Water and Energy, the Basis for Human Society: Are They Globally Sustainable through the 21st Century?

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Water sustains life on Earth. Energy is the basis of human civilization. The absolute number of human beings on the Earth and the rate of human-population growth establish the quality of human life on Earth.

Introduction

Suppose we want to design a system for resource management so that human beings and human civilization can survive over the next thousand years. If the only constraints are the permanent biogeochemical processes which link the major planetary systems of the planet Earth—Hydrosphere, Atmosphere, Lithosphere, and Biosphere—and that system must function and evolve so as to sustain the human species at no less than its present level of "civilization," indefinitely, what will be the design criteria for such a system?

The answer to this presumptuous but necessary question must be found.

It is our great good fortune that the human species evolved over cosmic and evolutionary time on a small planet not far from a medium-sized star in a vast, cold, and expanding universe. We are not alien residents. We were born here. We belong here. We already live on the largest inhabitable "space station" in the known universe.

Space-travel fantasies that envision our long-term ability to mimic earthlike conditions in humanmade micro-environments during generations-long interstellar voyages remain just that for now—fantasies.

We are here, on the planet Earth, now and during the foreseeable future. We must learn to acknowledge this simple fact and accept it. We must make this cosmic perception the core of our human creativity. We must learn to live within our means—the resources of our planet.

Earth—The "Blue Planet" (Weiskel, 1997a)

Discovering our place in the cosmic order is a struggle. We are slowly coming to realize that our life on Earth has been possible only because this is a "Blue Planet"—one on which the temperature range over most of its surface coincides with water in its liquid state. It is that liquid state of water that makes life—human life and all other plant and animal life—possible. Most human cultures have grasped this profound truth at some level.

Long before the development of modern science, peoples and cultures around the world recognized that all life depends on the seemingly endless cycling of water on our planet. Water determines the places we live and the quality of our lives. Perhaps that accounts for the pervasive sense of the sacred character of water in many cultures.

The problem of sustainability is therefore one of learning how to manage our human activities in the context of the larger cycles of the dynamic general system that is our planet Earth—the hydrologic cycle, the carbon cycle, the nitrogen cycle, the sulfur cycle, the phosphorus cycle, among others—all at work with the biogeochemical processes of the planet.

Sustainability

Let us stop pretending that rivers naturally flow uphill. Let us stop kidding ourselves about the ability to sustain "civilization" throughout the world in the face of continued exponential population growth. Let us stop playing the charade of continued unlimited growth and cease intoning the mantra of "more is better." Let us explore the ancient wisdom that enough is best; balance is necessary.

"Overshoot" and "collapse" are part of a well-established, long-rehearsed, and depressingly repetitive syndrome in the history of the human enterprise. It is an undeniable pattern in the affairs of human beings.

Since we have become a global and globalizing species, our last, best chance for continued survival now lies with our capacity to anticipate, dampen and stabilize this reckless, repetitive overshoot–collapse syndrome with rational countermeasures to assure that our human species will survive and continue to advance a uniquely human civilization.

In considering our future, natural resources are crucial. Water sustains individuals and useful reliable energy sustains society.

Simplistic Sustainability

All human actions whether social, political, scientific or academic that affect the human beings who inhabit Earth today and who will inhabit Earth in succeeding generations must proceed from a fundamental awareness of the basic need for "sustainability."

In classroom after classroom, from podium to podium, we hear the unceasing refrain, "Substitute consumption of non-renewable resources with wise use of renewable resources" (Weiskel, 2000). A wonderful idea if we can envision a society for human beings without any metals or plastics, without the use of petroleum or natural gas, and without even sand and gravel to make concrete, much less granite and marble for our monuments.

What is overlooked in the rhetorical excesses that characterize discussions of resource policy these days is the inescapable fact that our civilization today developed from use of non-renewables, from stone tools to copper and bronze tools and ornaments, through a series of technological steps to the manufactured goods of today. The ancients depleted their copper mines with what today we consider primitive technology, but new technologies located more resources and made them accessible to society.

If we carry the creed—stop consumption of non-renewable resources or at least reduce the consumption of renewables to at or below their rate of renewal—to its logical conclusion, we will quickly assure the early death of as many as 90% of the world's people from starvation and disease.

Remember that most of the medicines in the world today are derived from petroleum and natural gas, and nearly all the world's commercially grown food crops require oil or natural gas in order to make the journey from seed to dinner table.

The outcry against consumption of non-renewable resources is easily muted by the reality of the world in which it is heard. However, the logically inevitable afterthought that follows that outcry is often heard as a kind of Greek chorus from the wings chanting the mantra of ignorance, "Reduce the consumption of renewables to at or below their rate of renewal" (Berry, 1996).

Unfortunately, even if we knew what the renewal rate for "renewable" resources actually was, you cannot reduce consumption of renewables to at or below some rate of renewal without significant limitations on population growth and, at least temporarily, government-sanctioned starvation!

Nevertheless, we must stop trying to sustain the illusion that high-entropy "consumption" of non-renewable resources can continue indefinitely.

Waste

Many of those concerned with the contamination of our freshwater and marine resources—and we all should be—present another glib recipe for sustainability, "Enter nothing into the waste/nutrient stream that cannot be eaten safely by another organism" (Berry, 1996). The problem is that there is already too much human waste for our natural systems to accommodate. Again, reduction of human waste requires significant limitations on population growth.

A Look Back from the Future

Yet, when future archeologists look back upon the remains of our current civilization, many public works in major cities around the world will no doubt appear to them as sad and tragic reminders of engineering arrogance based on ecosystem ignorance. Perhaps they will call to mind the words of the poet Shelley,

I met a traveler from an antique land
Who said: 'Two vast and trunkless legs of stone
Stand in the desert. Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them and the heart that fed;
And on the pedestal these words appear:
"My name is Ozymandias, king of kings:
Look on my works, Ye mighty, and despair!"
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare
The lone and level sands stretch far away.'
(Shelley, 1818)

In city after city they will be able to see evidence that, despite our concerns, we became mired in our own muck while the well ran dry. From their vantage point, future critics will be able to observe a fact that we daily choose to ignore— we are fast heading for a world in which there is not enough potable water, process water, or water of suitable quality and in sufficient quantity at

the place where it is needed to support the diverse populations of plants and other animals upon which human civilization depends.

One obvious answer to the problem is still politically unacceptable—limit the number of people to the capacity of the existing natural systems required to support them, sustain their culture, and assure the future of their society.

Reality

Resources from the earth are the basic elements of a society's wealth. Society's needs for natural resources will direct the ultimate resolution of the debate. Arable land, potable water, and usable energy are the fundamental capital assets of civilization.

Arable land and potable water are gifts of nature. Natural biogeochemical processes brought those gifts to the human race with the unspoken admonition to use them wisely for the benefit of life on this planet until the end of time.

Despite the increased environmental sensitivity in the United States which has improved many aspects of our natural environment, insensitivity to social needs, shrinkage of real wealth, and administrative confusion in implementing often conflicting regulations have dulled the awareness of environmental factors in many social and societal decisions.

Any national environmental policy that seeks to assure an acceptable quality of life for the mainstream of human society must include the disadvantaged and disheartened of America in the calculus of costs and benefits.

