations cannot provide any certainties.

Many things *are* certain. Greenhouse gases are increasing. This is certain. The average global temperature is increasing. This is certain. Species, such as the Golden Frog, have become extinct. This is certain. These changes will affect humanity. This is certain.

What is uncertain is the rate, magnitude, and patterns of global climate change, as well as the long-term impact on the biosphere and on the anthrosphere. What is also uncertain, especially considering time lags, is whether we have passed some critical factor, and the system is already going to the next state, which may be detrimental to human civilization. There may not be any signal or rite of passage when we pass a threshold of climate change. Because of the scale and time lag, we may not notice any real change for decades or longer. (Lovelock uses a good example of falling into a black hole—a participant would not feel the threshold, and although a participant would be torn apart, to an observer dependent on light, if might seem to take forever). We have no way of being certain. But, we have developed ways to deal with uncertainty, such as adaptive management, which we use for resource management, at least, and might use for civilization.

It is also certain that things can be changed immediately with conscious action. Although we are not war with nature, Lovelock's suggestion that the imperative of war can cause a whole nation to act quickly and in unison is a good point. Catastrophes, more than just fast, visible, small-scale tsunamis and starvation, are happening. It is an emergency, and we do need to act immediately in response.

There are things we can do, small things, big things, and heroic things. We can regulate our lives better, especially the three Cs: Cattle, cars, and chain saws, that Lovelock identifies as massive problems. Other small things include: Saving energy with better light bulbs, driving and traveling less, consuming less more wisely, conserving more land, and participating in new strategies. Bigger things include: Stopping eating meat, sharing tools and machines, planting trees, reducing landscape conversions, revitalizing mass transportation and eliminating cars, and changing the tax structure. There are heroic things: Quitting carbon burning (starting a global carbon budget and decarbonizing the grid with integrated solar, wind and nuclear), reducing energy consumption to 1960 levels, planning for children and reducing the population to under 4 billion within 30 years (then basing it on biological and cultural carrying capacities), preserving and restoring extensive wild areas, recycling and upgrading buildings while stopping urban sprawl with arcologies with integrated energy generation, participating in Jeffersonian kinds of revolutions, and giving much more power to a revitalized UN.

8.6.2. *Evil Mother Threatens to Leave Prodigal Children with Wicked Problems*

In a recent book, *The Vanishing Face of Gaia*, James Lovelock continues to be right about so many things relating to planetary cybernetics and medicine. He is certainly right about the fact that 'energy is not renewable' and it cannot be recycled. He is right to characterize the shape of climate change as more like a range of mountains than a slow smooth stretch of highway, and to recognize that climate models do not include the physiological responses of the ecosystems of land and sea. Lovelock is most likely right about our predilection, like our theological forebears, to produce truth in a virtual world rather than to discover it in nature, and to see that science is manipulated for political reasons, with consensus often forced.

Perhaps Lovelock is correct about Gaia's retreat as well. We could visualize Gaia's face vanishing underwater, and why not, it is a water planet after all. Like Brigid, the mythical Lady of the Lake, she has just given us a sword—a tool for cutting—and now she is retreating to her depths, her face becoming distorted with the depth. The water is probably polluted. What shall we do with this tool? Fall on it because we cannot take the responsibility for the problems. Use it to cut the Gordian knot of our own making? Perhaps just display it as a work of art, not to be used, but to provide inspiration, a model for the tools we could create, an icon of all that is beautiful in nature and human nature? Lovelock seems to think Gaia is fickle sometimes or aged and suffering from Alzheimer's. Perhaps there is a link to the polluted water. Her bodily functions are still working well, but the mind does not recognize where it is or who has offered to care for her.

The Gaia Hypothesis has been very fertile, as the source of a green movement as well as for predictive statements. Many predictions of the Gaia Theory have now been supported by scientific evidence: Mars is lifeless; Elements are transferred from ocean to land by biogenic gases; Climate is regulated by biologically enhanced rock weathering; Climate regulated through cloud albedo linked to algal gas emission; Oxygen has not varied by more than 5 percent from 21 for past 200 million years; Boreal/tropical forests are part of global climate regulation; Biodiversity a necessary part of climate regulation; And, there is a biological transfer of selenium from ocean to land as dimethyl selenide. But, this book also contains some odd themes, strange ramblings, erroneous conclusions, and missing recommendations, which might be identified, discussed and corrected. Lovelock seems resigned to the worst.

8.6.2.1. We Cannot Do Anything

Humanity is too big. Gaia is too old and cranky. Lovelock states that the human population is too high, and it is impossible for 7 billion people to live in 'first-world' comfort. Given our recent history this is most likely true; human populations, including the Mayans, Khmer, and Rapa Nuans, always seem to use every resource and technical upgrade to fill in a region so there is no flexibility and adaptability to drought and change. We are now doing our 'thing' on a planetary scale and the potential for collapse is high. But, Lovelock also states that "No voluntary human act can reduce our numbers fast enough even to slow climate change." Maybe that is true, but we have in the past and could in the future, drop our numbers dramatically in one generation, especially if we planned it as an emergency action. Lovelock concludes that contemporary industrial civilization is hopeless unfit to survive on an overpopulated, under-resourced, urban planet, self-deluded by hyper-clever inventions and stale ideas of progress. The history of cities suggests that they were good adaptations to short-term droughts (perhaps 2-8 years at a time) and climatic changes, but history also indicates that they cannot cope with 10 or 100-year droughts or longer. Lovelock thinks that Gaia has been bumped out of balance by human numbers, and that Gaia's disease may be polyanthroponemia—similar to a disease that individuals sometimes suffer from, polycythaenemia, which is an overpopulation of red blood cells.

Lovelock concludes that Gaia is 'aged,' not far from her end, based on solar evolution. Later, he states that Gaia is in her 'old age. Then, he notes that Gaia was young 65 million years ago, when she survived a global impact catastrophe that set back dinosaurs. Actually, if Gaia is old now, she was old then. That would be like going from 59 and a half to 60 years in human terms. Perhaps middle age is a more appropriate analogy, since Gaia is much more loose than a biological organism. The sun could last another 5 billion years or more. Gaia should last another 1 billion in some stable form or perhaps 2 billion as a desert planet.

Although, Lovelock is generally open and careful with criticisms of Gaia Theory, he accepts Dawkins criticism that there is no way for life to regulate anything beyond the phenotype of its individual organisms. Even so, could the biospheric system do the regulating—the whole earth system, with rock, air and water?

In referring to criticism that a planet cannot evolve or reproduce, Lovelock states that "something that lives a quarter the age of the universe surely does not need to reproduce." He carries it further by saying a grandmother is too old to bear children, and so is not alive by a biological definition. Apparently, he has forgotten that a grandmother, by definition, has already reproduced. But, the question can be addressed further. How could a planet have offspring? Could Gaia send viruses, bacteria, organic molecules, and humans to seed a nonliving, young planet? And, that leads to a larger question: Does the universe reproduce? It is a living universe of course, since we can ask the question.

Correctly, Lovelock knows that we cannot save the earth; we do not have the power. It is not likely that we will have to or need to save the earth; it can save itself, as it has done before. But, Gaia needs an optimum number of ecosystems on land and water for her self-regulation. And, we do need to save the environments on which we depend and to which we have adapted. This we have the knowledge and power to do, using common sense, conservation, and regional and global ecological design.

8.6.2.2. Everyone is at Fault

Lovelock notes that Herman Kahn and others had a nice, simple, attractive message: Carry on business as usual and all will be well. And, of course, we want to hear that. It is the momentum and comfort of business as usual. Business as usual, however, increases people and livestock. And, the damage from fuel use depends on population size, as does the danger to atmospheric change. Obviously, business as usual has made things critical, ignoring extinctions, starvations and collapses. Lovelock chides scientists at the Amsterdam conference for being ambiguous, for speaking of self-regulation without specifying an aim, goal, or set-point for the system. And, these are needed, for regulation to have any meaning.

For the green movement, Lovelock reserves a special disdain. He feels it is a new religion, and the giant wind turbine is iconic like a cross. He concludes that the greens are failing to save the planet, like Baptists failed to save people from alcohol. Worse, he says: If we follow a pure deep green path to a pre-fire existence, very few will survive. He might be right. But, a few surviving well on a healthy planet might be a good goal; that goal, perhaps 500 million to a billion, has been presented positively by Paul Shepard, Dave Foreman and others. Lovelock states that the metabolic needs of a hot Gaia could be met with a mere million humans. One problem that the Greens, and perhaps we should not lump them all together, have is the problem of scale. One wind turbine might be iconic, but 6000 is an industrial solution on an industrial scale, and may create as many problems as coal-burning.

It may not be a bad thing, for greens or Baptists, to try to save people and the planet. The Baptists were right about alcohol, it is a terribly wasteful and expensive addiction. The greens are right about many things, such as using alternative energy for most things and planting trees to restore native ecosystems. Lovelock personally worries that it might not have been right to plant trees near his home, even native ones, even with the advice of a forest ecologist. He implies that it was not naturally a forest ecosystem. Was it a plantation? Even plantations can evolve. Perhaps a better forest ecologist would have suggested extending the ecosystem and not starting one from scratch or just planting grasses if the area was a grass biome. Most greens are aware that systems should be restored intelligently, depending on the kind of environment. Earlier, Lovelock had stated that the "clearance of forests for farmland and biofuels" is proceeding so rapidly that there is little chance that tree planting can keep pace. In fact, biofuels on an industrial scale, and the endless expansion of farmland into wild ecosystems (and the expansion of urban areas into farmland) are wasteful ideas that will certainly upset more natural balances. We need fewer conversions and more restorations. We need far more appropriate tree plantings around the planet—it was a forest planet, after all.

8.6.2.3. We or the Planet—or Both—are Doomed

When we started using fire for food, we denied the micropredators their prey, us, claims Lovelock. Perhaps we violated their rights. This is a strange thing for him to say, since Gaia and every living form tries to deny their predators, simply so that they can live. The problem has always been, not trying to live well and to escape threats, but our massive interference with every living thing that could possibly threaten us. Fire may have started us on that path, and trapped us in the path, but chemicals and biocides have broadened it to extinctions. Most people think science could manage or improve the planet. The war for or against science, by many individuals and groups, is stimulating. Lovelock examines some of the technical proposals to abate atmospheric warming. In addition to the press for nuclear power, Lovelock also recommends considering the direct synthesis of food from carbon dioxide, nitrogen, water, and tissue culture. Lovelock recognizes that the worst dangers are less from climate change itself, than from starvation, distribution failures (and inequity), trade competition for resources, and violent direct competition in the form of war. Oddly, he uses the metaphor of war on the next page, stating that our thinking is flabby, and the nation needs to be bound together in a single-minded effort "to wage a difficult war."

Lovelock notes that Gaia is not a cozy mother and cannot be propitiated by gestures like carbon trading or sustainable efforts. Although she can be benign like an ancient goddess, she can also be ruthless. In a greenhouse state the earth could simply cull us, just like we did with competing species by changing their environments to be more difficult for them. In several earlier books, Lovelock had suggested that we practice a kind of planetary medicine, an excellent idea. But, the problem with planetary medicine is that we have to be smart and consistent, and persistent and flexible enough to keep addressing successive problems, from CO_2 rise to ocean acidification to extinctions and ecosystem collapses. That is, we have to keep trying to correct our imbalances and excesses.

8.6.2.4. Let us Keep the Lights on Anyway

In his argument for discontinuing fossil fuel energy and converting to a massive nuclear energy program, Lovelock debunks the myths that nuclear energy emits large quantities of CO_2 is as polluting as fossil fuel, and is very risky. The carbon generation numbers are impressively dramatic, in terms of pounds of carbon per Megawatt hour: 8.8 for nuclear vs. 1822.0 for oil, and 2101.0 for coal. However, he neglects the massive carbon releases from building the plants using concrete. The numbers for pollution are just as dramatic. Nuclear produces less waste. However, it is a different kind of waste, more immediately dangerous and longer lasting. Lovelock made an excellent point about scientists and politicians not being able to predict CO_2 change and global climate for 50 years, or even insure that the governments and agencies would last that long, but when talking about nuclear power he is willing to accept a stable government storing nuclear waste for 600 years. Nuclear fuel does occur naturally, of course. A natural reactor formed in Gabon millennia ago, from natural uranium deposits. It kept bacteria warm. But, that was not a common occurrence and it was not at an industrial scale. He recommends a nuclear revolution and argues that it can be fast, with planning and technology. Elsewhere, he recognizes that rushing invention rarely works, especially in war or crises; even the Manhattan project was based on prewar discoveries, and its peaceful use took another 40 years of stable peace. Nuclear is based on extant technologies, except for waste disposal. It seems just as likely that nuclear generation will be as slow as the population change that he predicts. Of course, we should use nuclear power to shift from fossil fuels for intense manufacturing, but alternative 'green' power is equally good for home use, especially at local scales. As for the risk from nuclear, Lovelock points out our irrational fear of some things and makes a good comparison with the risk of failure from hydroelectric dams and the consequences downstream.

The possible advantages of a high-tech, advanced civilization are listed: Synthetic food, equality with empowered women, equality in opportunity for education, high standard of living, and smaller population supported by solar energy. Lovelock then discusses geoengineering as purposeful human activity that significantly alters the state of planet.

We started with fire, a biocide and shaper of ecosystems, but now we need to address the challenge of atmospheric heating. He distinguishes three approaches: (1) Physical, like changing albedo of the planet with orbiting mirrors or clouds formed by doping; (2) Physiological, like tree planting or biofuels production; and (3) Active or Gaian, using ecosystems to power the process or change the feedback of climate. In concert with the high-tech theme, he wonders if we could change our genes, if we had time, and we do not, to love and live lightly on earth. It would not work, since natural selection made us tough predators (Page 231). Many others, from Rene Dubos to E.O. Wilson, have suggested that our genes have gotten us into our selfish, short-term ways. One important response that he has neglected, and we know to be effective, is conservation. Although he admits that the best way to improve use of energy is to avoid waste, he has not considered the scale of savings from conservation. It may be difficult, and we may suffer some discomfort, but we can change. A shark cannot become vegetarian through an act of will, but we could change our wasteful ways through willpower, if we could act as if we were wise.

8.6.2.5. & Make Better Models

The exhalations of all humans and their animals, domestic livestock and pets, Lovelock notes, are responsible for 23 percent of all greenhouse gas emissions. And, the entire footprint of humanity is more critical than just the carbon footprint. A footprint is a popular metaphor that we use to model our impacts. Lovelock says conscious animals are model-makers.

But, he decries the acceptance of models that show smooth rises. They have not even predicted past events, such as melting polar ice, much less future events. We think using metaphors and models. Obviously, we need better models. Lovelock mentions his Daisyworld model, which shows how a simple global ecosystem could stabilize the temperature of the atmosphere. Daisyworld is Darwinian. It demonstrates that organisms do not evolve independently of their environment that changes them and is changed by them. Lovelock repeats another model of the atmosphere: at 450 PPM of CO2 there is a 9-degree rise in the model. The earth seems to have two stable states: greenhouse and icehouse, with metastable states between, like our current interglacial. The best known hothouse was 55 million years ago, the Eocene, the dawn of mammals. Lovelock states that the earth system is preparing escape to a new safer hot state with a stable climate. Why is it an escape if there are several states?

Gaia is habitable because species that improve habitability survive, he notes. Those that foul go extinct. But, the interactions can kick the planet to a different state. Lovelock agrees with Garth Paltridge that planetary environments are naturally selected to maximize production of entropy (waste heat). But, environments are selected for complexity, or ektropy order, which produce entropy as part of the process. The goal is order, not waste heat, which is what the planet avoids with changes in cloud cover.

Lovelock uses other metaphors, such as the lifeboat metaphor. The earth is not a lifeboat—or a ship or a machine. That kind of mechanistic thinking is what has contributed to our problems. The ecosystem metaphor has more metaphoric power. We cannot exceed certain limits without causing a catastrophe. Ecosystems have changed over billions of years. The first 3 billion years all forms of life were microorganisms and systems were simpler. But, Lovelock contends that Gaia can never be based on sparse life, such as thermophil bacteria. And, he must be right, that a maturing planet requires a certain scale for self-regulation.