One of the great quasi-scientific mistruths is that we are "running out" of a particular resource such as oil, iron, copper. . . . The geologic truth, however, is that the availability of natural resources is limited only by economics and government policy. Human need for particular resources at particular times in human history controls price and value. We run out of resources that we are unwilling to pay for or unable to afford.

During the 1974 oil embargo and the consequent precipitous rise in gasoline prices at the pump and heating oil at home, we conserved. Now, during the lowest prices in recent history, we use oil freely. Technology provides resource alternatives only when the marketplace demands them.

Justice

At the heart of any discussion of "sustainable water and energy" is the question of "justice." It is here that science, politics, ethics, and the law come together in what will be Armageddon or Utopia.

The question, "Are water and energy globally sustainable through the 21st century?" raises other questions that must be considered in public-policy discussions. "Sustainable for whom?" and "Sustainable at what level of consumption?"

According to the Oxford English Dictionary, the word "ethics" has a number of meanings. As an adjective, "relating to morals; treating of moral questions, and of ethics as a science." As a singular noun, "The science of morals; . . .A scheme of moral science." As a plural noun, "The science of morals; the department of study concerned with the principles of human duty. . . .In a narrower sense, with some qualifying word or phrase: **a.** The moral principles or system of a particular leader or school of thought. **b.** The moral principles by which a person is guided. **c.** The rules of conduct recognized in certain associations or departments of human life. In a wider sense: The whole field of moral science, including besides Ethics properly so called, the science of law whether civil, political, or international."

If ethics is to be more than a vague ideal in the platonic sense, it must truly govern human conduct through meaningful laws—laws that are ecologically sophisticated, environmentally responsible, socially relevant, economically rational, and politically feasible.

But, for any law to effect justice it must conform to the natural law.

Scientists are familiar with the natural laws that are manifest throughout the physical world. The power of a natural law like gravity is that it exists and it commands obedience whether we like or not. You can disobey a fundamental natural law like that of gravitation, but you do so only at your own peril.

In the moral sphere and in the law as the body of rules and regulations governing the conduct of human beings in society, there are also natural laws.

Much of the difficulty in recognizing the natural law as an acceptable element of Anglo-American jurisprudence can be attributed to the rise of logical positivism as a philosophical system during the eighteenth and nineteenth centuries. The positivists insisted that the only source of human rights was positive law pronounced by some lawgiver, be it King or Parliament, Shaman or Congress, and enforced by some executive power supported by an armed force or

the "will of the people." The core of the positivist philosophy was the proposition that the positive law was independent of any natural law or universal law influence.

The positivist view of law leaves no room for equity, much less a philosophy of law which must concern itself with right, wrong, justice, and injustice. As the legal positivists contend, just or unjust are identical with what is permitted or forbidden by positive law, there remains no room for any consideration of a philosophy of law, since it has all been stated by the positive law of the moment in any particular state or principality. Positivism continued to dominate the philosophy of law until the end of World War II.

In 1932, Radbruch provided the philosophical support for the position that the judge and jurist must disregard their sense of justice and obey only the command of the law as written by the state. Thus instructed, the jurists of Nazi Germany established the "justice" of the Third Reich. The theoretical powerlessness of the German judiciary to resist the implementation of unjust laws made those judges agents for the imposition of policies such as genocide.

However, the same Radbruch whose writings and teachings left German jurists impotent before Hitler in 1932, wrote in 1947—after Nuremberg:

> The traditional conception of the law, [t]he positivism that for decades dominated German jurists, and its teaching that "the law is the law" were defenseless and powerless in the face of such an injustice [the Holocaust] clothed in the form of the law. The followers of [judicial positivism] were forced to recognize as 'just' even that iniquitous law.
>
> The science of the law must again reflect upon the millennial common wisdom of Antiquity, the Christian Middle Ages, and the Age of Illumination, that there exists a higher justice than [positive law—] a natural law, a divine law, a law of reason—briefly a justice that transcends the [positive] law. As measured [against] this higher justice, injustice remains injustice, even when it is given in the form of a law. Before this higher justice also the judgment pronounced on the basis of such an unjust law is not the administration of justice but rather injustice (Radbruch, 1947).

It appears that legal positivism, as a justification for ignoring the natural law, was a hypothesis wrecked by the gruesome reality of history.

Environmental Legislation

The engine of our national environmental policies must be science, not rhetoric. The rational basis for our national environmental policies must be the scientific method, not power politics.

America and the World cannot afford a return to the days of *laissez faire* resource economics and environmental anarchy when the natural ecological systems and resources upon which the human species depends for survival were "free goods" which belonged to everyone and for which no one was responsible or accountable.

Legal definitions that are contrary to scientific fact cannot be tolerated if we are to keep public faith and popular support for rational policies sustaining the physical environment.

Any legislative act, executive policy, or administrative fiat which fails to consider the ecological integrity of the region in which it is supposed to operate or ignores the interrelationships among each element of the land and the landscape and each natural resource of that region is scientifically incomplete and legally defective.

Any legislation or executive action be it for village, town, city, country, state, or region, which fails to fully evaluate its effects upon the regional environmental systems within which it is supposed to operate is ultimately doomed to become a costly and even deadly hoax on the community. It should fail as legislation, and it will fail in the courts; just as every attempt to ignore the natural limitations imposed on the human use of natural resources must fail.

The Errors of the Past

In order to develop an ecologically sophisticated, environmentally responsible, socially relevant, economically rational, and politically feasible national environmental policy we must at the very least address the patent inadequacies in our past deliberations.

1. Failure to accept the need of developed industrial societies to preserve, at the very least, their present standard of living.
2. Failure to understand that the Science of Economics is not the same as the Philosophy of Economism.
3. Failure to reach consensus on environmental standards.
4. Failure to establish environmental priorities.
5. Failure to recognize that our national dialogue over "environmental" issues is driven, and to a large extent controlled, by the mass media.

6. Failure to identify spurious issues, and "issue inflation."
7. Failure to confront those special interests with less than fully disclosed, much less clearly articulated, agendas.
8. Failure to recognize that effective environmental action must be based upon high-quality holistic science.

Failure to Recognize Societal Needs

Land and landscape, water and minerals—earth resources—are not accorded the same significant role in public-policy discussions that they actually play in sustaining the economy and structure of human society. Our social fabric is woven from the resources of the Earth upon which we live, but the weaver seems to be unaware from whence comes the thread.

Increasing urbanization has created an intellectual chasm separating widespread resource consumption from popular understanding of resource origins. Little connection is made between turning on a television set and mining coal; dressing in new clothing of manmade fibers and drilling oil and gas wells or a life-saving medicine and those same oil and gas wells.

One reason for this lies in the great divorce of the American people and their counterparts in other industrialized societies from their most widely used earth resources: land, water, minerals, agriculture, forests, and energy.

Many years ago farm kids laughed at city kids who thought milk came from bottles in grocery stores. Unfortunately the farmers never delivered their message and now the source and the product are no longer connected in the minds of consumers, creating seemingly irreconcilable conflicts over access to natural resources.

Standard of Living, Wealth, and Population

The true wealth of the American people that maintains our standard of living is the intrinsic value of the resources taken from the planet Earth and the value added to those resources by our human efforts. The profound insight is that: The standard of living in any region is directly related to the wealth of the region and declines as its population increases.

In 1993, Gerhard and Puderbaugh, expressed the fundamental relationships among **S**tandard of Living, national **W**ealth, and **P**opulation as, **S = W/P** (Gerhard and Puderbaugh, 1993).

Limiting national access to resources from the Earth, whether water, timber, farmland, minerals or hydrocarbons, rashly assumes that such limitations will mean that fewer Earth resources will be used. In America, limiting access and increasing the costs of adding value to locally obtained resources simply substitutes foreign earth resources for our own, and transfers American wealth elsewhere to pay for the substitution.

Population in the United States continues to grow—from 125,000,000 in the mid-1930's to over 281,000,000 in the year 2000. The United States has managed to increase its wealth in proportion to its population growth until recently, but the ratio is declining. This reflects a decrease in the rate at which the American standard of living increases. When coupled to the trade-balance figures over the same years, there is an absolute decrease in standard of living in the United States. (figs. 1, 2).

The obvious consequence of this decline in the rate of growth of the American standard of living is its disproportionately dramatic impact on the standard of living for those who are already financially disadvantaged in America. The effects of a poor economy, whatever the cause, generally fall most heavily on those least able to afford it.

Our social fabric depends on our standard of living. Arguments that the standard is "too high" beg the question, "Too high for whom?"

Markets and Metaphors

At the heart of all the controversy and misunderstanding pervading any discussion of "sustainability" is the fundamental mistake of relying upon metaphors of market valuation in formulating and legitimating public policy affecting the environment.

Since the 1970's, much of our public discourse about the environment has been reduced to a series of catchy cliches and oft-repeated mantras suggesting in one way or another that nature is an economy, the ecosystem is a marketplace, and that our relationship to nature and the ecosystems of which the human species is a part and upon which human civilization depends can and should be calculated in terms of cost-benefit analysis.

With our money as capital we are exhorted to invest in the environment as part of a prudent portfolio. We are encouraged to think that, with proper management, we can obtain a continuous material flow of goods for our infinite personal and societal gratification. In this context, the value of biodiversity is

FIGURE 1—Percentage of earth-resources vaule in the gross national product.

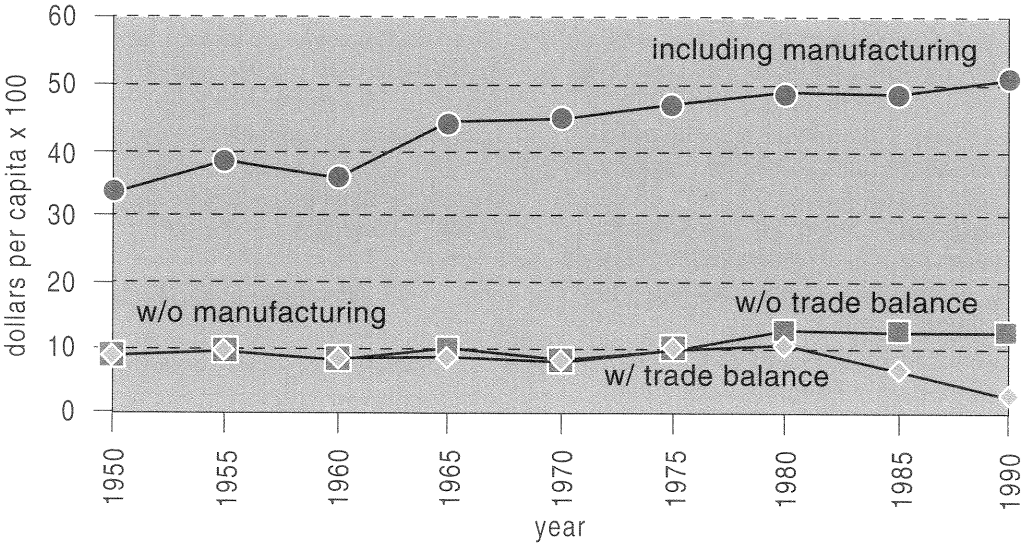

FIGURE 2—United States wealth per capita.

extolled for its future market potential as a source of food, materials for our creature comforts, and drugs which may well some day hold the cure to cancer and other illnesses of civilization.

However, in an increasingly service-driven economy, we are becoming more aware of the services that nature provides for us at little direct cost, but which would be very expensive to replicate.

Many professional economists seem to feel that they have no choice but to crudely cram the magnificent richness and manifest wonder of biological diversity into the impoverished concepts of "market commodities" and "ecosystem services." (Costanza et al., 1997). However, there is no need for political leaders, scientists, and other concerned human beings to sign on unquestioningly to the economists' commodification of ecological systems.

In part, the difficulty arises from the fact that there is a superficial element of truth in talking about aspects of nature with market metaphors. Beans and barley, porkbellies and pigeons are regularly sold for cash in markets around the world. But the kernel of truth in the

market metaphors is not the source of their extraordinary power. The power of these metaphors resides ultimately in the fact that they succeed in controlling our behavior by mobilizing primordial beliefs and deep-seated emotions rather than rational thought and considered judgment.

The Power of Metaphor

In effect, metaphors come in packages, and the power they exercise in generating thought derives not from their inherent truth, if any, but from their "extensibility"—their power to call up an internally coherent vocabulary of virtual images which can mirror, however warped and distorted the image might be, certain aspects of the real world (Lakoff and Johnson, 1980).

The substantive connection between any given metaphor and the reality it purports to illumine may be very tenuous. Given the selective and incomplete nature of any metaphor, the virtual imagery may obscure rather than clarify important aspects of reality. Such is the case when economic metaphors are used to describe complex environmental systems rather than using ecological metaphors to describe human economic systems.

Metaphors are far more important than simple figures of speech. Every metaphor triggers a cascade of reflexive reactions, associated images, and unconscious mental processes which we uncritically accept and adopt as our own whenever we choose to enter a given metaphorical milieu. Thought is short-circuited by symbol, and groups of symbols are linked to one another in wide networks of implicit images which channel, direct, and sometimes even preclude, thought.

Economic metaphors constrain our thinking about the environment by defining the range of "thinkable thought" (Herman and Chomsky, 1988; Chomsky, 1989, p. 48). Even in democratically organized societies, thought control manifests itself in the far more subtle form of self-censorship. It is not what it is forbidden for us to think about, but rather what it does not occur to us to think about, that establishes the bounds of publicly acceptable thought in democratic society.

In this context, economic metaphors function to define the range of "responsible" public thought. Goals which are widely acknowledged to be desirable and good but which are thought to be "expensive" are often characterized as "unrealistic."

The metaphor of "economic reality" is swiftly invoked to label specific kinds of thoughts or proposals about "sustainability" as unsuitable for public discussion and "out-of-bounds" because they are "unrealistic," "unreasonable," "irresponsible," "too idealistic. " Whether or not the metaphor "economic reality" corresponds to anything more than an extended fiction is never questioned because market metaphors have been accepted as the organizing framework and only acceptable paradigm for responsible discourse.

Perhaps the most insidious feature of the pervasive use of economic metaphors in our thinking about "sustainability" takes the form of the question, "Can we afford a sustainable environment?"