Metaphors, models, and anecdotal thinking have some value. He notes that a false positive is better than a false negative in terms of survival. So, if the present world is unsustainable, how can we retreat from it sustainably? He uses an analogy with a submarine, so it must be a technological retreat. He suggests, that with all-powerful leaders, we could: Ban pets and livestock, force compulsory vegetarian diets, and synthesize food. Each of these could be discussed at length. Pets, for instance, are sometimes the only link urban dwellers have with nature; the first pets came from partnerships with animals who benefited from our wasteful habits. Any of these could be controlled with taxes or cultural rules better than being dictated. Orderly survival requires great degrees of human understanding and leadership. He mentions that we might have to suspend democratic government during the emergency. He should realize that changes in lifestyle are bound as unpopular as changes in business and agriculture. Taxes and subsidies are easier, but may not go far enough in the wanted direction. Although as part of a voluntary emergency action plan, on a global scale, they might be more popular and more effective.

8.6.2.6. Because We have to Try

Humans have put their rights before their obligations to the planet, Lovelock notes. Then he raises the subject of religion, noting that if we are in a god's image, then we cannot improve our behavior. In fact, according to J.B. Cobb, Jr., religion could reverse our bad behavior and bind us to the earth (refer to Section 7.7). Both Cobb and Lovelock agree that we need to evolve into a self-regulating species.

Under pressure, any crowd can be a genocidal or matricidal mob. Communities, however, are far stronger than crowds of individuals. Is that what is happening? We are acting as crowds, not communities? Social insects formed nests and became subjects of queens. They lost personal freedom, but gained a stronger community. We invested energy in our individual intelligence rather than in strength or community. Individual intelligence may not be enough anymore. We communicate knowledge and learning and experience. We act coherently as a group. So we prevail against the incoherent insects. Yet, like termites, humans evolve to social cities that can reduce contacts with the living environment, Gaia. Our error is to take more than the earth renews.

Perhaps we are like a cancer, as Alan Gregg suggested, or a virus. Civilizations destroy themselves with ideologies that disable their operating systems, like a computer virus would. Gibbon thought Christianity a virus that destroyed the Romans. Maybe Marxism enfeebled later states. Maybe we have doomed ourselves, crossing some invisible limit. Maybe there is only a small chance of reversing global heating. These things are uncertain. Natural and human affairs are uncertain, but human decisions have to be certain. We have to choose and have faith in our choice. Using common sense, science and principles like precaution and conservation, we can try to restore balances. Using global ecological designs during a recognized global emergency would be a good start. Lovelock has suggested that the greatest value of the Gaia concept may be the metaphor of the living earth. He states that Gaia's face from space is beautiful. We need to remember that as we act as responsible offspring—but also remember that the faces of Mars and the other planets, and stars and the universe, are also beautiful (even if far less supportive).

8.6.3. *Wicked Problems & Wild Design*

In the 1960s, Rittel Horst defined a wicked problem as a kind of social problem which was ill-formulated, with confusing information, too many clients, and conflicting values. Gaia is an example, even more so than social political structures (or human ecosystems), of a wicked problem, due to its history, immensity and complexity. As a system, the planet may be too complex to understand fully, much less manage.

Many people have complained that the planet actively threatens human civilization with tectonic changes and extreme climate events. In his *Medea Hypothesis*, Peter Ward claims that life is predatory and self-destructive and will return the planet to its abiotic condition. The hypothesis raises some interesting questions, many of them addressed by Lovelock and others in connection with the Gaia Hypothesis, but then it sidesteps measured responses with fallacies, errors, contradictions, assumptions, and overwhelmed models.

One example is the Oxygen Catastrophe (or Great Oxygenation Event) 2.4 billion years ago, which wiped out many species of anaerobic bacteria; it also reduced carbon dioxide in the atmosphere and may have triggered the Huronian Glaciation (Snowball Earth). Ward argues that this catastrophe was caused by cyanobacteria and that those life forms were destroying life at a large scale by their innate desire to convert all resources. This argument depends on the Fallacy of Simplicity, where multiple interlocking factors are ignored in favor of a single cause. The photosynthesis of bacteria was producing oxygen, before and after the catastrophe (and it was a catastrophe for multitudes and generations of anaerobic bacteria), but earlier some organisms and massive quantities of dissolved iron were capturing free iron (leading to Rustball Earth first). Only after minerals were saturated did excess free oxygen accumulate in the atmosphere. Before the catastrophe, submarine volcanoes reduced oxygen and removed it from the atmosphere; by the Archaean/Proterozoic boundary about 2.5 billion years ago, continental volcanoes started erupting and oxygen levels in the atmosphere increased. The evolution of plankton put oxygen into the oceans. Although oxygen poisoned anaerobic bacteria in the atmosphere and its interface with the ocean, through photosynthesis it provided much more energy to organisms; it promoted more diversity in organisms and it increased the diversity of minerals through oxidation (which provided more resources to living organisms). The interaction of oxygen with ultraviolet radiation produced an ozone layer that protected organisms from radiation and permitted the colonization of land. The catastrophe did produce an opportunity for the later expansion and diversification of life.

Of the five great extinction events and the five lesser, Ward blames all but one—the bolide impact 65 million years ago—on the suicidal tendencies of life. Under closer examination, all the greater and lesser extinctions occurred under complex conditions with multiple factors, including bolide impacts, volcanism (and flood basalt events), sea-level drop, deep ocean anoxia, glaciation, sustained warming or cooling, and abrupt climate change. Climate is driven by many factors, such as orbit, wobble, plate tectonics, and atmospheric gases.

Life has become a participant in climatological and geological change, so biogenic factors are important contributors, although astrophysical and geological processes seem to be more potent drivers. The crust of the planet is formed by volcanoes and earthquakes, and by the actions of bacteria, lichens and trees, which break down rock with acids and roots. Processes of life concentrate resources. Metals and gases toxic to life are isolated and end up sequestered in geological formations, although geological processes can release some of them suddenly, resulting in methane eruptions or mercury poisonings, and related extinctions. Ecosystem stress is a possible cause of extinctions, especially compounded by a sudden shock to the system. Some species with high turnover rates may be vulnerable. Predation can cause extinction under some circumstances, when the predator has multiple prey species but concentrates on one favorite (otherwise predator and prey dance around limits). By now it should be obvious that the causes are astrophysical and biogeochemical.

Graphics showing carbon dioxide and extinction events indicate that the extinctions are related to changes in carbon dioxide and oxygen and to changes in temperature and moisture. Obviously those are related to living processes that moderate them. The argument seems to be: 'Over 99% of all species are extinct; over 99.99% of individuals are dead. Life killed them. Death to life!'

Ward relies on Franck's model for carbon cycling. Although the model has many acknowledged limitations in terms of temperature spikes, volcanism, and mass extinctions, Ward uses it for the distant past and deep future projections. Ward defines species success in terms of numbers, biomass, and range, as well as ability to survive. He uses this measure of success as a way to compare hypotheses. For instance, he calculates that the total biomass peaked a billion years ago (in the Achaean and Proterozoic periods), before the Cambrian explosion, and has been declining ever since; he relates this to the gigatrend of declining carbon dioxide in the atmosphere. Ward concludes that future changes will cause the death of plant life, then oxygen starvation of animals and death of ecosystems.

He also calls prey to other fallacies, such as 'begging the question' (*Petitio principii*), where the premises are insufficient to establish the conclusion, when he argues that 'As life uses up all its resources, it is being destructive.' Other pragmatic and semantic fallacies invalidate many of his other arguments.

Ward seems to blame the planet for not adequately protecting living systems from external events or from the actions of each other. The planet is a stochastic system. Life is an emergent process for producing experience within new kinds of order. Life changed the order of the planet, which allowed living forms to exploit various forms of matter, energy, and structures, including other living forms. Life creates ecosystems of aggregates. These systems develop so that different forms complement each other functionally. Living systems become more resilient than nonliving systems, modifying all systems while maintaining stable states. The variety of interactions increases; competition, emphasized by Ward and others, does enhance or eliminate forms, but kinds of predation and cooperation shape living systems in a living environment. The living biomass produces waste biomass that enters soil as well as geological forms. Evolution or atmospheric regulation are just descriptions of the historical development of life in the planet.

Life is not a loving motherly goddess (Gaia) or a murderous mythical one (Medea). Life is not benevolent or destructive, just opportunistic. Living systems do not intend to destroy every living system. They adjust to changing conditions and exploit them to stay alive. Nevertheless, Lovelock, Ward, and others have raised interesting questions. There are positive and negative feedback cycles in the biosphere. Living organisms contribute to shaping all the planetary spheres. Species do tend to reproduce beyond the capacity of the environment (and its resources), especially in the absence of other species and environmental restraints, which can end in catastrophic decline and extinction. But, does a species even measure the environment to calculate limits? Is there a law of growth in life?

If life was so determinedly suicidal, how did it survive over a million years, much less over three billion? If it *is* suicidal, then the evolutionary evidence suggests that it is ineffective. Will life destroy the living planet before a physical catastrophe can? Is this a problem innate in living—the desire for nothingness? The problem is with a variety of conditions, from constant entropy to galactic dust lanes. The living system of the earth has to react to a variety of external events, from energy bursts to asteroids, orbital changes, and tilts. And, these changes cause challenges, such as higher or lower temperatures over periods to which living systems have to adjust.

The living environment is a wicked problem for design, especially now, when anthropogenic changes are contributing to the interglacial global warming. Traditional or ecological design may have difficulty with so large a system. But, global ecological design can address the difficulties at the appropriate level. Global ecological design is as subversive as any art or design; it can overturn wicked design problems. Global ecological design is a wild way of thinking that can mesh its approach with the wild planet, using an ecological perspective, systems understanding, participation, and standards of knowledge.

8.7. *Wild Design: Creating Global Ecological Designs*

We have had great success designing toasters and pencils. We have even had some conscious success designing parks and forests, but for the most part, designs, especially of cities and regions, and of humanity itself, have been aggregated or assembled from all of the small individual and group decisions. They often do not work well together; they do not work well with ecosystems and biogeochemical cycles. In fact, sometimes they disrupt international politics or interfere with systems and cycles.

8.7.1. *Global Scale Designs*

We have addressed designs on small scales, from the design of idea and objects to the design of objects in interacting systems and systems of interacting objects. We have not been concerned as much with the design of objects and living beings in ecosystems joined by regional and global cycles. This is the broadest scale that we can design at our current stage of development. We can imagine and discuss redesigning the solar system and the galaxy, but we do not have the knowledge, power or humility to try that, yet.

We need big designs to address at least five major concerns. The first is the planet itself. We need to design land and ocean ecosystems in a way that lets them regenerate without damaging interference. Essentially, we are designing human systems that fit around many systems and interface with others. We need to let the system produce forests and deserts, wetlands and grasslands. Then, we might be able to influence the extent of deserts and forests; we might be able to restore some and create new associations carefully.

Our cities need to be rethought and redesigned secondly. How can we design them so that they do not interfere with ecosystems or watercourses? How can we design them to withstand floods, earthquakes, and volcanic eruptions? If we cannot do that, where should we place them so that those threats are minimized? How can new cities withstand three 20-year droughts in 100 years? Should we have farms on roofs of most buildings? Vats of food, storage in cans or freezers for 20 years?

The third major concern is agriculture. If people are concentrated in cities, can we simply trade foodstuffs from distant farms or from wild animal harvests? We could reduce our reliance on a few foods, such as corn and wheat that are grown everywhere, often at great expense and great costs to the environment. We could reduce the number and extent of fields, and make them more organic and labor-intense.

Waste and pollution are a fourth concern, now that they are global. Finally, population growth needs to become planned to reduce the impacts and interferences on ecosystems.

8.7.1.1. Units of Design: Memes to Xemes

The tools of design have been hands, knives, and more complex things. The medium of design included wood, brick, clay, bones, and other things. Now, we might want to create a novel approach to design, using units of design that have new names and meanings, such as gene or meme. Our recent experiment with changing the basic shape of part of the universe, directly, was learning to manipulate genes—a gene is a physical blueprint for a protein that controls one or more of the physical traits of an organism or the activities of other genes. We now combine genes directly from plants and animals to try to add a characteristic that is useful to use, such as frost-resistant strawberries.

Genes in a species developed over the several million years that is the lifetime of a species, and in terms of spreading between species or altering species, the genes have been developing for several billions of years. Combining new genes in a species is challenging, but we have basically no idea what will happen to the gene or the species during ecological interactions in the environment over time. There are ways to design genes that are less dangerous, and that is by combining the organisms themselves in ecosystems. That is part of restoration. Of course, we may be able to reconstruct recently extinct species from genes as part of a restoration strategy. That would be less dangerous, since the genes have already existed in a known combination for a known ecological context.

We can name the global context as a 'xeme,' where the atmosphere, ocean, geosphere or biosphere are xemes. The biosphere is the source of the wene that we have called wilderness or nature as a cultural interpretation. The biogeochemical cycles can be combined under the idea of 'fenes,' where a fene is one cycle. The ecosystems could be labeled as 'nemes.' Since the ecosystems can be scaled from pond to the planet, other terms, such as landscape, are used for human artifacts. Naming things in this way allows us to distinguish between the human sphere and the wild sphere, although they are coevolving like genes and the environment or like culture and nature. We use these terms to discuss designs and problems.

Different words would be needed for the nonhuman universe, that is, those things that are physical, existent and not dependent on human thought or construction, such as the universe, the solar system, the planet and its spheres, and cycles and ecosystems.

8.7.1.2. Considerations for Global Design

The ecological design of a toothpick, for instance, requires the consideration of many factors. The goal, to clean food from teeth, has to be articulated; other goals, such as picking up food to eat or holding seeds above the water in a jar, can be explored. The materials are examined, as well as their source; perhaps one of the possible materials, wood, is rejected because too many white pines were cut and the ecosystem has been degraded. Perhaps another material, plastic, cannot be disposed of properly and can eventually interfere with ocean ecosystems. Some materials, like ivory, may be rare or objectionable on ethical grounds. Some materials, such a cattle bone, may work to reduce waste from slaughterhouses. Then the design starts: Determining the size, length, thickness shape—round or squared, color, grooves, which of course depend on the variability of teeth, the cultural meaning of colors, and other factors. The design is then sandwiched between the manufacture, packaging, delivery, and marketing of the item. Disposal has become a recent problem. The waste could be put in a landfill, burned, or recycled—the material might be used in plywood or flooring, depending.

8.7.2. *Global Spheres, Cycles & Systems*

If global design used the same approach as traditional design it would be unacceptably anthropocentric. Many of the same factors could be addressed in specific cases. The planet as a whole and the solar system are special cases. Can we design probabilities of actions and reactions? Can we anticipate or control large-scale changes as a result of planetary changes or extraplanetary events, such as collisions or solar changes? Will we be able to react to a greenhouse world or a new ice age? What would design have to do to anticipate and adapt to those scale of changes? How would we design for massive volcanic eruptions? These are low-probability events in the near future, but likely high probability events in terms of millennia or certainly ecosystem or landscape time. Obviously, we can create international scientific monitoring bodies to get early indications of changes.

In the distant future we would have to be concerned with the result of the evolution of our star. But, that is less likely, as our species would probably die after another million or two years, long before solar changes would be significant. Of course, the species could change or technology extend it and colonize other planets in or outside of the solar system.

8.7.2.1. Atmosphere

In thinking of designing the atmosphere, we have to consider the goals of the atmosphere, beyond existence and continuity. Is it to maintain the same composition of elements, like oxygen and argon? Is it to change its composition to adapt to the inexorable increase in solar output? Can that change be accomplished by speeding up or slowing down cycles in the atmosphere? Or by altering the interactions of certain cycles?

The composition of the atmosphere is basically gases, including nitrogen, oxygen and water vapor, with some solids, such as dust and spores. Should we considering adding materials to the atmosphere? We have already been adding novel materials, such as CFCs, without planning or thinking and with unfortunate results. There have been proposals to orbit clouds of mirrors in the upper atmosphere, even though reflection is more effective in the lower atmosphere. Have we considered removing them if they are not useful or when the function has been performed?

We could consider shaping the atmosphere. We have the technology to create clouds. We have accidentally shaped patterns of wind, especially through and around cities, which concentrate energy so much that they become heat islands that alter the flow patterns of air. We intend to use wind energy, perhaps in cities as well as large-scale wind farms, to generate electricity. This will have several effects, from concentrating even more energy in cities and buildings to slowing down wind speeds in some areas. We might want to pay more attention to the effects of cities on the atmosphere as a whole.