The evident absurdity of the question, however, is not confronted, because the question itself is never overtly posed. It remains implicit. It lurks in the background, conditioning every decision we make and suggesting on a subconscious level that a viable ecosystem is now a "luxury" no longer available to great numbers of individual human beings, and even entire populations of human beings.

The implication of this subconscious image is that if you are rich enough, you can "buy" a healthy productive environment which can "sustain" you as an individual at your desired standard of living. As a bona fide member of the affluent society, you need not concern yourself with those who are left out of this process because market metaphors encourage you to focus only on your own personal role as an autonomous consumer.

The "magic of the market," it is argued, is that the system as a whole works best if everybody concerns themselves only with maximizing their own self-interest. The "market" is portrayed as "natural" and equitable in its impartial and impersonal operation. Where market logic is supreme, we are taught to believe that it is both possible and desirable to buy a private solution to a collective problem.

Collective Problems

Society cannot solve a collective problem simply by multiplying private solutions that try to opt out of the circumstances that cause the problem. All this accomplishes is to continue or recreate the collective problem on a larger scale at a later date. Yet, from within the internally coherent virtual world of market metaphors, there is no vantage point from which individuals can see that attempting private solutions to a collective problem is a fantasy that has become a delusion.

Indeed, as consumers we are urged to think that market alternatives are the only solutions available. We are taught that the only legitimate goal of public policy is to protect the "rights of the consumer." The role of citizen-consumer is so thoroughly established in public discourse that we are made to feel that simply buying anything at all is a patriotic act required to keep the economy growing.

Growth, Smart Growth, Sustainability

The consequences of unrestrained growth, aimless growth, anarchic growth are now too apparent to ignore, while the appeal for smart growth has been slow in coming.

The notion that conventional patterns of economic growth should stop altogether has been forwarded by some, and it has gained prominence since the publication in 1972 of the influential Report to the Club of Rome, *Limits to Growth* (Meadows, 1972; Meadows et al., 1992). However, many who challenged the notion of "limits to growth" did so in strong moral terms as well (Walter, 1981; Beckerman, 1995).

The question now is, "Who gets to call what, 'smart'?"

The difficulty is that systemwide troubles are bigger than merely human problems yet we are pursuing what we have come to embrace as "smart growth," the idea that we can manipulate the natural environment at will to maximize human benefit. The elegance of "smart growth" rhetoric blinds us to its hubris. We are in danger of fine-tuning disaster. Rather than avoiding extinction, we may be making it more efficient.

Human population growth may itself be the problem in the larger system. We need to have the courage to entertain the question: In a world already choked by the human enterprise where so much of the natural world suffers from our collective species footprint, isn't "smart growth" an oxymoron—an arrogant contradiction in terms?

The Numbers

It is important to get the numbers straight in this regard because rhetorical excess has made public discourse and daily economic life thoroughly confusing. It is not uncommon, for example, to hear phrases like "steady growth" or "sustained growth" in discussions of the economy. In the larger biological system, however, it becomes apparent that the idea of steady, sustained, or continuous growth is simply not possible. It is an illusion.

Over the course of human generations, all economies function as subsets of ecosystems. Therefore, it is important to establish the fundamental laws of ecosystems firmly in our minds.

At the level of organisms and populations, growth is best understood as a "phase" phenomenon. Individual organisms or populations go through a "growth phase" in their development. However, this growth phase is not—and it cannot be—a permanent state of affairs.

Unrestrained growth is not feasible; nor is it healthy. A "steady" growth rate is potentially explosive because a constant rate of growth in reproducing organisms leads to an exponential growth of the population as a whole. The typical form of exponential population growth takes on the appearance of a J-shaped curve with a long period of gradual growth followed by a rapid expansion of organisms in a very short period (fig. 3).

No biological system can tolerate this kind of growth pattern on the part of any of its constituent

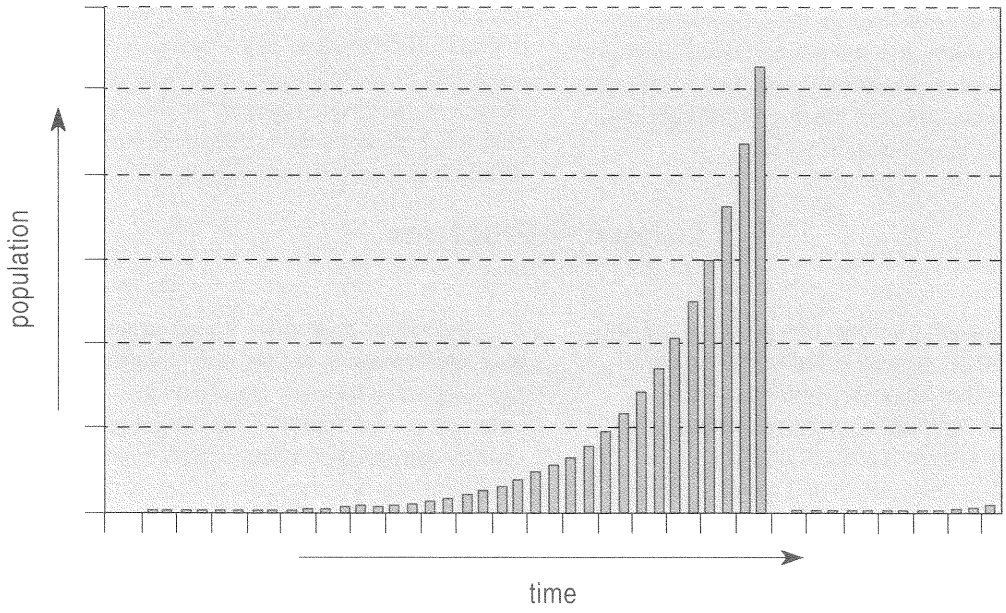

FIGURE 3—An exponential growth pattern.

species for very long. If the population itself shows no change in its reproductive behavior, it sooner or later is subject to the external limits of habitat or nutrient availability, and it "overshoots" and then rapidly collapses when the limit of the environmental "carrying capacity" is exceeded (fig. 4).

Over time, there may be nothing fixed or permanently determined in what is referred to as the carrying capacity of a system with reference to any one population. It could—at least in theory—expand or increase if the population were to adjust to another pattern of consumption or self-maintenance.

In principle, this might mean that populations could periodically exceed their carrying capacity in a given system, but that in subsequent periods they could enjoy an increased carrying capacity and expand to that new level before overshooting and collapsing.

Mathematically, this can be modeled simply as a system with a population growing at a steady rate but one within which the carrying capacity expands over time after periodic episodes of population collapse (fig. 5).

Of course nothing in an ecosystem assures that the carrying capacity of an individual species will expand over time. Quite the contrary; when populations overshoot and collapse, they can frequently be quite destructive to their "life support" systems—the complex web of organisms that provide the biogeochemical cycling required for the steady flow of nutrients, water, and energy that each organism requires.

So, it is quite often the case that the phenomena of constant growth which leads repeatedly to a syndrome of overshoot and collapse systematically diminishes the carrying capacity of a system over time with regard to a particular organism. Thus, although the fundamental population growth pattern (boom-bust) of a population may not change, its actual population can decline over time in response to a deteriorating carrying capacity caused, in part, by the environmental devastation of repeated overshoot and collapse events (fig. 6).

Unlike a theoretical economy, an ecosystem has no externalities. We must abandon sector-thinking predicated on the growth of particular sectors of an economy for systems-thinking predicated on the stability and self maintenance of the health of the system as a whole. In healthy populations, as in healthy individuals, growth is a phase through which life-forms move on the way to maturity.

Continuous growth is not possible in healthy organisms or healthy populations. Continuous growth is the unmistakable sign of pathology and imminent death. Continuous growth is the ideology of a cancer cell. It is little wonder that urban policies predicated on the fiction of continuous growth leave us with a pattern of urban sprawl that resembles nothing so much as a form of cancer on the land.

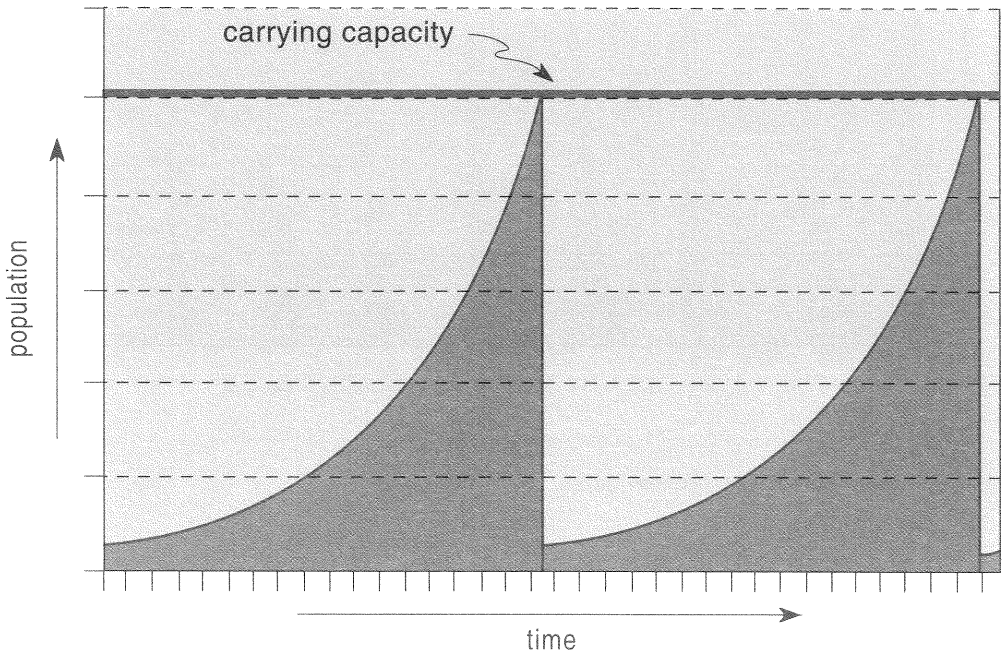

FIGURE 4—Population which grows at a constant rate within which the carrying capacity remains static.

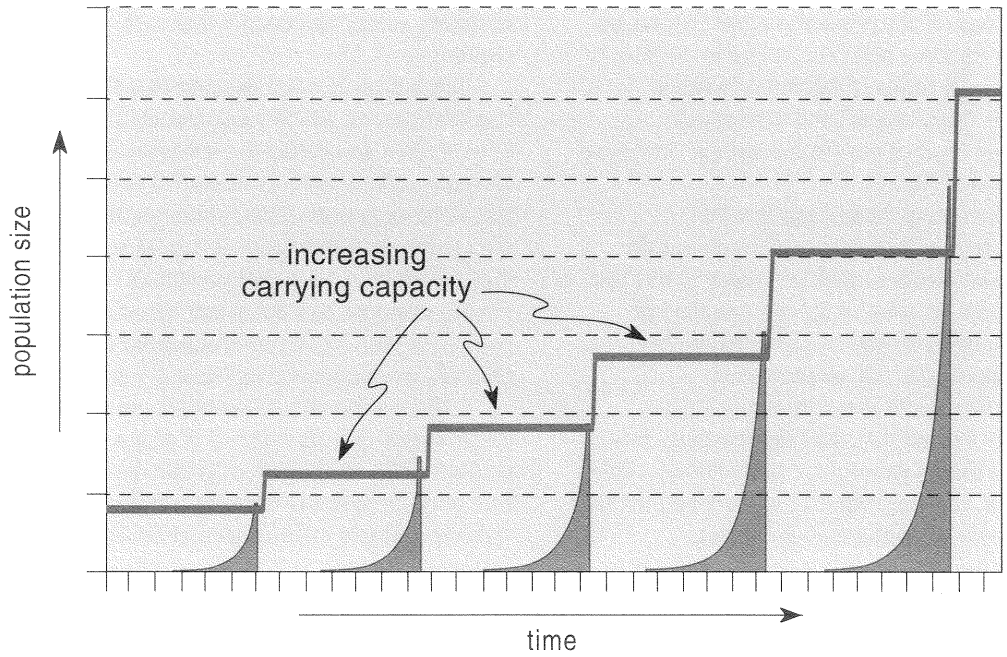

FIGURE 5—Population which grows at a constant rate within which the carrying capacity increases.

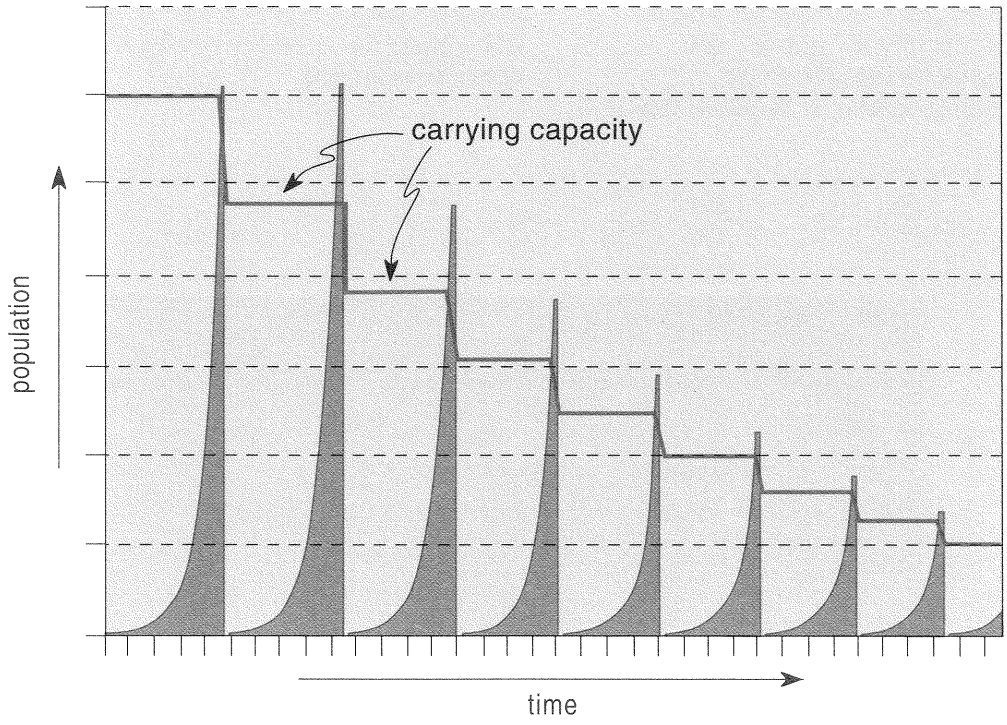

FIGURE 6—Carrying capacity can also decline over time.