Although we have had some experience manufacturing an atmosphere for spacecraft, we had trouble balancing plants and animals to produce a breathable atmosphere in a large warehouse in the desert. The scale of the atmosphere is such that we will not have the technical ability to manufacture a global atmosphere. The atmosphere is a very fast conveyer of particles and pollution around an entire hemisphere. So far, it has been able to absorb much of our waste, and spread it to other systems. What processes could we design to limit the emissions of our wastes?

Global climate change, however, may be too long and large a trend to modify at all. Certainly human additions make a difference and we could reduce them. We have some technologies that might work to temporary stall the trend, although they may have unforeseen disastrous consequences.

8.7.4.2. Ocean

Let us approach water the same way. What is the goal of water? To flow, and to absorb as much as it can? To stand or to escape gravity of the planet? To host living things? Our goals for water a quite different: We want clean water to drink, wash and cool things. Moving water even furnishes us with aesthetic pleasure.

Water is the basic material of the ocean. It tends to stay in its basins, unless provoked by winds and geological activity. Due to its flows it is not as fast or pervasive as the atmosphere. Things in three levels of water tend to stay within their level, with some exceptions. Moving water tends to make then stay in its channels. Those things we have designed, in the form of dams and concrete or clay channels. To that extent we can shape the flow of water, although we have not learned how to deal with massive high-water events in rivers or oceans. We have noticed, however, that many ecosystems have become accustomed to hurricanes and tsunamis. We have noticed that many river channels have been shaped by floods and can accommodate them in surrounding wetlands. We have even started to mimic some of these landforms, rather than rebuild cities in them.

We can manufacture water, although it is relatively expensive. We can clean water and recycle it, although these processes are also relatively expensive—more expensive than not polluting water anyway. The characteristics of water as a solvent allow it to be useful to remove many kinds of waste, from feces to chemicals. We can design processes to recycle the feces without water and in fact use it to enhance soils, recreating a traditional use for it. We can design industrial processes to eliminate many kinds of acids and substitute lemon juice, in computer manufacturing, for instance. We can neutralize many of the substances we do use, without putting them in water.

What kinds of problems could we face with oceans? Could the Gulf Stream stop? Vaclav Smil states that the Gulf is not driven by thermohaline circulation. Like the Kuroshio and the Agulhas, it is a wind-driven (due to solar radiation) and torque-exerted (from the rotation of the planet) flow. He further says climate does not require a dynamic ocean. Perhaps, but local weather requires it. The average may be the same but the details determine habitability and crops. Diluting the stream may not stop circulation, but it would change the heat balance and form of the current so less heat would move north. It would be prudent to restrain human activities to limit fresh water impacts on the stream.

8.7.4.3. Biosphere & Wildness

What can design do about the massive degradation of the biosphere? What can design do about overconsumption? What can it do about the use of fossil fuels? Obviously, one thing that design can do is create a set of paths for human demands to be reduced. To reduce per capita consumptions above a threshold figure amount.

Wildness is easy. Wild things just want to exist. Designing wild areas is basically creating semi-permeable boundaries to limit access for human activities as well as exotic species. We can restore wilderness, as a cultural concept, and wild ecosystems, as independent xemes.

Ecological restoration is a conscious intention. The past provides the reference conditions, and this information can guide the goals of restoration. Of course, we are trying to set quasi-natural patterns that will generate self-making and regulating ecosystems in the future. But we need to have the goal, the image, a statement of the intent that becomes the design and is written or inscribed in the plants and animals. The design, as the physical manifestation of the intent, has to try to be as wild as the subjects of the work. The design has to link the historical basis, the integrity of the system.

Ecological design is the primary way of restoring damaged and transformed ecosystems that need to be made more complex, more active systems. Because we are humans and have cultural ideas and images, and because we have impacted ecological systems for ten thousand years, culture is part of any restoration.

One problem with ecological design is the time scale. Douglas-fir forests may need 300-400 year plans. Redwoods 900 years, and some pines and cypress can live over 4000 years. How would be design that, plan that, manage that? Will the government agencies last that long, if they haven't? Human design has been *ad hoc* in the short-term, but global design needs to be long-term and *ad omni hoc*.

Another problem is the physical scale. Wilderness areas have to be large enough to incorporate all of the interior species that make up the system. There is no way we can recreate a complete system without having an optimum size.

Global physical design, such as northern hemisphere wolf paths, also express values that many communities can hold in common. A global approach to design can adjust the entire metabolism of the planet to be sustainable (whereas community designs and some regional designs cannot consider the whole cycle, for instance, of water to provide fresh drinking water. Obviously global design will take more effort and many more financial resources. But, these will involve nations and communities.

We cannot manage ecosystems on a local level. But, we can restore, replant and expand areas that are subject to natural processes. We have to contain ecosystems locally. We cannot restore them by pouring some kind of global soup into the mix and letting things sort themselves out, as some technologists and green builders recommend. If we force the global pool from a set of local pools into one big, open, global gene pool, than only the fiercest bacteria and viruses, only the most aggressive animals and plants will remain and dominate the planet. Interior species will be lost, Closely adapted species will be lost. Much biodiversity will be lost.

Design can design wildernesses and conservation areas, in terms of sizes and shapes, as well as visitation or exploitation, which would guarantee healthy ecosystem services under normal conditions. Design can suggest ways to enhance or protect biodiversity in many ecosystems, through the design of reserves or the removal of roads or the limitation of human impacts on those systems.

8.7.5. *Designing Cultures & Continuous Turning*

Cultures were assembled out of sets of behaviors that worked in specific environments. Although a few cultures developed behaviors that did not adapt them to their constraints, many worked well for thousands of years. Most cultures do not consciously shape their actions and behaviors. Less fitting behaviors simply drop out. Ones that work are repeated.

Design has to consider culture. Culture has to control the impulse to irrational, selfish or violent behavior with cultural rules. Cultures are adaptive mechanisms that can change quickly that can embrace new courses under threatening circumstances (even if the threats are slow, invisible, large-scale, long-term threats). Human society has been getting more complex, and many actions are now global. With the awareness of connections and greater ways of cooperating, people can control their behavior. The new technologies of communication and calculation, of observing and trading, can help the management of global commons, to combine conservative ways (of living frugally) with high- technology improvements of energy and food production and waste.

What kind of culture could we design? Can we go back to hunting and gathering, foraging, fishing? We have some of those cultures. We could set aside areas to reinstitute that kind of culture. Obviously, foragers are much more flexible in terms of movement within their territory. If territories were extended north and south and upland, then threats from climate change would be minimized, relatively speaking. Can we design a cooperative transition to a series of eutopian nations? Can we design new global human group norms? That is, can we incorporate new behaviors into a culture consciously?

Design needs to consider the entire frame of human history, to recognize that anthropogenic environmental change has resulted in catastrophes to some human cultures, and that those cultures disappeared or were radically changed. Design will have to consider the entire global human population, and show ways tat the populations can be lowered to those indefinitely supported by ecosystem limits.

Design can present visible limits on the size and consumption rates of the human demomass, as a global phenomenon, then suggest ways for us to respect those limits while still producing enough material food and goods for human needs. Many of these limits will be global as well as local, so the local will have to be defined as a percentage of the global.

We can effect the cultural uses of materials and energy. Design can create soft energy paths to reduce the dependence on fossil fuels. It might consider the hard technology of nuclear fusion, if standards for safety and continuity can be set and met. Certainly soft energy paths can be used to reduce use of fossil fuels. Conservation alone could cut demand by half or more. Otherwise the immense flows of renewable energies will cause more problems. Design can reduce demands through vernacular building designs. Part of the problem of energy use is that too much energy is put into the system, which did not develop to handle so much energy. Although technical expertise can provide new sources of energy, it has to be combined with limited use. People have to be convinced to forgo doing everything that is wanted or possible. This is a moral consideration, and design has to suggest ways that cultures can convince people to want to limit their use and its impacts on other species.

8.7.6. *Coevolution of Design and Wildness*

Design should coevolve with wild nature or xemes. Global design has to evolve with the planet. Thinking ecologically makes us aware of interrelationships. Design is recognizing these global and regional processes and contexts. Design is a primary element to stimulate possibilities.

A framework for design can work at any scale, from a small building, at one end of the scale, to preparing an urban design framework or master plan for an entire planet, at the other. Models at global scales may be insufficiently realistic. That is why we need a design skeleton, a framework, to hang the medi- and micro-models on. The Potsdam Institute for Climate Impact Research, for instance, is constructing a unified, global-scale model that is tractable and isomorphic. It employs one set of quantitative functions to describe all human impacts, all human adaptations to environmental changes, and all impacts of environmental change on humans—this is where design is important, to limit or modify those impacts with a framework of design. Within a framework of planning, we need to be able to accommodate the unplanned and the unimaginable. The framework will be incomplete; it will lack detail and definition, but it can be used by all the participants to coordinate actions within physical, ecological and mutual constraints.

8.7.7. *Wild Design & Global Patterns*

Thoughtful rational design works well with many kinds of tools and buildings at a small scale. It may not work with wild systems on a global scale. Human agency may be limited, but it could incorporate into its design natural processes that could be effective at the planetary level.

Design works out challenges and problems in an artistic way. Art is wild. We cannot control the effects of art, or even anticipate all of them. We cannot anticipate the changes it might make. That artistic way is a wild way of thinking and can mesh with large-scale design better than a simple technical approach. Design needs to become wild. Wild design is not human-centered, as most all design in the past has been human-centered. Wild design is based on radical ecology (Wittbecker 1978)—it is the push, beyond human interests, to consider the character and patterns of ecosystems. Not to subvert or interfere. We can guess what the system wants with reference to its past behavior. Well, we know what it wants: To exist, to regenerate. We need to create the conditions for the system to flourish. And, if we use any of it, it has to be limited to that level of productivity that does not interfere with the survival of the system. We are reintervening in a natural system at different levels rather than using or interfering for human benefit.

The word design is modified in this sense to be power with natural processes, not power over them or control of them. Wild design is a conversation across time. We listen, ask, and contribute. We inscribe human stories on the larger stories of the system. Participating means living in the systems. We can reciprocate by giving our bodies back to the system. It cannot hurt to give our minds to the shape of the system. It is knowing what not to do, as well as what to do, when to do it, if we do it. The future is already connected with the past through the present. It just gets complex and unpredictable away from the present. Too complex.

We rarely look at diagrams of large-scale patterns. Although we are entranced by light patterns all over the planet from cities, campfires, and various burnings, we less frequently see the flyways of the Monarch butterfly or the smaller semi-annual paths of salamanders. Most of the paths of wolves or bears are invisible to us, although we sometimes walk on deer trails or try to follow the migrations of birds or whales (the more expensive ecotourism).

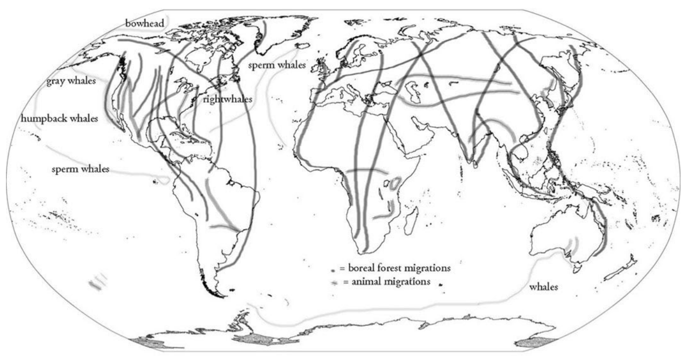

Figure 877-1. Bird & whale migrations

Wild area may still occupy over 30 percent of the planet, but they are mostly in less desirable territories, covered by mountains, ice, and sand. There are some areas that have been protected by their danger from flies and infections; these are thorn forests, wetlands, and remote jungles, and many of these are being identified as hotspots for biodiversity, with more recent efforts to save them through purchase or trade.

Animals create paths for their regular movements between habitats (in fact, many of these were used by Archaic peoples and then by industrial highways). Some animals migrate hundreds of miles. Birds may migrate hundreds or thousands of miles. We have identified many of these paths and flyways and can see them on maps. Many of these could be left in place, or many human roads could be intersected carefully with them.

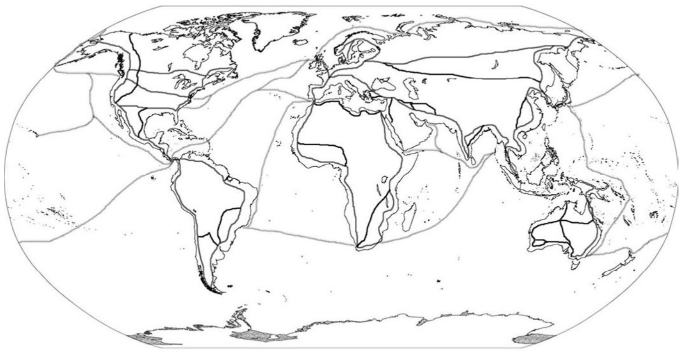

Figure 877-2. Highways & Shipping Lanes

The use of wild animals, such as elephants, and domestic animals, such as cattle or camels, creates large-scale patterns. Many of these patterns have been changed by human exploitation of the species. In Figure 877-6 gray areas show the native ranges of selected species while black circles indicate highest density of similar domestic animals.

By shifting agriculture to a more wild agriculture, or conversely, a more urban agriculture, many wild ranges could be maintained, and even exploited reasonably for 'bushmeat' or exotic foods. Changing the locations and densities of cities to areas with less fertile soils would permit many more shore, shallow water, and prairie species to make comebacks.

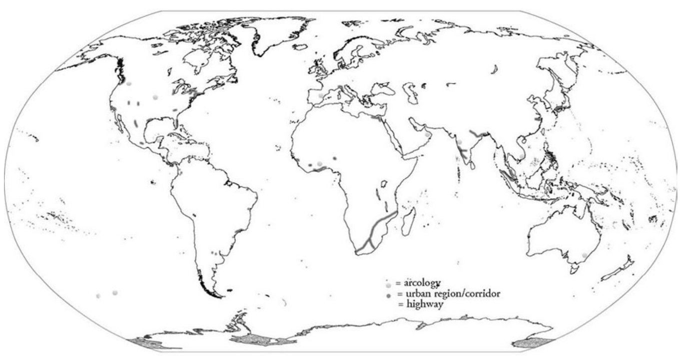

Figure 877-3. Sites of Arcologies (Potential)

Wild design has to be heroic, especially due to the scale of working on a global level. Heroic design and extravagance in life is needed. It is not contradictory or antithetical to frugal lifestyles or restoring a healthy environment.

Wild ideas are needed. For monitoring natural systems. For closing local loops in energy or matter. In closely linked webs. With connections and collaborations. Our cultures, made more intense in cities and by technology, like the web, can be the incubators of new forms.

8.7.8. *Restoring Balance*

As the natural balances are upset by human settlements, the settlements also suffer. C.A. Doxiades discusses the need for a global ecological balance. He suggests a scientific analysis of such a balance to replace the luck, and trial and error limits (or a Buckminster Fuller states, the "trial and error error error"), of hunters and cultivators. But we cannot wait until we learn.

To achieve a global ecological balance, we need to set goals for each kind of ecological spaces. We need the concept and goals for the overall system, also, to have the local ones make sense. We also need to have a global coordinating body like the UN to design and implement a global ecological balance. And, at a regional level, nations and communities can go further balancing regions and locales.

Design will have to balance the gains and losses on a global scale. It will have to do it in an equitable manner, with attention to past and current inequities between cultures and peoples, between regions and economies.

Obviously, redesigning the planet means redesigning human structures, paths and influences. Trying to change the patterns of consumption to conserve the capital of nature. Trying to limit human influence. Trying to contain human mass to a limited area of the planet. Simple conservation makes the most sense, as we just reduce the flows, and have less to bury or deep-place in the ocean, or to avoid with solar screens or aerosols. Efficiency alone promotes more consumption, therefore conservation must limit quantities and uses.

We can create thought experiments for all these situations. We can create possible scenarios for dealing with them. We can create ways to reduce the possibility. We have had catastrophes. We may always have them. Bacteria and earthquakes are part of the entire system, as are asteroids and irrationality. And, we have adapted to change. We can adapt to almost anything, Rene Dubos worries, from overcrowded slums to a desert hot world. So, we need to balance our ability to adapt with our strength at making goals. These approaches will be the best bet to reduce the patterns that may influence global climatic chaos, extinctions, and ecosystem conversions. And, they may lead to better places for human beings as well.