The Specter of Social Darwinism

Market commentators encourage us to think that self-interest, greed, and unbridled competition are an expression of the natural order of things—the only order that has ever existed or could ever possibly exist in the "real world." We live in a world, they assure us, characterized by "survival-of-the-fittest," which they easily transliterate to "survival-of-the-fattest." Such is the world view of the economic reductionist.

In its extreme form, the creed of competitive individualism became Social Darwinism—the doctrine that social progress and individual justice consist in the *bellum omnium contra omnes,* in the law of tooth and claw, endless war leading to the survival of the fittest (Spencer, 1851).

The Social Darwinism of Herbert Spencer is one of the classic examples of an idea which has attained much wider acceptance than the evidence of its validity warrants. It offered the business tycoons of the late nineteenth century a perfect rationalization for their brutal exploitation of human labor and their ruthless competition with each other and the lack of concern for the public interest out of which they gathered their riches and power.

Spencer, the social philosopher, not Charles Darwin, the natural scientist, coined the phrase "survival of the fittest," which provided the robber barons of America and the Continent with a pseudo-scientific justification for their tactics. They survived and prospered because they were the fittest in the struggle. Financial success in business was the obvious measure of the validity of Social Darwinism, the theory which linked the rapidly developing natural science of the nineteenth century to the newly emergent social sciences.

Social Darwinism provided a convenient way for industrialists and entrepreneurs to ignore the social consequences of their actions done in the name of "business."

It seems hard that a laborer incapacitated by sickness from competing with his stronger fellows, should have to bear the resulting privations. It seems hard that widows and orphans should be left to struggle for life or death. Nevertheless, when regarded not separately, but in connection with the interests of universal humanity, these harsh fatalities are seen to be full of the highest beneficence: the same beneficence which brings to early graves the children of diseased parents, and singles out the low-spirited, the intemperate, and the debilitated as the victims of an epidemic (Spencer, 1851, p. 353).

No one can deny that human affairs can be characterized at times by self-interest, greed, and competition. Still, the question remains why should this narrow range of human attributes be selected as the cornerstone of public life? Alternative and more powerful human values like compassion, empathy, kindness, discipline, honesty, generosity, loyalty, integrity, bravery, a sense of fairness, a sense of belonging, a capacity for self-transcendence and selfless service, and a need to search for meaning and affirm belief all characterize the human experience at least as well as greed or selfishness. However, this rich panoply of human values are summarily dismissed by market ideologues when it comes to considerations of public policy.

In 1902, John D. Rockefeller, Jr., with surprising unconcern for his family history, sought to explain the business success of his father and justify his own predations with a fascinating analogy,

> The growth of a large business is merely a survival of the fittest. . .The American Beauty rose can be produced in the splendor and fragrance which bring cheer to its beholder only by sacrificing the early buds which grow up around it. This is not an evil tendency in business. It is merely the working out of a law of nature and a law of God (Ghent, 1902, p. 29).

By rejecting many of the universal attributes of the human condition as "unrealistic," and giving unquestioned priority to market metaphors, our vision is being narrowed to such an extent that soon we will know the cost of everything and the value of nothing.

Market Metaphors

Market metaphors arbitrarily restrict the notion of what is possible to what is profitable and thereby truncate the range of policy options open to political leaders. In this framework, market metaphors make it all but impossible to even rationally discuss "sustainability," much less formulate effective policy to promote "sustainability."

The insidious thought control exercised by market metaphors in the public discourse needs to be squarely confronted and firmly rejected. The economy is not a video game featuring virtual reality. Only by stepping outside the virtual make-believe world of these market metaphors is it possible to see why they mystify rather than clarify our environmental circumstance.

Essentially, market metaphors project a fundamentally false image of reality. Despite frequent appeals to the "real world," advocates of market metaphors live in a self-contained virtual world of abstract models, statistical fantasies, and paper currency that serves as a proxy measure of real wealth. In reality, the real world is quite a different place.

There is nothing virtual or abstract about coal, oil, natural gas, or radioactive decay. The hydrologic cycle is no fantasy. Economic minerals are still the support for paper currency. The inherent value of paper is as a medium for communicating human thought and ideas.

The abiotic and biotic natural resources of planet Earth and the permanent biogeochemical cycles which establish the relationships between and among those resources are the "General System" which supports all human life on the planet and the ultimate construct of human beings, human civilization. The human economy needs to be understood as just another elemental subsystem of the Earth as a General System (Daly and Townsend, 1993; Daly and Cobb, 1994; Weiskel, 1997b).

Economics the Science is not Economism the Philosophy! (Weiskel, 1997c)

There are obvious connections between the public good and private gain. It is certainly possible to do well by doing good; however, economists should know better than to let their work on prices be mistaken for a discussion of values. It is not economics that is at fault but rather economism that has produced the overwhelming tendency to frame disputes over public policy primarily in terms of comparative costs measured in terms of paper money. Economism is the belief that principles of market economics can and should always be used to resolve environmental public policy dilemmas.

With a few notable exceptions, economists have been unwilling to engage in meaningful public discussion of environmental values beyond questions of market pricing ((Boulding, 1968; Boulding, 1970; Boulding, 1978).

Establishing Environmental Priorities

It seems that no priorities have been assigned to environmental issues that have become part of national policy debates. Each special-interest group devotes its energy, time, and resources to limited positions on narrow issues, without understanding the overall impact of the issue, much less its proposed solutions, on Earth as a general system.

Often the costs of proposed "solutions" are much greater than the costs associated with the problem. Often special-interest groups ignore large systemwide problems in favor of creating a furor based on popular sentiment for small-scale essentially local issues.

It is possible to scale environmental issues over a range from micro-issues to mega-issues in terms of their impact on the Earth as a "general system," human beings, and human society (Gerhard, 1994).

Micro-environmental issues are short-term or in-home issues, such as disposal of household chemicals, lawn mulching, recycling of household wastes, and similar small-scale individual decisions. These issues are resolved by personal decisions, and although they impact the lives of others, the impact of each decision tends to be very local, and action agendas can be very personal.

Macro-environmental issues are of larger temporal scale and cut across geographic and political boundaries. They include air pollution in large cities, major aquifer contamination or de-watering, factory-smokestack output, or single-tributary stream-basin issues. Organizational action rather than personal action is required.

Meso-environmental issues are regional in nature and may affect very large numbers of people. The Mt. St. Helens volcanic eruption and the eruption of Mt. Pinitubo in the Philippines are examples of natural phenomenon that fall into this category, as does acid rain. Automobile efficiency and offshore-drilling policy are of similar scale in their potential long-term effects on standard of living. Population growth is at least this important. Pesticide regulation, predator control, insect control, and crop fertilization are all issues of this magnitude and have great impact on nearly all of human society.