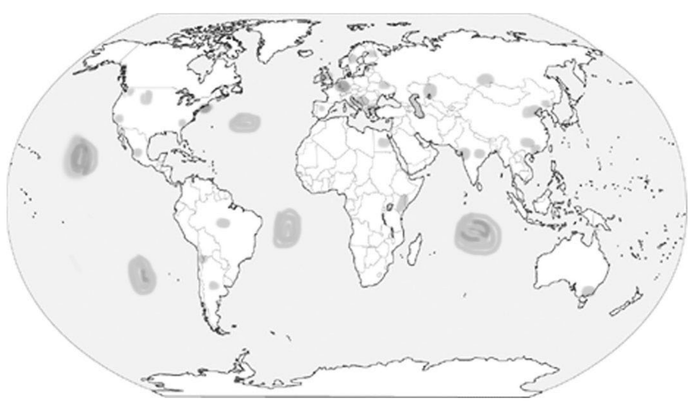

Figure 877-4. Trash sites in gyres & on land

8.8. *Creating a Planetary Framework for Design*

The Eutopias framework possesses three levels of authority, each with its own area of responsibility. There is a global authority to protect both the planet and human cultures. This authority, the United Nations (UN), is responsible for all land, air, and water utilization, for global cycles, and for interactions between Nations. The UN gives equal opportunity to nonwestern, nonindustrial cultures to flourish.

Local organizations, called nations or republics (from the Latin words meaning 'thing of the people'), are based on traditional cultures, which have long-term lasting power. Nations are responsible for protecting local environments and for providing a context for individuals. Both globalism and the simple community are necessary, if the community is not to be diseased and the globe impersonal.

The locus of political sovereignty is the individual, who is limited in giving away proxy rights. Politics has to be a participatory process, where an individual has some power over decisions affecting him or her. Participation is necessary, not only politically, but to establish the existence of common values throughout the population as a whole. Individuals have responsibilities for themselves and to their cultural governments.

8.8.1. *International Functions: United Nations*

Our many individual national attempts at social improvements, however, have proceeded without adequate reason, without order, without sufficient insight or broad perspective, without enough confidence, without a comprehensive plan, and without a great dream. Our efforts to provide the infrastructure for our civilization are guided by anonymous builders, mediocre designers, minimalist engineers, and rapacious financiers. Our politics have been corrupted by special interests. Historically, however, the creation of states has not been through reason, China, France, Germany, Italy, and the United States, among many others, were united by force.

The notion of a world government seems to satisfy a basic human craving for unity and order. And, an implicit world system is evolving through economics and science. A global order is necessary to govern the system, but, at the current stage of international relations, there seems to be no agreeable path toward a benevolent world order. The partial adoption of international institutions is insufficient for a world order, especially if they are only advisory.

The United Nations (UN) is the only existing body with the machinery for constructing a world order; the beginnings of a comprehensive politics can be found in the special services of the UN: UNESCO, FAO, WHO, and the various technical aid services. As long as ecological and political problems are addressed in a framework of nationalism and military power, however, these organizations are treated as peripheral and relatively impotent.

Rather than replace the UN with a new construct, we must revise it. The UN has been a half-hearted investment, but it has historical appeal and wide support. It is a nascent global order, but it must be reorganized and empowered, as first advocated by the Jackson Report (1969) and the Hammarskjold Report (1975). These recommendations are just a continuation and emphasis.

As it is structured, the UN is not capable of handling the responsibility for world order. For example, the UN's solution to economic problems is "sustainable development" within environmental constraints. The Bruntland Report, which proposed that solution, indicated a five to ten-fold increase in world industrial output within the next one hundred years before population stabilization. While the appeal to growth is unarguable, it is really not likely to be sustainable in any meaning of the word, since this kind of growth does not recognize or respect known ecological limits. Considering that the current level of industrial output has imposed severe threats on human society and environmental health, even a five-fold increase should be able to destroy the cultural and ecological diversity of the planet. Other actions of the UN, such as restricting membership in the Security Council to "great" powers with nuclear arsenals, or its use of the veto principle, indicate that the organization has been captured by the status quo. Furthermore, even when the UN does make good recommendations, it does not have the power to coerce any nation to follow them.

There is already a world system. But it is not, and should not be, a stagnant, monolithic industrial system—to say that there is a human body is not to say that all organs have decided to become kidneys. A global order is necessary to govern this system. The United Nations, an elected body, shall have the regulatory powers necessary to maintain an healthy global environment It shall have regulatory and advisory powers to maintain the independence and integrity of its constituent nations. It shall have regulatory and punitive powers to rectify resource and human rights infringements; only this body will have police powers and impersonal weapons. Various advisory bodies will recommend policies and actions to nations. The United Nations has several basic functions: (1) To Ensure a Diverse Biosphere, on which All Humanity Depends, (2) To manage common resources, (3) to protect unique human cultures, and (4) to coordinate the representation of cultures, and (5) To provide services to nations and individuals.

8.8.1.1. New UN Powers and Responsibilities

The United Nations, an elected body, shall have the regulatory powers necessary to maintain a healthy global environment. It shall have advisory and regulatory powers to maintain the independence and integrity of its constituent nations and their peoples and places. It shall have the regulatory and punitive powers to rectify resource and human rights infringements. Only this body shall have international police powers and large-scale weapons. Various advisory bodies shall recommend policies and actions to nations. The UN shall have several basic functions.

8.8.1.1.1. To Ensure a Diverse and Healthy Biosphere

All life, including humanity, depends on a healthy biosphere. The UN works to conserve ecosystems and genetic resources. The preservation of ecosystems is addressed on a global scale. The UN is responsible for monitoring all major biomes and their ecosystems. The definition of basic landscapes sets the framework for making conservation and development policies. Many natural and artificial values are conserved this way. At least five categories of landscapes are distinguished.

8.8.1.1.1.1. *Foundation Landscapes*. Wildernesses have basic value as pools of existence that reflect the styles of existence, from viruses to human beings. Wilderness is a vital organ for the life of the earth, the generator of hydrological, geochemical, and atmospheric cycles. It is also where ultrahuman species live—it is their sanctuary from humanity (interestingly, in George Orwell's dystopian novel, *1984*, the rulers of the police state abolish wilderness because it supports freedom of thought and action).

There is no scientific answer as to how much of the earth's surface should be reserved as wilderness, free from human use. All areas of the planet that have remained effectively unused (approximately 32 percent, mostly in polar regions, deserts, and tropical forests) are placed in this category. A very large percentage of oceans, lakes, estuaries, and wetlands are included in this category. The addition of representative areas of all types, including grasslands and temperate forests, may increase the size of the category to almost 50 percent of the total land area of the planet.

8.8.1.1.1.2. *Preservation Landscapes*. These lands are those that have cultural values and are maintained by limited human intervention, such as ruins or many kinds of grasslands. Many of these areas would permit only limited access for cultural or recreational purposes. Preservation Areas are also home for archaic cultures.

Large areas under continuous habitation by archaic cultures (primarily hunting/gathering or Swidden agriculture) would fall in this category. Herding and nomadism by archaic cultures would be normal, but only with traditional tools. Other landscapes maintained by human or domestic animal presence would be included, for example, parts of the Mediterranean, some of the English landscape, Japanese shrines, or various central continental grasslands.

8.8.1.1.1.3. *Conservation Landscapes*. These areas assume the regular exploitation of ecosystems by humanity, but well below natural (nonhuman-subsidized) regeneration rates. Natural wildlife would be controlled and exploited by humans, including the commercial exploitation of uncultivated forest. Commercially exploited areas, natural forests, shorelines, wetlands would be included in this category; exploitation of wild plants and animals would be part of normal activity. Transport machinery (rail, air or road) would be permitted as impacts would be limited to right-of-ways. The greater pressure on these conservation areas would require greater care. The kinds of communities permitted in these areas would include communities that depend on natural ecosystems and permanent camps. Recreation would be allowed, but with limited machinery.

8.8.1.1.1.4. *Domestic Landscapes*. These areas have been simplified for human needs and must be maintained with human labor. These forests, grasslands, seas, and wetlands would be manipulated for human benefit. Typical activities would include traditional agriculture (nonirrigated) and animal husbandry, with appropriate tools (may be mechanized), herding, and animal shelters. Managed forests, using appropriate methods of cultivation, would be present, as would modern agriculture (large scale), using modern methods of cultivation, and livestock, including some factory farming, automation, industrial methods, and a larger scale of energy, which implies the subversion of the natural landscape. Special and general recreation would occur, with a provision for large-scale human recreational needs, such as hiking, skiing, and boating, using limited mechanical aids, excluding built-up settlements. Rural communities or organic communes would be evident, with minimal services.

8.8.1.1.1.5. *Artificial Landscapes*. These lands have been completely modified and have few remaining natural features. Human dominance would vary from light residential areas to cities and heavy industrial zones. Residential areas would include permanent paved roads (following existing ones where possible or if not new roads planned to make minimum impact; restricted lanes and volumes of air and water transport) and full services, including light commerce at low density, with provision of facilities and services, including some cottage employment, increased commerce at medium density, and recreation of any kind, with any machinery. Cityscapes may be dominated by central area functions (communications, services) at high density, interspersed with manufacturing transitional areas for light industry and services. There would be an isolated area for heavy industry and the disposal of noxious waste. Although a high biomass of animals and plants may exist, there would be low diversity and few wild species.

Each land or ocean system is classified and put into an appropriate category, ranging from pristine to heavily industrialized land. Each category occupies a different percentage of the planetary surface, depending on calculations of minima and maxima and depending on cultural values and decisions. Fifty percent of the land area would occupy the first division (eighty percent of ocean and water surfaces); sixteen percent in each of the other three (four for water); leaving two percent for completely artificial landscapes—industrial or city (two for water). These figures are consistent with several earlier proposals. Eugene Odum, suggests thirty percent forest cover world-wide, with sixty percent in tropical areas. Paul Shepard offers seventy-five percent of the land area left wild in a techno-cynegetic society. Constantin Doxiadis suggests fifty percent surface area in wilderness. We cannot preserve less until we learn more.

8.8.1.1.2. To Manage Common Resources

The United Nations would have the power to designate areas for conservation, including the oceans and atmosphere. It would regulate all industrial and residential use of common resources. Furthermore, it would:

8.8.1.1.2.1. *Form new institutions*, both regulatory and advisory, such as a United Nations Environmental Agency, to deal with land and sea categories, resource availability and alternate technologies.

8.8.1.1.2.2. *Create global scientific bodies* to study global ecological balance, collect data on global systems, and explore remote areas, maintaining a central library of all information on sciences, technologies, and cultures.

8.8.1.1.2.3. *Maintain reserves of food* and minerals for emergencies. The United Nations performs a resource function for all nations, maintaining large crop margins, for instance, seven years, to secure survival. Future survival depends on systems sufficiently flexible and elastic to sustain moderate failures in parts of the world without causing catastrophes. This attitude applies to the entire technology and survival controversies: irrigation, tankers, nuclear power, pesticides, population, deforestation, and genetic engineering.

8.8.1.1.2.4. *Recommend optimum populations* for nations, although it would not enforce those figures. Optimal sizes are calculated, based on social and ecological limits, as well as on traditional values. National cultures could range in size from twenty thousand adults to an extended population, as a result of technological, organizational, and educational factors, of ten million or more. Societies with as few as twenty thousand individuals fulfill the function of having cultural amenities.

Every state needs a comprehensive population policy, closely related to environmental and technological policies, and within the constraints of their agriculture. A single population policy for the world is unfair, since cultures are at different stages of development. There are dilemmas posed by necessity to equate global balances and national needs. Since the allocation of resources to a nation and the representation of a nation would be determined by area and not by population, there would be no reason for a nation to exceed the optimum figure. If a nation wanted to expand its population, it could do so through a number of means: trading off with other nations or through the development of new food technologies, such as increased greenhouse area. If growth exceeded a safety margin established by the UN, demographic policies would be strongly recommended by the UN, without prejudice or malice.

8.8.1.1.3. To Protect Unique Human Cultures

Cultural patterns relate human communities to the ecological areas in which they are embedded. Any culture is only one of many possibilities. There is no single or correct way. By 1900, humanity had spread through 1,000 different cultures and 3,000 languages—roughly equivalent to the number of natural biogeographical provinces and subprovinces on earth. Whenever groups were geographically separate, there was differentiation, which enforced separate identities. The real feelings of innumerable groups of people center on much smaller regions of the world than nations. For example, Britain is composed of Scotland, North and South Wales, Northern Ireland, Anglia, and Saxony. It means more to be Welsh or Irish than to be British, or Quebecois than Canadian, Kurd than Iraqi, Mongolian than Chinese. Forced cultural integration breeds tensions; in the USSR, the tensions exceeded the force and advantages of integration. Rwanda, and Tanzania are additional cases.

Many cultures in established countries, like Scotland in Britain or the Nyiha in Tanzania are organized communities, but are not permitted to join the UN because they do not possess armies. A new world order would permit autonomous groups to join the United Nations according to cultural or linguistic affinities and not merely force of arms. Nations could break up into preferred "natural" units. Every cultural group, or republic, is considered equal, regardless of size or sophistication.

8.8.1.1.4. To Coordinate the Representation of Cultures

Each nation provides support for the UN, which functions as a global coordinating body with unique powers and limits. The UN would be responsible to:

8.8.1.1.4.1. *Create a representative body*. Each republic would provide a set number of representatives to the governing body of the United Nations. It would provide a forum for designing the governance of the earth, one in which everyone can participate.

8.8.1.1.4.2. *To support its programs*, the United Nations would have authority to tax all nations. A new UN branch, the UN Treasury, would levy taxes on luxuries, including planned obsolescence; resources, especially nonrenewable ones; services provided by nature; pollution and waste generation, including the distinction between single-point and pervasive pollution; harmful commodities, such as drugs; land use by institutions (to control the scale of economy and avoid speculation); transportation between nations (above a determined level); and the growth of societies beyond a sustainable local level.

This approach would have several benefits, including furthering the process of equalization and regulating international corporations and organizations. Long-term UN financing is necessary to extend the effort beyond the lifetimes of politics.

8.8.1.1.4.3. *Set human rights standards*. This would provide the basis of any civic intervention into the affairs of nations.

8.8.1.1.4.4. *Regulate technologies* affecting nations and global systems, for example, energy use and transportation. Regulation may mean denying, as well as limiting the implementation of a technology.

8.8.1.1.4.5. *Redress inequities* through redistribution. Inequity is the current rule for individuals, communities, and nations. Soil, water, and minerals are all distributed unequally. Traditional economies create and sustain differences. Redistribution would require great vigilance and regular redistribution of some kind. Equality of that kind is unstable and the cost would be high. But, it is necessary due to the historical imbalance. Even partial equalization would allow trust, and trust would allow many customs and prejudice barriers to fade.

8.8.1.1.5. To Provide Services to Nations & Individuals

The Marshall Plan, which channeled $12 billion for rebuilding Europe after 1945, was a combination of altruism and political ambition. However, its extension to the world in 1949, as foreign aid, failed. Eighty billion dollars and 25 years later most recipients are still poor. The expectations were unrealistic—Europe recreated an industrial civilization, but unbalanced cultures trying to copy industrial cultures faced something new in their experience. Also, it was funded at twenty times less per person, and it was extended indefinitely. Rather than repeat the mistakes of foreign aid, the UN would furnish only temporary aid in the form of help and education. The kinds of aid would be threefold.

8.8.1.1.5.1. *Rescue and assistance*. Responses by the UN to earthquakes in Peru (1970) and Nicaragua (1972), droughts in Africa, floods in Bangladesh, and other disasters, are indicative of the promise of cooperation, although many efforts have been minimal or diverted into administrative mazes. Special units would be supplied by and based in every nation.

8.8.1.1.5.2. *Civic action* would be concerned with representation and voting. Mass media would be available to every culture for referenda. Technical projects, such as farming or reforestation. Civic action groups, similar to the American Civilian Conservation Corps (1930s) or Peace Corps (1960s-), could apply appropriate technology on request.

Education would be especially important at this level, since cultures would dispense local specific information. All scientific and technological knowledge shall be available to all states, as regulated by the United Nations. Scientific research and development, especially on environmental problems, will be promoted in all states. The UN will support a free flow of scientific information and experience. The UN will also ensure that appropriate technologies are available to all countries. The UN will award basic educational and research grants. An earth university might be established to consider global concerns.

For public health, the UN would create indicators of social and biological health, as well as monitor health, trade, and social quality. It would establish centers on epidemic and disease control, recognizing that health in general depends on healthy global cycles and ecosystems.

For financial health, the UN would standardize exchange rates and provide banking facilities. It would work to stabilize the prices of commodities and materials and set common business standards in terms of work and pay units and wage values—the unit of wage shall be a human work unit, which shall have equal value for all.

The United Nations would provide laws and courts to address problems of justice. It would offer distributive justice to member nations to attempt to restore the proper proportion that has been disturbed by unfair economic practices (of course, each community determines the proportion between people and goods, according to its customs).

8.8.1.1.5.3. *National armed forces* could be replaced by an unarmed UN police force; UN enforcement would consist of a persuasive presence for the observation of law and order. The UN force in Cyprus (1960s) performed this function admirably. A UN charter would ensure the inviolability of personnel and their right to intervene in any conflict when asked by any group. A police force, in a peaceful unarmed international community, would ensure a secure international, intercultural community. The security of each community would be a function of the security of other cultural communities.

With world consciousness, the weak and disadvantaged can get food and shelter by appeal or right, without plundering, without war. War would be allowed to evaporate with the protection of all people by a central governing body. Fighting would occur, between individuals and small groups as interests conflict and communications falter. Nonviolence is possible only between rational individual human beings. Sometimes force is necessary. Therefore, some armed security would be necessary; a shift from military to police forces could provide that security. This police force could provide humanitarian intervention, ignoring local jurisdiction to establish the dignity of all peoples.

8.8.1.2. Redefined or New UN Structures

The UN should seek a new location, perhaps in the World Park in Antarctica, to minimize the domination by any one nation, especially industrial nations. It could also modify its existing structure to reflect smaller, more peaceful memberships. It could add new structures to perform new functions.

8.8.1.2.1. *A General Assembly*, in which each culture has one vote. Votes by population size or geographic area are fundamentally unfair and only encourage increase and expansion.

8.8.1.2.2. *A Delegation*, limited in size, that represents a culture in assembly. The limited size would include all support personnel. It would include a representation of at least one minority from each subculture. And include representation of international corporations (depending on their home base of operations); many corporations are already larger than nations, and have more influence and fewer restrictions.

8.8.1.2.3. *A Secretariat* elected from the members of the General Assembly to serve a tenure of ten years. Independent from the influence of cultural governments.

8.8.1.2.4. *A Court of International Justice*, to hear and decide issues of consequence.

8.8.1.2.5. *A Communications Agency*, to regulate international telecommunications, post, and transportation.

8.8.1.2.6. *Financial Institutions*: World Bank, International Monetary Fund, World Treasury and World Trust.

8.8.1.2.7. *A Security Council* elected from the members of the General Assembly to serve a tenure of five years. A Police League to be composed of volunteers (or appointments) from nations. An Inspection Unit for monitoring weapons.

8.8.1.2.8. *A University*, for global ecological and cultural questions and research.

8.8.1.2.9. *Agencies* for helping autonomous societies: FAO, WHO, UNIDO, and ILO. UNESCO is too ambiguous an agency; science needs to a separate global scientific association that would limit the effects of fads and censorship.

8.8.1.2.10. *Cultural embassies* in every nation, to replace the formal embassies of nations.

8.8.1.2.11. *A Wilderness Agency* to represent ultrahuman nature. The planet and its biomass need formal representation due to intercultural effects, such as ocean fishing, and to scale effects, such as pollution.

8.8.1.3. Following Five Simple Steps

The new UN can be based on the old UN, but with immediate responsibilities and powers, for protection and preservation, as well as some temporary powers, such as taxation. Five immediate steps are necessary.

8.8.1.3.1. Transference of powers

The major military powers would grant their powers to the United Nations and relinquish their efforts towards global leadership; they also resign from the security council, cease propaganda activities, renounce foreign policy objectives, call back soldiers from foreign countries, and stop giving away produce, factories, or weapons. They put their technical and educational surpluses at the disposal of the UN. If the USA or Russia is to be a world leader, let her lead in tolerance or in trust. Let her be the first to give allegiance to a world organizing body, the UN, the first to divest themselves of nuclear weapons. If they fear for safety, they need only remember the success of nonviolence in India or of guerrilla actions in Southeast Asia and Central America.

8.8.1.3.2. Disarmament

Complete disarmament could be accomplished within a week. Earl Osborn proposes this concept of sudden disarmament in response to the tedious phase-out envisioned by most plans. An agreement would not involve much negotiation. Taking this first step would add to the prestige of the country bold enough to do it. The UN could post a police force to disable all military ordinance. A thousand planes each carrying one hundred trained inspectors could be distributed at all major centers in the nuclear countries within 24 hours.

8.8.1.3.3. Formation of Nations

Independent cultural areas within nations shall have the status of independent nations within the UN. Any culture would be given legal recognition, protection, and full autonomy over their boundaries by application to the UN, which would determine priority of claims (by archaic peoples, agriculturalists, pastoralists, or industrialists). No action would be taken to disband existing nations. Nations could still remain allied with nations as independent or dependent regions. The nations would determine the use of allocated resources. Local economics and technology would provide for populations. Traditional religions and customs are maintained or permitted to develop.

8.8.1.3.4. Catastrophic Measures
The United Nations promotes a decade of consideration. Starting with population growth, all growth would be suspended. Earth parks, in the Antarctic, Amazon, Arctic, Oceanic areas would be declared immediately. Ecosystem restoration would be begun; massive planting efforts are undertaken. No further expansions are permitted for development in wetlands or other sensitive areas. Destructive searches for resources are suspended, in favor of substitution and recycling. No new building is encouraged until uninhabited ones are restored or recycled.

8.8.1.3.5. Paths for individuals
Depending on religious, economic, geographic, or personal preference, individuals can join any culture (within ascribed limits); most would probably remain in their native culture. The designation of cultural nations does not involve a major revolution for most people. Revolution is a false dilemma, it does not reflect possibility of thousands of individual actions on farms, factories, and families, all at local levels. Individual actions add up to fate (in Tolstoy's vision). Individuals can work to regain control of their lives. They can make choices to be self-reliant or to limit their impact on their supporting ecosystem.

With the removal of war capabilities and the equalization of wealth, the remaining issues are not the kind to incite violent passions. Disagreements over the best way to raise wheat or to maintain a forest may be more easily resolved than deciding the best nation or truest religion. The death of large-scale dogmatic ideology and national idolatry could also mean the end of organized slaughter. Perfecting the art of resolving conflict through social debate would free unprecedented resources to satisfy social needs. Perhaps a planetary electronic referendum would open communication.

In designing the world, everyone can participate. We can reduce the violence to nature and ourselves and transmute it to debate. That which has been hitherto left unsaid-what we want to become, what we could become-could become explicit. Now is the time to define goals in terms of population, quality of life, and preservation of biomes. Goals are not some final state reached once for all time—they are a horizon. The UN offers continuity towards the goals.

8.8.2. *National Functions*
Individuals are preserved in societies that are preserved in places that are preserved by individuals and societies. Laws, politics, architecture, sports are things of place. They are shaped with local knowledge. A local area is limited by the limits of vision, a horizon. As protectors of place, Nations have five explicit functions.

To Conserve Local Ecosystems and Places. Nations have the responsibility of keeping their environment healthy.

To Manage Local Resources with Appropriate Technology. Every nation has the power to use its local sources in any manner, within the limits of regional and global damage and pollution set by the United Nations. Every nation has the duty to conduct activities in a manner respectful of their effects.

To Maintain the Health of Cultures & Individuals. Traditional cultures provide personal security, respect for the individual, responsibility for actions (self-discipline), social integration, concern for others, and reverence for nature. Nations educate their members;

they are responsible for the ecolacy, numeracy, and literacy necessary for individual survival and actualization within the culture.

To Provide Power for Individuals (Political Self-rule). Politics can start at the community, over community issues, like housing, transportation, or pollution. People need to save their own identities and places first from corruption and degradation. Power can be shifted to local levels through self-reliance and participation. The function of politics is to ensure that decisions are taken at the right level. A nation protects individual freedoms, guards regional culture (values and identity), and holds groups accountable for the use of power. The size of nations would be defined by place and culture.

And, to Provide for the Needs of the Individual (Economic Self-reliance). One necessary condition for the preservation of finite resources is sovereign power. To share resources without the discipline of power invites a tragedy of the commons. The limit of sharing has to coincide with the limit of sovereignty; otherwise runaway destruction could result. Every nation has the responsibility to conduct its economy without causing damage to its ecological base or to other nations.

8.8.3. *Individual Responsibilities*

The planet is experienced on a smaller frame of reference than global unity or nations; people live on the local level. Local knowledge is knowledge in place, earned in place by generations of inhabitants, through visions and trials, experience, and stories. Thus, individuals are preserved in societies that are preserved in places that are preserved by individuals and societies. Laws, politics, architecture, sports are things of place. They are shaped with local knowledge. A local area is limited by the limits of vision, a horizon. The UN is part of a trilogy of an international government, separate nations, and individuals. Each part has rights and responsibilities. The individual is the basis of decision. Each individual has responsibilities that cannot be evaded or given away.

To Cultivate the Self. Each individual is responsible for her body, for her health, for the direction of her education. An individual can achieve self-realization through participation in place, that is, home. Education is a life-long project, involving the investigation of and respect for other points of view.

To Find Good, Meaningful Work (Buddha's right labor). One should choose work that is interesting and positive, using proper technology and recycling waste. Work should be respectful of resources, foster a cooperative approach to economic problems, and promote self-help and self-sufficiency.

To Practice Simplicity. One should share with others, practice stewardship of domestic landscapes, and be frugal. Simplicity also involves not interfering with self-governing nature (in general) and not imposing one's personal morality on others. Physical enjoyment and cultivation of the inner life are valuable.

To Share in Governing Process. One should get involved in government and change, focus on political effort. Everyone should work to decentralize and debureaucratize institutions; work to make laws to equalize representation; work to create new goals and purposes for society; and offer services to others, by volunteering for civic groups and challenging discrimination and prejudice.

And, to be Peaceful. Practice nonviolence (Gandhi's lesson) towards people and towards the ecosphere. One should be vigilant against military intervention, practice conciliation, and resolve differences face to face. Individuals could try to deinstitutionalize legal confrontations.

8.8.4. *Considering a Realistic Argument*

For most people in agrarian countries, even freedom from hunger and sickness is utopian. For most people in industrial countries, the choice of a fulfilling profession is utopian. Grinding poverty, economic dislocation, homelessness, are more painful than a transformation to a new global order would be. Already most cultures have been transformed by cash crops, mining, tourists, highways, high-rise housing, and condominiums. Physical disruption has been more extensive than the transition to a UN-directed order could cause.

Industrial cultures have replaced older patterns with great suddenness. The new UN cannot seem more sudden than the loss of a home or place. Industrial cultures have reduced people's control over the means of production and power. The new UN does not offer less control. Whole communities have been destroyed by industrial scale. Our social structures are already changing rapidly and impractically. Let us just make the changes conscious and more practical. The UN offers movement towards common, achievable goals. The UN is a framework for cultures, where different human experiments are tried. Its variability would insure that we could reject any of the local visions that fail.

There will be questions regarding the breakup into more natural cultural divisions. Some will want to decide boundaries by ecosystem; others through culture, watershed, or political power. The UN will have to decide when two groups claim the same place or when cultures combine through unions and conspiracies.

There will continue to be problems. Cutting trees in Nepal causes floods in Bangladesh, and floods cause deaths because overcrowding has forced the poorest people to live on flood plains. The poor in the highlands everywhere effect those in lowlands, often adversely. The quest for ecological balance means that some ecosystems must be maintained by systems managers, who often overmanage. The larger the human impact, the more control is necessary. The UN seeks to improve people's circumstances by enlisting them to save their environment, their way of life.

People cannot be given material equality instantly. But things can be leveled within a culture; cultures with excess may be taxed by the United Nations. Providing work for everyone is one way to narrow income differences. The UN, communities, and families must provide it. Worthwhile work requires imagination. The large work force employed by military contracts in industrial countries will be dislocated at first, but that employment is supported by taxes, which could be reallocated for construction and deconstruction of the many highways and manufacturing plants and abandoned buildings.

Crime and civic unrest will not disappear. The UN and nations could reduce many kinds of global and victimless crimes with new policies. Because most cultures have strong policies regarding drugs, abortion, and prostitution, among other things, the UN would not impose rules on every crime. Dangerous weapons, from automatic guns to tanks, and dangerous products, including nuclear reactors and biocides, would be strictly regulated.

People will still choose badly in Eutopias. If a form of government is bad or ineffective, they can alter it. In the UN framework, they can learn from mistakes or unintended side-effects-as when doing good causes evil. The scale is small, so the catastrophe is small. There will always be some injustice, inadequacy, and unpredictability. Large political and economic institutions have only made it worse. If the UN turns out not to be the proper framework to solve these problems, it might lead to a better way.

People may object to giving up too much or not gaining enough. The UN may be called anti-human, anti-progress, anti-scientific, anti-technological, or anti-educational, but it is merely a new framework for conducting traditional human activities. Natural environments and human societies are wobbling. Opposite impulses are leading to unbalance; some countries want to consolidate into economic powers and others want to secede into independent units. Human civilization will tear itself apart unless we slow it down and direct it.

The need to maintain our comfortable status for as long as possible, fatalism that nothing can be done or it is too late, prejudice, ignorance—all are keeping us from moving. There are other reasons not to move: Failure of knowledge, failure of communication, failure of imagination, and failure of nerve. Much human suffering is caused by self-deception, which leads to isolation and then anger, reaction, and more suffering. Real change is difficult in this state, but change is more difficult for people who are starving or oppressed.

Human ills cannot be cured by a return to idyllic hunting and gathering groups or to a quasi-agricultural, ecologically-caring society. There is no possibility of complete return. Most industrial nations are urban; agricultural countries pack their surplus peoples in cities. Nor can there be a return to 4th century B.C. Greece, or to 17th century China, or to 1910 France, or to any time. Many traditional cultures no longer exist; others are disintegrating under pressure from industrial cultures. Nor can there be a jump to a complete technological future, where technology transforms hydrogen into wealth for everyone.

The UN works with traditional cultures and realistic planning. Detailed planning of complex open systems is not necessary. Planners are not in a position to attempt detailed models of future situations because many relevant parameters remain unidentified, and many of those known cannot be quantified. Plans can be made within the limits of variables, although it is not safe to be limited by lethal variables, as Gregory Bateson recognized; closeness to limits reduces flexibility, that is, uncommitted potential for change. The very potential we need to keep developing rather than using.

To minimize untested conclusions, the UN is based on the values and forms of traditional cultures. Rational planning can catch up as it develops. The framework is an open, flexible, and partially-planned global relation, instead of a finished, closed, completely-planned society, as imagined in utopias. The UN accepts the imperfect nature of humans and the changing ambiguity of nature. The UN detoxifies cultural rivalries. Racism, sexism, ageism, and speciesism lose their importance in a cooperative society of advanced communication, automation, equality, humane scale, and meaningful preservation.

The empowered UN addresses the inadequacies of the present system; it offers a drastic system change from the institutional gridlock of elitism, but the change is not so drastic that the feasibility of acceptance is too low. The benefits must be worthwhile to justify the costs. The benefits cannot be vague and unsatisfying when the costs are immediate and painful. Communication and education must prove that the benefits exist, so that the alternative can be called. It must be a participatory movement, and it must appeal to a large segment of the total human society. Since not all interests will be satisfied, there must be opportunities for transformations or for alternate paths.

We have to invest and cultivate our inheritance. We must enlarge our human identity, to include other beings and the earth, to include our own posterity and its image of the future, without which we lose the will and capacity to solve problems. Creating the future is necessary to maintain the present. It is meaningful to construct a world that we will never live to see, to plant trees that take two hundred years to mature, to save some of the forests and soils—not for the oil and timber elite or even for the backpacking elite, not for social abstractions or for personal profit, but for our heirs and other beings that share the planet.