It is over meso-environmental issues that we hear many concerned citizens cry out for "government" to expose, denounce, condemn, and punish those who consistently and intentionally violate certain precepts which they believe represent responsible "ecocitizenry." For this reason, great care must be exercised in the application of governmental power to ensure that the issues addressed are not symptoms, and that the solutions devised are real, necessary, and do not cause large-scale, negative downstream effects.

National governments are responsible for exercising this concern and care, but must do so in open discussion among informed participants recognizing that the exercise of government power in dealing with meso-environmental issues can affect the entire Earth as a general system.

Mega-environmental issues are of global scale and include three popular issues in America today: global climate change, ozone concentrations, and biodiversity. However, overpopulation, mass famine, soil erosion, desertification, and pandemic plagues are much more pressing mega-environmental issues to the rest of the world.

Societal Impact

Once issues have been scaled in scope and size, they then can be scaled as to their impact on society:

Human Health and Safety. There should be no argument that issues adversely affecting human health and safety should be assigned the highest priority for environmental action. The energy and resources we direct toward resolving those issues should reflect the geographic scale or number of individuals in need. Thus, a mega-environmental issue affecting human health and safety would be the most important issue of all.

Perturbations of Natural Systems. Earth systems suffer human interference poorly. Whether groins installed to preserve one beach that in turn cause erosion down the long shore for all, or unwise construction on floodplains or in earthquake zones, much human suffering and death occurs when geologic systems are ignored.

Thirty-thousand deaths in an Indian earthquake recently only underscore the need to consider earth systems and geology as one of the most significant environmental parameters affecting humans.

The 1993 midwestern United States floods also emphasize the problems of human interference in natural systems. Artificial river-control measures added significantly to flooding, and unrestrained residential development of floodplains was responsible for much preventable damage.

Societal Interest Issues are primarily conflicts between perceived environmental issues and property valuation. Facility-siting problems are at the root of most of these problems, although occurrence of pests, moderate air pollution, and other inconveniences resulting from human activity fall into this category. Many of these issues also reflect changing values and perception of personal risk in society.

"Environmental" considerations have replaced "zoning" as a popular means to preclude mixing of incomes, social classes, establishment of social-support facilities, and transportation routes in particular neighborhoods. Frequently these issues are expressed as "NIMBY" (not in my backyard) issues.

Esthetic Issues are among the most loudly contested environmental issues involving earth resources. Some people regard an oil-drilling rig in the Rocky Mountains as an engineering marvel, others regard it as an aesthetic affront to a pristine view. Mines and mining districts are variously regarded as environmental eyesores or as significant historical artifacts of our heritage.

In the discussions over many of these issues, the perspective is individual perception or personal displeasure and not scientifically predictable long-term negative impact on existing environmental systems. Many times arguments over esthetic issues pit region against region, community against community, and neighbor against neighbor. Recreational concerns have precipitated many confrontations, since many of those seeking recreational access to commonly held national natural resources are the financially advantaged and politically powerful.

These scalar values—from micro-environmental issues to mega-environmental issues can be plotted against a wide variety of perceived and perceptible impacts ranging from human health and safety to recreation and aesthetics so that each participant in a discussion of environmental issues can critically examine their stance, identify the "significance" of the issues, and then argue about the priority to be assigned the issue.

This kind of analysis speaks to the often-ignored questions, "Impact upon whom? Impact upon what? Impact from what particular action or activity?"

With this table as a conceptual model for discussion, both scientists and non-scientists can focus on the highest priority, most critical resource and environment issues, while demonstrating the relative place and value to society of other issues.

Design with Nature

We are now coming to realize that much of what has passed for clever urban design and good engineering in the past has, in fact, been based on a tragically truncated vision of the Earth, its history, its resources, its biogeochemical cycles, and its environmental processes. Time and time again throughout human history, the human race has engineered massive monuments to myopia.

Nowhere is our poor design, faulty aesthetics, and shallow theology more apparent than in the contemporary design principles and public aesthetics manifest in managing our urban water supply. Urban water-supply issues are always locally critical, but not necessarily of universal concern.

A new kind of aesthetic informed by a new kind of theology will be required to engineer our existence for sustainability. In most general terms, we need to learn to design within the limits of the possible.

We stand at a moment of choice in cosmic evolution. In geological terms we live in the "terminal Cenozoic." Thomas Berry would have us choose between the "Technozoic" or the "Ecozoic" as our next epoch (Berry, 1996), but that is a Hobson's choice that denies the adaptability of the human spirit and the strength of human will.

Ecology and technology are not mutually inconsistent. Ecological reality challenges artists and engineers alike to transcend the insolence of physics and the arrogance of humanism to derive new principles for sustainability. *Design With Nature* (McHarg, 1969) is not just the title of another coffee table book. It is the mandate for environmental policy.

Building Consensus for Environmental Standards

The planet Earth and its biota have been changing for billions of years, and change continues.

Human beings are part of the Earth's biota. The works and deeds of human beings are part of the Earth as a system with which we must work. Wishful thinking and social engineering will not change that. We, as human beings, must agree or at least reach a consensus about certain matters as the "ground rules" or "ordering program" or "operating system" for any rational discussion of policy issues whether the discussion is between or among individuals or their representatives in government.

At the present time, there are still no generally accepted international environmental standards reflecting a consensus of the disparate people of the world. There are not even generally accepted consensual national environmental standards. There is no national consensus about ultimate goals for environmental policy.

But before we can develop any environmental standards, we must first state clearly the generally accepted ultimate goals for environmental policy. In the United States, that agreement on ultimate goals will not be attained by a simple majority vote of the Congress or any other legislative body nor by the fiat or order of any executive or administrative agency.

The stated ultimate goals of a national environmental policy will have to reflect a consensus of all people and that will require rethinking all priorities in light of the objective constraints of the biogeochemical processes which determine the place of human beings in the biosphere of this planet Earth.

We must use the logic of energy efficiency, materials recycling, and systems optimization to develop new metaphors for human existence. From these metaphors a new environmental ethic can emerge making it easier for large numbers of people to understand and accept the basic facts of human life upon this Earth:

- We did not create the world.
- We cannot really control it.
- We should not destroy it.

We are participants in a well-ordered system of materials exchange and energy flow, governed by the second law of thermodynamics. If we wish to survive, we had better become aware of our "place" in the broader ecosystems of which we remain only a single constituent species.

We must learn to live as ecologically responsible citizens within the Earth's ecosystems of which we are a part. We must limit our vain and arrogant attempts to dominate the natural systems which sustain us. We must stop pursuing a lifestyle which pathetically seeks to ignore our place in the dynamic General System that is the Earth.

Unlimited growth in a finite system is impossible.

National Consensus; Regional Differences

In order to build a national consensus on environmental standards, it will be necessary to recognize that regional differences exist and adjust standards to these differences. Legislation which is too general and regulation which is not regionally specific enough fosters civil disobedience to environmental laws and evasion of environmental regulations.

Clearly, population density is a controlling factor in mitigating environmental damage and preventing environmental degradation. Population-density criteria should be included as elements of any program of environmental regulation.

Baseline Information

Unfortunately no government agency or scientific organization has yet established realistic, scientifically supportable, baselines for the chemical, physical, and biological characteristics of water, air, and land in their "natural" (undisturbed by direct human activity) state. Acquisition of baseline information about the system of concern and the relation of that system in the overall systems of the Earth and human society of which it is a part, should be a national priority. Baseline information should precede regulatory action.