Science presents us with too many facts, yet we crave to have more. Philosophy presents us with too many values, but we have too few. Technology presents us with too many things, but we do not know what we need. We do not need more information or rules, but we need meaningful ideas. Our attitudes and feelings toward nature need to be revitalized with evocative metaphors that let us accept responsibility for the part of the earth that we build, namely human culture and human landscapes.

The truths of our unique cultures and the wild earth are apprehended through myths. The poetic language of mythology can fit all the facts and values, things and images, into our hearts so that we can feel them and act upon them—so that we can make good places. An empowered UN can provide the order to accomplish this.

8.8.5. *Eutopian Actions at All Levels*

Utopias are the inventions of great visions; Eutopias are the inventions of small, good actions—perhaps later there will be enough time for greatness. Where utopias offer revelations promising a desired future, Eutopias offers limited references for improving our situation now. There is no mechanical prescription for making good places; there is no blueprint or timetable. This work is not a presentation of another utopia—it is a comprehensive vision including political, social, and economic principles, as well as psychological, architectural, and ecological ones, not usually included in utopias. No details of societies are presented here; there is no description of a new consciousness or a new elite. It is an outline of a framework for the creation of good places in times of catastrophe.

8.8.5.1. Acquire an Attitude for Catastrophe

Catastrophe has its own psychology. Humankind possesses incredible scientific evidence of environmental wobble, biological imbalances, and the unfitness of many domestic species, but knowledge moves few to action. Catastrophes, on the other hand, concentrate attention forcefully. When a dam breaks, millions of people mobilize to meet the emergency. When the earth quakes or volcanoes erupt, the emergencies are met quickly. The psychological effects of a hurricane—fear of suffering and dread of loss, accompanied by exhilaration—have admirable side-effects; the definiteness of danger and the immediacy arouse women, men, and children to great heights of cooperation. People react admirably to catastrophe. They choose sensible directions and agree to practical expedients. War also produces relatively fast, far-sighted—if wrong-headed—policies. War is actually stimulating to many individuals and often produces a national determination and purpose that peacetime does not. War unites whole peoples in a common cause. There are times when human beings face rapid and catastrophic change without chaos. Cultures can adjust with popular reasons.

Immediate foreknowledge provokes a greater response than indefinite expectations: hurricanes occur periodically, but not always in the next three hours. Probably nothing will be done until catastrophes become common experiences. As choices become more important, more urgent, errors are more disastrous. It should not take catastrophes to precipitate corrective measures. There are millions of people starving every month in India and Africa, and others in Europe, the Pacific, and the Americas. This is a catastrophe, although it is slow, constant, and distant, and perhaps because of that, it is neglected. Perhaps distance limits the ability of people to react to problems.

Furthermore, whole species are disappearing, and whole ecosystems are wobbling, from exploitation, desertification, and pollution. Environmental deterioration proceeds so slowly that the change is invisible, that is, until a catastrophic threshold is crossed. Those catastrophes, in places from the Tigris and Euphrates to northern Africa, seem to be long-term. The trouble with complex, self-regulating systems is that very small changes have large consequences—shifted rainfall patterns caused whole cultures to disappear. In some cases, where conditions, like drought, are cyclic, in the Sahel region of Africa, humans expand during the good times, only to perish when the drought returns. In other cases, human activities, such as deforestation or overgrazing of herds, can cause climatic changes. The scale and rate makes our situation seem natural, but that is because it has been a slow catastrophe, just now approaching the threshold.

If we could precipitate a disaster psychology for slow environmental catastrophes, then the priorities and motives of people might be changed. But how should everyone be convinced that there is a crisis? The change is so slow: fewer eagles, fewer salmon, more people, more beverage cans. The causes are so complex, and responsibility is so difficult to assign. Unfortunately, a history or theory of catastrophes does not engage us. People need to feel situations before they act, and people will need to feel themselves as part of a delicate web of relationships before they act with ecological wisdom, as once they had to feel that the earth was round by going around it, as lately they had to see that the earth was an oasis in space by leaving it. Random, uncontrollable fate or slow, inexorable degradation causes little anxiety.

Humanity is enormously adaptable and resilient We can probably survive most physical or social conditions by adjusting to them; for example, overcrowding and smog are acceptable in some areas. But adaptation has its own dangers. We might become less humane, less creative, less concerned with starvation, suffering, crowding, or destruction. Our goal should not be to survive under any conditions, however difficult and unpleasant. Our goal should be to create an optimal life in an optimal environment. We need to adapt consciously to slow catastrophes. The environment is changing too fast for genetic adaptation, so our change will have to be psychological and social. Social changes can occur very rapidly when the time is right for them. Oil-producing nations, for instance, became financial equals of industrial countries within months. Pressures are building for radical change.

8.8.5.2. Act Immediately

A eutopian framework could be implemented immediately. Most global studies state or imply that change cannot be fast, that people cannot adjust, that social disruption would result, and that chaos would finish what ignorance and technology could not. Their most serious drawback is the time of implementation. The first Club of Rome report claims a 20-year feedback lag. *The Ecologist* plan cites a social inability to adapt to rapid change; the attempt would be self-defeating. Everyone assumes the time scale remaining before collapse will be long enough for their plans to be implemented. But these studies also propose slow, long-range plans, while warning at the same time that the earth is facing imminent, drastic change. If their plans are implemented too slowly, and if the population or pollution doubles again, surpassing some unrecognized critical level, there would be worse disruption.

A long view seems meaningless when so much suffering already exists. An immediate, realistic, coordinated program of action is needed, capable of being implemented by communities and global agencies. We must face our responsibilities directly, declaring that there is no place in a eutopian society for monopolistic and multinational corporations, for the maniacal religion of merchandise, for genocidal military establishments, for urban explosion, for state socialism, for overbearing bureaucracies, or for technocratic politics, we must act to end them. The declaration must be political, through cooperative networks or leaderless consensus, by persuasion and example. The problem of human existence on the planet must be approached without deference to artificial boundaries of states, races, or castes. Poverty, pollution, repression, are concerns of every human community. We must stand and state that nature has limits, that we cannot have all we want.

The application must be immediate. The crisis of exponential growth and destruction cannot be solved just after some final limit is approached or passed. The crisis of ignorance cannot be solved by hurrying ahead and creating more problems. Paradoxically, the best thing to do is stop—stop growing, stop producing, stop running; suspend the race and contemplate a direction. We have been asking how the earth will survive its human populations and how they can be lowered. Let us just freeze growth and see what happens. Let us just freeze the populations—a year or decade of no births. We know that whole countries have lost a generation and continued. We know they have rebuilt again from ruins. We could build from recycled materials alone, so there is nothing to fear from stopping. Immediate social reforms, the reallocation of resources, and the preservation of wilderness are necessary, because of the nature of the problem; we cannot predict global climatic or ecosystemic catastrophes. Substantive change and research cannot be delayed until academic controversies are resolved.

8.8.5.3. Implement Catastrophic Measures

The United Nations promotes a year of consideration. Starting with population growth, all growth would be suspended. Earth parks, in the Antarctic, Amazon, Arctic, Oceanic areas would be declared immediately. Ecosystem restoration would be begun; massive planting efforts are undertaken. No further expansions are permitted for development in wetlands or other sensitive areas. Destructive searches for resources are suspended, in favor of substitution and recycling. No new building is encouraged until uninhabited ones are restored.

8.8.5.4. Do it All at Once

The transformation must be complete; it cannot be done partially. Global political and economic institutions must all be changed. The United Nations must have authority for the preservation of nature and human cultures. Holistic change will permit the reorientation and balance of local institutions. For example, air pollution is not independent of industrial processes, transportation, and employment patterns. Communities must be of a size that their members can feel responsible for them. These changes are demanded by new situations, ecological balance primarily among them. New institutions must be compatible with these new values.

The approach must be pragmatic and flexible. By its nature, the eutopian frame could reduce some of the stresses of transition, the uncertainty, ambivalence, or reversion. The readjustment to the realities of our new intricate involvement in the whole order of nature and her ecological balance will cause social swains. Some capital of energy and materials may be wasted. Population will be matched to solar budgets or net ecosystem productivities. Production will be redirected to communal needs in transportation, housing, food, and recreation.

For most people in agrarian countries, even freedom from hunger and sickness is utopian. For most people in industrial countries, the choice of a fulfilling profession is utopian. Grinding poverty, economic dislocation, homelessness, are more painful than a transformation to Eutopias. Already most cultures have been transformed by cash crops, mining, tourists, highways, high-rise housing, and condominiums. Physical disruption has been more extensive than the transition to Eutopias could cause.

Industrial cultures have replaced older patterns with great suddenness. Eutopias cannot seem more sudden than the loss of a home or place. Industrial cultures have reduced people's control over the means of production and power. Eutopias does not offer less control. Whole communities have been destroyed by industrial scale. Our social structures are already changing rapidly and impractically. Let us just make the changes conscious and more practical. Eutopias offers movement towards common, achievable goals. Eutopias would be a framework for cultures, where different human experiments are tried. Its variability would insure that we could reject any of the local visions that fail.

There will be questions regarding the breakup into more natural cultural divisions, if we adapt a decentralized design. Some peoples will want to decide boundaries by ecosystem; others through culture, watershed, or political power. The United Nations will have to decide when two groups claim the same place or when cultures combine through unions and conspiracies.

There will continue to be problems. Cutting trees in Nepal causes floods in Bangladesh, and floods cause deaths because overcrowding has forced the poorest people to live on flood plains. The poor in the highlands everywhere effect those in lowlands, often adversely. The quest for ecological balance means that some ecosystems must be maintained by systems managers, who often overmanage. The larger the human impact, the more control is necessary. Eutopias seeks to improve people's circumstances by enlisting them to save their own environment and way of life at the local level.

People cannot be given material equality instantly. But things can be begun to be leveled within a culture; cultures with excess may be taxed by the United Nations. Providing work for everyone is one way to narrow income differences. The UN, nations, communities, and families must provide it. Worthwhile work requires imagination. The large work force employed by military contracts in industrial countries win be dislocated at first, but that employment is supported by taxes, which could be reallocated for construction and deconstruction—so many highways and manufacturing plants and abandoned buildings.

Crime and civic unrest will not disappear. The United Nations and nations could reduce many kinds of global and victimless crimes with new policies. Because most cultures have strong policies regarding drugs, abortion, and prostitution, among other things, the UN would not impose rules on every crime. Dangerous weapons, automatic guns and tanks, and dangerous products, including nuclear reactors and biocides, would be strictly regulated.

People will still choose badly in Eutopias. If a form of government is bad or ineffective, they can alter it. In the eutopian framework, they can learn from mistakes or unintended side-effects-as when doing good causes evil. The scale is small, so the catastrophe is small. There will always be some injustice, inadequacy, and unpredictability. Large political and economic institutions have only made it worse. If Eutopias turns out not to be the proper framework to solve these problems, it might lead to a better way.

People may object to giving up too much or not gaining enough. Eutopias may be called anti-human, anti-progress, anti-scientific, anti-technological, or anti-educational, but it is merely a new framework for conducting traditional human activities. Natural environments and human societies are wobbling. Opposites impulses are leading to unbalance; some countries want to consolidate into economic powers and others want to secede into independent units. Human civilization will tear itself apart if we let it. We can slow it down and direct it.

Taking these steps would solve many of the problems addressed earlier. The satisfaction of physical and cultural needs, as a result of living in stable and small societies, would contribute to the health of people. Fitting economic costs and needs to the limits of ecosystems and monitoring the economic process would reduce wastes and pressures on natural processes. The coupling of agricultural productivity to a solar budget, and the conscious restoration of degraded systems, would contribute to the health of ecosystems. Sufficient wilderness would allow the self-maintenance of global cycles. With the increase in security, wealth, and self-esteem, human populations could be dependent on ecosystem productivities and still be diverse and unique.

With the removal of war capabilities and the equalization of wealth, the remaining issues are not the kind to incite violent passions. Disagreements over the best way to raise wheat or maintain a forest may be more easily resolved than deciding the best nation or truest religion. The death of large-scale dogmatic ideology and national idolatry could also mean the end of organized slaughter. We have to perfect the art of resolving conflict. Mastering it through social debate would free unprecedented resources to satisfy social needs. Perhaps a planetary electronic referendum would open communication. In designing the planet, everyone can participate. We can reduce the violence to nature and ourselves and transmute it to debate. That which has been hitherto left unsaid-what we want to become, what we could become-could become explicit.

Human ills cannot be cured by a return to idyllic hunting and gathering groups or to a quasi-agricultural, ecologically-caring society. There is no possibility of complete return. Most industrial nations are urban; agricultural countries pack their surplus peoples in cities. Nor can there be a return to 4th century B.C. Greece, or to 17th century China, or to 1910 France, or to any time. Many traditional cultures no longer exist; others are disintegrating under pressure from industrial cultures. Nor can there be a jump to a complete technological future, where technology transforms hydrogen into wealth for everyone. Eutopias works with traditional cultures and realistic planning.

Detailed designing and planning of complex open systems is not necessary. Designers or planners are not in a position to attempt detailed models of future situations because many relevant parameters remain unidentified, and many of those known cannot be quantified. Plans can be made within the limits of variables, although it is not safe to be limited by lethal variables, as Gregory Bateson recognized; closeness to limits reduces flexibility, that is, uncommitted potential for change. To minimize untested conclusions, Eutopias is based on the values and forms of traditional cultures. This could allow rational planning to catch up.

The eutopian framework is an open, flexible, and partially-planned global relation, instead of a finished, closed, completely-planned society, as imagined in utopias. Eutopias accepts the imperfect nature of humans and the changing ambiguity of nature. Eutopias detoxifies cultural rivalries. Racism, sexism, ageism, and speciesism lose their importance in a cooperative society of advanced communication, automation, equality, humane scale, and meaningful preservation.

Eutopias addresses the inadequacies of the present system; it offers a drastic system change from the institutional gridlock of elitism, but the change is not so drastic that the feasibility of acceptance is too low. The benefits must be worthwhile to justify the costs. The benefits cannot be vague and unsatisfying when the costs are immediate and painful. Communication and education must prove that the benefits exist, so that the eutopian alternative can be called. It must be a participatory movement, and it must appeal to a large segment of the total human society. Since not all interests will be satisfied, there must be opportunities for transformations or for alternate paths.

We have to invest and cultivate our inheritance. We must enlarge our human identity, to include other beings and the earth, to include our own posterity and its image of the future, without which we lose the will and capacity to solve problems. Creating goals for and images of the future is necessary to maintain the present. It is meaningful to construct a world that we will never live to see, to plant trees that take two hundred years to mature, to save some of the forests and soils—not for the oil and timber elite or even for the backpacking elite, not for social abstractions or for personal profit, but for our heirs, for them to see and decide to save or use.

Now is the time to define goals in terms of population, quality of life, and preservation of biomes. Resolving conflict through social debate would free unprecedented resources to satisfy social needs. That which has been hitherto left unsaid—the goals of humanity-could become explicit. Goals are not some final state reached once and for all time, but a horizon. Eutopias offers continuity between goals, designs, and practical implementations.

Science presents us with too many facts, yet we crave to have more. Philosophy presents us with too many values, but we hold too few. Technology presents us with too many things, but we do not know what we really need. There may be too many futures to choose from, but we can limit them to three possibilities: The fake ones, with amenities for some and cute lodges in tame wildernesses surrounded by wastes; the technical ones, with a real fenced-in wilderness, and some kind of technological scheme of a world city; and a eutopian one, based on cultural wisdom, traditional forms and an ecological sensitivity.

We should not underestimate the evolutionary potential of small cultures. We can afford to 'lose control' of other cultures, to allow their variability and experimentation. We do not need more information or rules, but we need meaningful ideas. Our attitudes and feelings toward nature need to be revitalized with evocative metaphors that let us accept responsibility for the part of the earth that we build, namely human culture and human landscapes. In order to know what is important and what is valuable, we need wisdom.

We can start by listening to the pragmatic wisdom of the whole planetary system, with its billions of years of running itself. We can let it organize and evolve itself to create diversity and uniformity, work and beauty.

Wisdom begins with knowledge of the larger interactive system, which if disturbed, can generate exponential curves of change. Wisdom is the recognition of and guidance by a knowledge of the total system. Lacking wisdom, we must behave "as if" we were wise, as if we had good sense (after the ideas of Hans Vaihinger and Jonas Salk). Humans have no choice but to live by fictions, as if this world is the ultimate reality, as if we are responsible for our actions. Humanity must plan for its future as if its days were not counted (or at least for several thousand years). Wisdom is a new kind of fitness. To survive, we must accommodate ourselves to the conditions of the earth.

Wisdom can be redefined as the disciplined use of the imagination with respect to alternatives, exercised at the right time and in the right measure. But we need practical wisdom, prudence, and intellectual control in virtue, in place of the theoretical wisdom taught by schools. The truths of our unique cultures and the wild earth are apprehended through myths. The poetic language of mythology can fit all the facts and values, things and images, into our hearts so that we can feel them and act upon them—so that we can make good places.

Figure 887-1. Merv Wilkinson's Wildwood Forest in Canada 1994

8.9. ***Wisdom & Action: Do Wisely, Do Now!***

Historically, we humans have used our skills and images to improve our lives and places. We have used our inventiveness to increase our ability to survive and to reproduce, as well as for our comfort and wealth. We have persevered despite many challenges and problems that have killed or impoverished many people or whole cultures at times. We have survived ecosystem collapses and cultural collapses. We have survived droughts and freezes. We have survived diseases and wars of conquest.

We have used tools to changes places and some of the processes of nature. We have used technologies to protect our plants from insects and our towns from invasion. We have created the possibilities of unprecedented luxuries and wealth. We have made designs for stimulation or profit, more than for safety or elegance.

But, we have failed to understand much of the detail and scale of nature. We have failed to use our imaginations for things beyond luxury or excitement. We have failed to share new wealth with most others or to share much of the planet with ultrahuman beings. We have failed to create designs that would incorporate us within the limits and cycles of ecological processes. We have failed to have the nerve or courage to try, since it would inconvenience some or disrupt the wealth of a few.

We have the conceptual tools. We have religions that bind us to cultures and places—that teach us simplicity and charity. We have sciences that allow us to learn ever more about ourselves and nature—that teach us. We have words and metaphors that can produce strong flexible images to guide our learning and decisions. We have the ability to create thought experiments and fundamental analyses of problems and catastrophic situations. We have the creativity to make ecological designs on a regional and global scale, to protect the ecological services that result from a living planet. We have the ability to expand our consciousness to include an ecological perspective of our situation. We have the possibility to share and open ourselves in a eutopian effort to balance the use of a common planet.

But, we have been seduced by our brilliance. We have become trapped by the changes we made to eating and living—by our close adaptations to agriculture and cities. We have become too comfortable in our habits and pleasures. We have allowed growth and inequity, dominance and slavery, to continue because it has become part of our perceived patterns of economic success. We have allowed intolerance, conflict and war to continue because they are perceived as unavoidable products of our success.

8.9.1. *Humility & Wildness*

Now, we are beginning to recognize that the scale of problems has become regional and global. We intuit that our economic styles, expanded to a global level, may not be healthy or sustainable. We allow corporations to enjoy unprecedented benefits from a minimum of regulations, because we think that they are necessary to continue the growth we think we need to be prosperous and happy. We start to question whether our modern cosmology—in the image of a machine—is appropriate to understand or relate to living beings, systems, and cycles. We are starting to realize that traditional and archaic cultures were more attuned to their ecological places, and to suggested limits that allowed them to fit into their surrounding ecosystems. We are beginning to realize that the scale of our changes is affecting the atmosphere and oceans, that we are making things change out of the range of desirable conditions. We worry that the entire planet is wobbling and fragile and could change into a configuration that is not pleasant for us or for the large charismatic mammals we love—from polar bears and whales to tigers and wolves. Maybe, Gaia will turn out to be the kind of wicked mother who may not favor human children above other children, or mammals above insects or reptiles.

We have started to save animals and plants, species and habitats. We have started to design ecovillages and more efficient automobiles. We have started to create standards for more intelligent buildings and roads. We have started to talk about and sketch whole communities or cities that may fit into specific places.

But, we are not thinking about all cities or all roads, not the planetary patterns that overwhelm places and movements of species. We are not paying attention to changes in scale or meaning. We are not considering some kind of economic equalization or the limits to our economic growth. We are not saving entire systems.

We need to understand the spheres and cycles of a living planet. Then we need to start to redesign our activities so that they are in line with these cycles. We need to identify areas to preserve or restore as wilderness, by making sure that they are the right shape and size to continue as self-making entities. We especially need to consider forests and many kinds of animals. We need to understand the factors that may act as triggers of change: Our conversion of ecosystems into domestic lands, the use of commons, or the scale of industrial manufacturing. We need to analyze our adaptive patterns, from agriculture and technology to urbanization and industrialization, and then understand how they developed and became dominant forms of exploitation of places and systems. Then we need to redesign them for the appropriate local or global scales. We need to design ecological cultures based on archaic one, without giving up the benefits of some urban civilizations.

We need to rethink design, to make it ecological and global. We need to apply ecological design to local ecosystems, whether forests and streams or cities and fields. We need to consider the design of regional areas, from common areas that are used for many cultures, and where natural processes, migrations, and exploitations are allowed to continue. We need to design areas that are independent of national boundaries, where animals and plants can migrate or move freely.

We need to rethink culture, to analyze the weaknesses and strengths of traditional cultures. We need to create a framework to fit cultures with the limits of human activity as well as within the limits of ecosystems and regions. We need to redesign economics and politics through an understanding of what their functions and goals really are. We need to create adequate legal forms for nations and nonhuman nations and the planet. We need to approach the planet through one framework of decisions, a framework based on understanding and shared goals.

We need a wild design to solve these large global wicked problems. We need to be surveying and monitoring so we know enough to design and act. We need to be preserving and restoring as much as we think the planet needs. We need a wild design that is based on traditional wisdom and known operating limits to address these problems all at once. We need a wild design to actually try to create good places using all of our geniuses and strategies over the whole of the planet. We need to do it together and we need to do it now!

8.9.2. *Advertising & Excitement*

Most of all, we need to make design and ecology exciting. The other day, tired of writing, I went to visit friends, who were watching a football game. They were drinking, shouting and throwing things to each other. It was nice; I got to play for a while, too. It occurred to me that only with entertainment industries is there so much technical fireworks and coordinated enthusiastic teamwork. Imagine all that energy and enthusiasm directed to appropriate technology for reforestation or the proper use of fossil fuels. Imagine television coverage of wetland restoration work with the same amount of attention and detail. Why not have a competition for the most beautiful productive forest or teams working to restore devastated city areas—broadcast by a major network as an important event?

Some people have noticed that this remorseless entertainment is an anesthetic against fear, emptiness, self-searching, or death. Continuous entertainment is a kind of guarantee of health, riches, and long-life. Everything that is pleasurable, thought George Orwell, seems to be an attempt to destroy consciousness. Television seems intent on proving him correct. Ecology or design cannot ever compete with entertainment if it raises troubling questions or difficult expectations. As long as the industry can guarantee many happiness and wealth through the arithmetic of fantasy, others of us will always seem to be complainers and false prophets—until it's too late, and then it is likely to be we who will be blamed for not avoiding the catastrophes.

Good design, good ecology, ecological design, and global designs require new images and new language. Getting new images and new language to engineers, politicians, financiers, and landowners, as well as to scientists and industrialists, is problematic. Perhaps poetry, art and design can help, although they are undervalued as forms of communication, not to mention as ways of shaping and making. Business has transformed much of art and poetry into advertising, to match the style and attention span of the people in industrial cultures. Advertising, quite literally from the Wall Street Journal to college textbooks, refers to its activities as "shaping the American dream" or the World Dream. Like art, advertising creates an image of a way of experiencing. Unlike art, it limits its focus for a specific goal—profit. Like art, it mirrors us. Unlike art, it intensifies and glorifies only the positive aspects of culture, ignoring the dark, negative aspects or the complex nonhuman framework.

The simplicity of advertising is irresistible. Our environment deteriorates according to ecologists, but always improves according to economists (who require it to improve to make a profit). And their pictures are much prettier. People want to hear that it is getting better. Advertising tells them it is. People want to act stupid, greedy, and selfish, and spend the inheritance of their children on themselves. Advertising tells them these actions are rewarded. The real issues of life and death, destruction and hope, make people feel helpless and anxious, so advertising draws their consciousness to comfortable trivia.

Despite the limits of the dreams of progress and growth, of waste and stylistic frenzy, advertising, using sophisticated techniques and narrowing the focus out of context, makes the dreams desirable and irresistible. People in agricultural and hunting cultures interiorize the abstract industrial vision. African farmers are convinced to buy inorganic fertilizers, even though it degrades the soil; women to buy powdered milk for their children, even if it kills them; tractors replace draft animals in the paddies in the Philippines, even though they are costly and less energy-efficient; French winter fashions are found desirable in tropical Brazil, even if they can only be worn in air-conditioned villas. People in industrial societies are convinced that their children will be ruined without personal computers, even if they become isolated game-players, unconcerned with wildness in remote locations.

Advertising has been serving the dream of progress, but progress is leading to catastrophe, a long, slow, global catastrophe. When people experience local, sudden catastrophe, they usually respond immediately, with heroism and sacrifice, aiding the victims of earthquakes or floods, or sometimes famines. Advertising could bring to consciousness the slow catastrophes of erosion and the destruction of entire forests, and, perhaps, invoke the same altruistic responses to them.

Advertising may be the most effective means to reshape desires and reform buying habits, as well as where and how we live. Advertising presents the symbols of modern experience effectively, even if they are just the trivial ones. It could present healthy symbols equally well. Advertising does incorporate traditional values, like family, friendship, and love, although to sell beer and cereal and, sometimes, churches and hospitals. And, like art, advertising lies, although Jules Henry thought it might be a new kind of truth—"pecuniary pseudo-truth"—not intended to be believed, or certainly, proved).

Advertising is beginning to support more informational functions, such as the dangers of drug abuse and smoking. Advertising also can create values—fur coats, fast cars, dark beer, slim cigarettes are certainly recent and artificial values—but it could be used to create positive ecological values and new identities that show that our needs for prestige, esteem, and belonging can be met without stylistic waste at mindless speeds. Advertising could promote new attitudes about appropriate technology, the rights of other cultures, and the place of people in nature. Good advertising could be as subversive and conservative as design or ecology (Pablo Picasso said art was subversive; Paul Shepard called ecology subversive). Good ecological advertising could avoid confrontation with people's values and emphasize positive aspects without negative ones. A good ad could capture and carry the most self-indulgent viewer—after all, for the most part, ads don't require effort, literacy, or consciousness, just attention.

Maybe we can present images that rival the industry images. Maybe we too can speak the languages of euphemism that large corporations use to conduct their businesses of larceny and fraud. Positive images and pleasing language skills are everything these days; no one really looks for substance. The devotion to money, beauty and youth is the old focus. Maybe that could be subverted with the beauty and wealth of nature.

To work towards this goal, ecological design groups, with conservation groups, preservationists, sportspersons, politicians, and actors, could define and promote an integrative mythology as the basis for the framework of diverse efforts to protect life and the environment in the whole planet. Ecological organizations could provide a meaningful philosophical foundation, as well as coordination for other humane, social, and conservation programs. But, the approach must be egalitarian: Respect for life cannot neglect human life and suffering. The approach must be eutopian: A new cosmology cannot ignore adaptive cultural traditions that arose in place over centuries. Furthermore, in addition to formal education, groups could fund and provide re-education through the most effective means, such as advertising. Wildlife groups could spend money advertising "humane consciousness," moderation, and the joy of living—instead of just consuming or winning. Ecological design ads would be unique and compelling, simple and effective. They could present our goals and successes, the importance of our efforts to redesign out human structures to protect and restore the planet. They would advertise not a product, but a way, not for a profit, but for a dream. And, we have to start now!

8.9.3. *Learning to Love a Planet?*

Do we start by loving the planet? Obviously, we can love ourselves and families and friends, even other animals and plants, but is it meaningful to say that we love the planet? Is it some sense of topophilia, or biophilia, or ecophilia? Are those labels too abstract? Perhaps we can understand them philosophically, historically or ecologically.

Early foragers became one with the animal hunted or seeds collected, to realize that they became part of you, living through you. On the other hand, when the relevant social unit was the tribe or nation, it was possible for the local mythology to represent others outside the bounds as inferior and its local inflection of the universal heritage of mythical imagery as the one, true, supreme image. The young of the group would be trained to love home and hate outsiders. Xenophobia was once adaptive; now it is anachronistic. But there are no outsiders, we are all passengers, inhabitants. All dividing horizons on the planet have been vaporized. We cannot hold our loves at home and project hatred outward.

The concept of tribe and state is growing toward an ecumene, an inhabited earth. Today, there is no outward on earth. Our mythology has to grow also, to include the whole planet. There is no practical elsewhere anymore. A global mythology cannot afford to teach of elsewheres. It must teach of a multiplicity of cosmologies. The difference between cosmologies is not due to the number of phenomena taken into account; it is due to the difference in basic postulates of thought. The difference is not a matter of truth or falsity. Truth and falsity are meaningless for cosmologies. Primordial water is no less true than six-dimensional phase space or primordial ylem. No one group's image is more true or accurate than any other's. Each group views and reconstructs the world through their experiences and values.

During the Renaissance, Christianity became affected by the spirit of affirmation, especially with the discovery and popularization of the teachings of the Stoic and Epicurean schools: Love of man was the virtue above all virtues. Albert Schweitzer believed that even if we despaired of comprehending the phenomenal world or the plans of God, we would not need to confront the problem of life with utter perplexity, because the ethics of Jesus, reinforced by reason, lead to the reverence for life, whose edict is the rule of universal love. This same reason would find the bridge between love for God, love for man and love for all creatures, and express reverence for all being, however dissimilar to our own, reverence and compassion for all that is called life. Such a foundation for morality forces the realization that when we establish gradations of values between lives, we only judge them in relation to ourselves and that is wholly subjective. How are we to know the importance of each? The principle of reverence for life rejects relativism— "it recognizes as good only the preserving and benefiting of life." Individuals must transform themselves from blind men into seeing ones by following the new commandment: Revere life. The quality of personal existence depends more on it than on laws and prophets; it comprises the whole ethic of love in the deepest sense; it is the source of constant renewal for humanity.

Schweitzer's love was abstract, yet he did not love nature. Part of Schweitzer's dilemma came from the prevailing myth of the opposition of life and death, strife and love. Opposites are necessary conditions for each other.

Leopold has proposed a conservation ethic, dealing with the human relationships to land, plants and animals. The land ethic Leopold had in mind was a sense of ecological community between human and other species. When we see land as community to which we belong, we will use it with love and respect. Such an ethic would change the human role from master of earth to plain member of it. Predators are members of the community; no special interest has the right to exterminate them for the sake of benefit for itself.

The aim of an ethic must be harmonious with the world's population of living beings. Michael W. Fox proposes a biospiritual ethic as a unifying set of principles, ethics and values that will bring about a nonconflicting state of one earth, one mind. The ethic is based on the biological fact that all humans and living beings are kin and that life is spiritual—love is stronger than violence. It arises from seeing humanity in an ecological perspective (from knowledge of evolution).

Other modes of knowledge must be accommodated along side science. Roszak proposed to define true knowledge as "gnosis,"—Gnosis is used in a generic way here, not the way the Gnostics used it—of which scientific rationality is only a small part. It is gnosis that is needed to perfect the universe and soul, mutually, with the spirit of love. Gnosis is the whole spectrum: the hard, bright lines of science, the hues of art, and the dark voids of religion. Gnosis is augmentative knowledge (intuition and revelation), in contrast to the reductivity of science. Tillich calls gnosis "knowledge by participation"—and that is what humans need to do—recognize that they automatically participate in everything, and that we cannot unparticipate by choice.

The principle of reciprocity in ecology is that no entity can exist by and for itself; everything is connected to everything else. In religious terms, this is the golden rule (according to Aldous Huxley's Perennial Philosophy). Reciprocity is the recognition of mutual obligation. All things are bound in bonds of mutual dependency. Ecology has become a philosophic viewpoint as well as a systematic discipline. The counsel of ecology is caution. Caution is an expression of love. Love is treated as the basis of religious feeling.

There are pictures called anamorphoses, which are fragmentary deformities to the naked eye, but reveal perfect forms in a conic mirror. Like the mirror, culture organizes the fragments of life. The life of an individual, often won at great cost, receives its complement from culture. But the conic mirror is lost to modern cosmologies; the world is fragmented. The pieces of experience can be reconstituted by a gestalt, a perception of the total pattern. Nature, myth or love can bestow the mirror again. Nature has an inherent order. Myth creates an order. Love combines orders.

Every cosmology includes ideas of the past, present and future. An ontology of temporal process would provide a global perspective on world order, on the coming to be of higher levels of meaning in the universe as a whole. As mysticism, with its synchronal sight, regards all beings as equal, science, with its diachronal sight, regards all equal through time. A complete cosmology needs science and mysticism. The proper attitude of such a cosmology is care, by which Heidegger meant the abandonment of the neutral attitude of consciousness. Care is an attitude that moves beyond its own preoccupations towards the beings of the world. It means letting be. It means reacting spontaneously to nature; loving, fearing or fighting when appropriate.

Gregory Bateson defines wisdom as knowledge of the larger interactive system. Wisdom is a perception of relationships and relativity, an awareness of the wholeness of things without losing sight of the unique particularities. It joins the left and right brains in a union of logic, poetry and feeling. It reintegrates knowledge with values. It implies making judgments in advance, infusing elements of older wisdom into a new expression. The wisdom of cultures forms a perennial philosophy of the human race. Gary Snyder discerned an undercurrent in civilization since the late Paleolithic. He considered Buddhist Tantrism to be its finest and most modern statement: "that Mankind's mother is Nature and Nature should be tenderly respected; that man's life and destiny is growth and enlightenment in self-disciplined freedom; that the divine has been made flesh and that flesh is divine; that we not only should but do love one another . . . these values seem almost biologically essential to the survival of humanity" (in *Earth House Hold*).

Myths (with transformations) and metaphors (with structure of integrated differences) are modes for conveying ecological wisdom; they are less concerned with survival than the survival value of a good fit between dualisms of life.

But we fear to try to create a just world order, a new design for living in the planet. But, fear casts out love, and with love, goodness, beauty, truth, and intelligence, until all that remains is fear of other beings and the unknown; fear of the smiling science and technology that take away more than is given; fear of fellow human beings, who are trying to regain what was taken. But what can cast our fear? Love? Love is the problem of an animal who must find the world compelling and symbolic. We confuse our symbols with the natural world, the present with the represented. Sometimes the image of love is loved more than the actual.

Certain elements—care, responsibility, respect, and knowledge according to Eric Fromm—define a loving relationship. The inexhaustibility of a being or of our relationships constitutes much of the nature of love. Human beings are compelled to seek other beings and love is the only approach.

Maslow presents "love-knowledge" as unlimited. Love creates an openness to experience, without judgment. Beings unfold. Contradictions abound in love's completeness. Love expands the awareness of the self and other beings. And its intensification of feeling pulls the frame through the focus, yet preserves the original distance. Love binds space and time in miniature. Its intimacy permits distance. Its duration reaches future generations of beings. Love personalizes the universe, but keeps it free.

The world is a living symphonic poem. The score does not fully determine the music, the passion and intensity. The present movement gives no clue as to how it will finish. Each voice fits in with others, but is not limited. We can be aware of the symphony as a whole and the individual voices. When we are attuned to it, control is not a problem. If we can trust ourselves to improvise as the need arises, we can trust nature, and not follow some rigid plan. Every cosmology has limits, of incompleteness, indeterminacy, and of locality. Our new ecological cosmology, expressed through our intentions and designs, recognizes its limits with love, and continues to act.

8.9.4. *Brief Summary of Global Ecological Eutopian Design*

We are weak and arrogant, clever and clumsy. We ignore gigatrends and hide behind bad metaphors and the momentum of recent industrial history—and the financial size of that current human system is $55 trillion in output in 2004. We do not see the long-term, slow, invisible or other catastrophes such as extinctions and ecosystem collapses, although climate change is being noticed. We neglect to question our adaptations to past conditions, such as agriculture or cities, even as they require prodigious amounts of energy that push basic ecological systems towards collapse. We chant our desired needs for luxury, money and growth. Then, we complain that the current local and global systems have no historical or cultural analogs. Global environmental change is considered beyond our management or control, so business can continue as usual, greenwashed or not. The massive destruction of ranges by livestock are considered an unavoidable by-product of economic growth. People sliding into poverty, privation and starvation are considered acceptable losses. The failure of ecosystems and landscapes is dismissed as being less important than discovering further deposits of fossil fuels. The decline of two-thirds of planetary ecosystem services does not get mentioned in the excitement at the behavior of actors and politicians. Nothing makes us happy.

Virtually all of our actions are unsustainable in the short-term and the long-term. Human civilization is living on borrowed time and stolen assets and services. The novelty and complexity of global interactions lead to thresholds that when exceeded will trigger unwelcome surprises.

Central to this effort to outline and initiate a participatory framework is the recognition that our catastrophic situation requires immediate emergency actions on a global scale, from expanding personal consciousness to reforming the very character of human civilization and its coevolution with wild nature. First, an international organization such as the United Nations has to assume control of the planetary commons for limited utilization as well as protection. It would manage the commons in the interests of all living communities. By charging usage, extraction or loss fees for water, fossil carbon and other resources, it would become self-supporting. By international agreement, it would have the largest and only standing army, with some large-scale nonnuclear weapons (nations and communities maintaining police forces for public safety and control). It would allow all nations—even minor landless ones or business entities like corporations—to join with equal votes. It would protect traditional and modern cultures in a loose framework, encouraging cultural health related to environmental health, stressing economic equity through a variety of measures, and trying to direct the emerging global culture. Through this organization, we could consider incorporating the planet as an interested party.

This international organization, as well as nations, communities and individuals, would start to question things; to learn to apply an ecological perspective to knowledge and processes; to understand and direct trends and gigatrends; to understand fields, systems and limits; to understand flows and connections; to understand the history of the planet, especially spheres and cycles; to learn how elements and materials interact in patterns and how patterns restrain them (and how this produces uniqueness and diversity); and, to understand how communities and ecosystems work. Every person and group needs to understand how challenging events can become problems, especially with water flows on land and air and with atmospheric change; to recognize others, such as cultural collapse, earthquakes, and diseases; to face the global problems of a chaotic changing planet; and, to comprehend the limits and weaknesses of cultures, especially bad images, incomplete cosmologies, maladaptations, drift, and traps. Creating an ecological cosmology, with new metaphors and logic, is an important step.

We need to emphasize science, especially addressing systems and synthetic thought. We need to end the thoughtless, large-scale experiments on ourselves, living communities and the planet, and imagine real thought experiments. We need to reduce our massive interference with ecosystems and landscapes, especially through conversion. We need to reduce and recollect many kinds of pollution, from plastic nurdles to carbon dioxide gas. We need to rethink and rework design at every level, from personal and local to regional and global, through principles and actions, then use design to recover our tremendous losses, to save and restore wild and common areas, especially extents of forests. We need to create surveying programs to inventory places and the planet, then monitoring programs to keep informed as well as to reconnect many plant and animal patterns. Human populations should be related to ecosystem productivity, as well as to rarity and diversity, even if this means a large reduction in numbers. Failed cities should be removed or refitted. New cities should be built with psychological and ecological prospects (perhaps as arcologies). Technology could be reduced and integrated to fit needs and limits, instead of being automatic. Many predominantly technological problems, such as carbon production, fossil fuel extraction, nitrogen pumping, phosphorus loss, and pollution, can be solved through a combination of conservation and balancing. New smaller scale forms of technology can be designed using precautionary principles. Industry could be reformed as limited artificial ecosystems. Appropriate technology could be directed and certified.

We need to learn to be healthy individuals in living communities, to reduce antibiotic use and unnecessary luxuries. In fact, we need to place health in the context of ecosystems and global cycles. We need to learn to adjust to our own psychological and social limits. This means addressing problems with patterns of wealth, especially growth, inequality, poverty, dominance, and slavery. We need to link economics to ecologics, especially at the global level. We need to redefine the nature and limits of corporations, especially with new goals and community responsibilities. We have to consider the problems of intolerance, conflict and war within a frame of ecological ethics, and to reconsider the goals and responsibilities of individual nations and a global community. Failed nations and communities will have to be rebuilt, after restructuring international politics.

We have to create new surveys, inventories, monitoring and planning, not only of local resources, but of global properties, not just of the atmosphere and ocean, but of bioregions and deep continents. We have to monitor all global threats, from earthquakes to meteors.

The design of new forms of human settlements and activities can be accomplished through ecological design. We can design the entire planet as a whole. We can integrate traditional adaptive patterns, from agriculture to technology and cities, to natural processes. We can consider our civilization and planet as part of the solar system and local space. We can strengthen religions with common understanding to bind people to their places and planet. We can make politics conscious and fair, with traditional goals and limits. We can make global designs, mostly to restrain humanity and restore balances of systems, but also to coevolve with the development of natural systems. We can create a planetary framework with clearly delineated functions at each level from personal to planet, based on an integrated approach of koinomics. And, we can advertise this to everyone so they can participate. Then we, they, all of us, can say what else should be done.

Perhaps our efforts will be as naïve as continuous war, or as utopian as ecosystem destruction, but we have to make the attempt, and to continue without pause or stop. Perhaps the ideas of global commons and small nations are as unrealistic as an infinitely growing economy or as warring for peace, but we have to try new patterns. We have to promote the appreciation of places, to awaken the delicacies and qualities of designs, to plan frameworks for development, and to allow everyone to participate in creating good, personal and social designs. Each single step is easy. Each challenge can lead to an adventure. Each change will have some effect. Each vision could inspire more efforts. And, all we have to do is to start to act, now!

Figure 894-1. Logo of SynGeo ArchiGraph LLC

9.0. Appendix

In addition to a final plea, this section contains Notes that are listed by chapter. The glossary contains common words from all chapters. The bibliography combines references from the chapters. An index allows you to find specific terms on pages where they are referenced. Short biographies of the authors have been added by the authors themselves. And, there is a page listing contacts for authors and institutions.

9.1 *Addendum: Is It Too Late?*

The largest, most unimaginable part of our recent predicament is the scale of change in the past 200 years—the human 'big bang,' that is, the explosive expansion of the human economic and political systems. Based on cheap, abundant energy, in unique and high concentrations, machine power increased, and the factory system increased efficiencies and productivities, buoyed by capitalism and nationalism, and justified by the ethos of a mechanical nature and progress. All this led to the process and worship of growth, so that through positive feedback and ignorance (or greed), growth became automatic and uncritical. Human numbers increased 6-fold in 200 years, but the size of the economy increased 10 times faster than population, over 60-fold; and energy use has blossomed 80-fold. The past 2 generations has created more change than the previous 500 generations. The explosion of our big bang has propelled us past anything any human being or culture has experienced.

There are dangers from this bang: Slow catastrophes, such as extinctions and conversions (ecosystem loss) and sudden surprises, such as dead zones in the ocean or holes in the ozone layer as a result of overfertilizing (or overenergizing or overpoisoning). Other dangers, such as human ignorance of change and uncertainty, make it hard to respond to very long-term changes (as opposed to short 2, 4 or 9-year limits). We might be approaching some limit to urbanization and population growth, which could lead to a drop in complexity, because of the processes of globalization.

Why are we not responding to the challenges or catastrophes? Is it because the catastrophes are effects of our civilization, and we do not recognize them? When we do recognize them, we expect that the same mindset and tools can correct them at some later point, when it is more convenient and politically feasible. The reality of short-term elections for temporary security tends to suppress the unpleasantries of long-term problems, such as human suffering or a chaotic planet.

Our catastrophic situation requires immediate emergency actions on a global scale, from expanding personal consciousness to reforming the very character of human civilization and its coevolution with wild nature.

We can start immediately to strengthen religions with common understanding to bind people to their places and planet. We can make politics conscious and fair, with traditional goals and limits. We can make global designs, to restore balances of systems, and to coevolve with the development of natural systems. We can create a planetary framework with clearly delineated functions at each level from personal to planet, in which everyone can participate.

We have to try new patterns. We have to promote the appreciation of places, to awaken the delicacies and qualities of designs, to plan frameworks for development, and to allow everyone to participate in creating good, personal and social designs. Each single step is easy. Each challenge can lead to an adventure. Each change will have some effect. Maybe it is too late to reverse our courses, but we must act 'as if' each step can improve our situation. We must promote our visions. Each vision could inspire more coordination and redesign. And, all we have to do is to start to act, now!

9.2. *Notes*

On 0.0. This section is based on discussions with R. Buckminster Fuller 1981-1983, when he and the author were at International College, Los Angeles.

On 0.3. Arne Naess's article is a based on the transcription of an address given at the University of Alberta in Edmonton, Alberta, Canada on April 4, 1996. The transcription became an article that was published in *Environmental Network News*, May/June 1996, pages 19–20. It has been reprinted in *The Trumpeter*.

On 4.5. Twila Jacobsen and Mike Barnes section taken from their lecture on Ecoforestry, Portland, Oregon, 1998.

On 4.6. Michael W. Fox's section taken from a book in progress, *Healing Animals & the Vision of One Health,* 2007 (published in 2011).

On 6.6.4. Alan R. Drengson wrote this section for the book, 2009.

On 7.2. This section was assembled from discussions with Paolo Soleri, 1983. Part of it was published in *Pan Ecology* 1984.

On 7.7. John B. Cobb Jr. developed this section specifically for this book. The discussion that follows is based on a review of his book, *Spiritual Bankruptcy: A Prophetic Call to Action.*

On 8.8. This section is based heavily on the recommendations from an earlier book, *Eutopias: A Poetic Commonwealth of Earth*, 1970, and from a later edition, *Eutopias: Making Good Places Ecologically & Culturally*, 1984.

9.3. *Glossary*

(Found in the book *RDP: Foundations* at www.syngeo.org)

9.4. *Bibliography*

(Found in the book *RDP: Foundations* at www.syngeo.org)

9.5. *Biographies*

Michael Barnes is the principal at Cascadia Forest Goods. He was Co-Director of the Ecoforestry Institute from 1993 to 1997.

John B. Cobb, Jr. is Professor Emeritus at Claremont College, where he was the Head of the Center for Process Studies. An author of books on religion, ecology, economics, and politics, he is still contributing to many projects and movements.

Alan Drengson is Emeritus Professor of Philosophy and Adjunct Professor of Environmental Studies at the University of Victoria in Canada, where he was the former Director of Environmental Studies and also taught philosophy. He focuses on Eastern philosophy, comparative religion, environmental philosophy and cross cultural technology studies. He practices meditation disciplines related to harmony with Nature, such as Aikido. He loves wild dancing, skiing, wilderness journeying and mountaineering. He has published many articles and books (for example, *The Practice of Technology* and *Beyond Environmental Crisis*). He is the founding editor of *The Trumpeter: Journal of Ecosophy* and *Ecoforestry*.

Dr. Michael W. Fox is a veterinarian with doctoral degrees in ethology/animal behavior and medicine from the University of London, England. Spending most of his professional life in the US as an advocate for animal health, welfare and rights, he has published over 40 books and writes the syndicated newspaper column *Animal Doctor*. Please visit his web site (doctormwfox.org).

R. Buckminster Fuller was a system scientist known for his world game efforts, designs, and synergic thinking. He gave many lectures and courses around the planet.

Twila Jacobsen taught Ecological Economics at Oregon colleges. She practices it with the Mountain Grove Community, the Ecoforestry Institute (where she was Co-Director from 1993 to 1997) and Cascadia Forest Goods.

Arne Naess was Professor of Philosophy at the University of Oslo and an enthusiastic mountaineer, who tried to "think like a mountain." His thinking led him to form his own ecological philosophy, ecosophy, which inspired the movement of Deep Ecology—the belief that our concern is for all of nature equally, including humanity. He was always appreciated for his exuberant playfulness.

Paolo Soleri is the visionary architect of new, intense human spaces that fit in ecological systems. He is the founder of the first arcology, Arcosanti, and of the Cosanti Foundation. He designs Windbells and lectures around the planet.

Alan Wittbecker is an ecologist with SynGeo ArchiGraph, LLC in Florida, where he works on a variety of wildlife and communication projects. He is also an Adjunct Professor of Environmental Science at Ringling College in Sarasota.

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Twila Jacobsen: twilajac@gmail.com
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Colophon

Type: Adobe Garamond Pro, 11/14
Hardware: Mac G5, HP3310
Software: Pages, Indesign, Acrobat
Design: Rian Garcia Calusa
Editing/Graphics: Alan Wittbecker
Place: A house in Tallevast