The baseline information upon which regulatory action is based should be clearly stated in every regulation so that Congress, state legislatures, and the courts can understand the basis for regulatory action that may have become the subject of public controversy.

For example, trash and garbage disposal in New York City where the population density is more than 1,000 people per acre is not an individual option. Care must be exercised to ensure that the mass of garbage and toxic chemicals disposed of in that teeming metropolis does not pollute the region. However, it is difficult to argue reasonably that the trash and garbage of one remote Wyoming ranch in an area where the population density is less than one person per acre should be subject to the same regulations as New York City.

The baseline information from which environmental regulations are developed should be provided by sources independent of the regulatory agency. The conflict of interest and restriction on scientific objectivity inherent in selective mission-oriented research by regulatory agencies is inconsistent with science, the scientific method, and the fundamental principles of American government. The lessons from the history of the Atomic Energy Commission should not be ignored (Calvert Cliffs, 1971; Project Rulison, 1969).

The Federal government should remove research on natural resources and environmental systems from those administrative agencies which combine legislative, executive and judicial power in a single entity and quickly become self-perpetuating and self-serving power sources unto themselves, effectively insulated from the people and responsible to no one but themselves.

Just as the State must remain accountable to the people, so must its agencies and officials. It is only the inherent right of human beings to self-government and spiritual autonomy that need not be accounted for to any tribunal or agency of the body politic. The people, as individuals, always account for their own decisions by their own sweat and blood.

"The woes of the people settle the accounts of the non-accountable supreme persons: State, agencies, ministries, committees, boards, staffs, rulers, law givers, experts, advisors—not to speak of the intelligentsia, writers, theorists, scientific utopians, connoisseurs, professors, and newspapermen" (Maritain, 1951, p. 52).

Special Interests and Agendas

The environmental debate is fraught with spurious issues, misinformation, and the hidden agendas of special interests. There is need to ask questions about issues, about motivation, and group benefits. There is need to analyze issues clearly and in language that all understand.

Our global environment is constrained by its geology, its chemistry, and its biology. It is ruled according to the inexorable laws of thermodynamics. The role of natural earth-system processes in constraining the environment and controlling human effects is still poorly understood even by those most directly affected.

Floods annually kill thousands and bankrupt entire communities, but little is done to mitigate these readily predictable effects by preventing the human activities which increase the risk of their occurrence. Nationally, we do not recognize what level of risks we really face.

Although 30,000 people died in remote India from preventable earthquake damage, the deaths of those men, women, and children in India which actually did occur do not seem to be of great concern to those who consider the possibility of less than 100 early deaths from naturally occurring radon a major national issue.

John S. Perry wrote for the National Academy's Board on Global Change (Perry, 1992) that, "each year will bring a new environmental crisis clamoring for redress in political councils—ozone depletion last year; climate this year; invasion of exotic species, ground water quality, chemical time bombs, tropospheric ozone, and so on in years to come."

Unfortunately, it is possible to sponsor controversial issues for personal or professional gain. There is much research money to be gained if your issue is perceived to be the "catastrophe of the year."

All the "environmental" and "social" issues clamoring for government action should be questioned. Certainly the solutions proposed to what are perceived as "immediate" or "imminent" disasters, catastrophes, or just problems must be questioned. Answers should be demanded with great specificity from the beneficiaries of any proposed policy. Some questions to be asked could include:

- "Who benefits? "Who is disadvantaged?" or more crudely,
- "Who wins?" "Who loses?"
- Why is the proposed action necessary?
- Is the scale of the proposed action appropriate to the scale of the long-term effects attributable to the action?
- Are positive effects fairly distributed among all those affected?
- Is any group unfairly bearing the burdens and paying the costs?
- If the policy changes involve "subsidies," "What is the effect on consumers?"
- "What is the effect of subsidies on producers?"
- "Will the inevitable economic dislocations of subsidies be significantly disruptive?"
- Is the risk being mitigated worth the risk being introduced?
- Are the proposed actions supported by substantial credible scientific evidence that they will succeed?
- Will the proposed action lead to a worse problem?
- Are anthropogenic effects carefully separated from natural effects?

Technology Assessment

To make a technology assessment, use a simple matrix. Each technology should be assessed against a number of constraints in a manner analogous to a series of sieves vertically stacked, each of a finer mesh.

What is left after testing the proposed technological solutions for our "problem" of concern at the moment is some rational and reasonable idea of which technologies are most suitable for deployment, and some guides toward where R&D priorities ought to focus.

In 1972, Roland Comstock, at that time, Presidential Staff Assistant at Northern States Power Co., set forth a method for technology assessment which provides every citizen with a convenient method of analyzing the claims that a new technological breakthrough is only a few months (years?) and a few million (billion?) dollars away, involved with legislative activities and long-range corporate planning (Yannacone, 1974).

Population

The evidence from the world around us clearly demonstrates that the human race is facing major adjustments in its collective lifestyle over the coming decades as a result of the cumulative affects of resource constraints, population growth, and global environmental change.

Occasional warnings about localized population growth and resource constraints have been made ever since the work of Thomas Malthus in the late eighteenth century. But what used to be an occasional warning from a lonely voice has now become a veritable chorus repeating largely the same basic theme: if human societies do not change their patterns of energy use, material consumption, and reproductive behavior, life for many humans and other species as well during the twenty-first century is likely to be nasty, brutish, and short.

In 1992, a group of over one-hundred Nobel Laureates reiterated this message, declaring that:

> Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about (Heidelberg Appeal, 1992; Union of Concerned Scientists, 1992).

In February of 1992, the *Royal Society of Great Britain* and the *National Academy of Sciences* issued a common statement reflecting their anxiety about present trends of human development and environmental transformation.

World population is growing at the unprecedented rate of almost 100 million people every year, and human activities are producing major changes in the global environment. If current predictions of population growth prove accurate and patterns of human activity on the planet remain unchanged, science and technology may not be able to prevent either irreversible degradation of the environment or continued poverty for much of the world (The Royal Society and the United States National Academy of Sciences, 1992, preface).

A Technology Assessment Matrix

Constraints	Assessment
Concept	Based on present information/knowledge, what is or at least seems to be workable? What technologies survive because the basic idea is sound?
Time	Limit consideration of technologies that have little or no chance of deployment until after 2025 A.D. and consider those that have near-term development possibilities.
Available resources	Of those technologies which have the potential for near-term deployment, what are the relative conversion efficiencies in relation to availability of natural resources such as fuel and water? Reject those which are inappropriately wasteful.
Practicality	Of those technologies which have the potential for near-term deployment and reasonable conversion efficiencies in relation to available resources, eliminate those which pose insurmountable operational problems.
Environmental Impact	Of those technologies which have potential for near-term deployment with reasonable conversion efficiencies in relation to available natural resources, and which do not pose insurmountable operational problems, eliminate those which pose unacceptable environmental impacts.
Scale	Of those technologies which have potential for near-term deployment with reasonable conversion efficiencies in relation to available natural resources, and which do not pose insurmountable operational problems, and unacceptable environmental impacts, assume maximum probable (or even maximum possible) deployment and then exclude those technologies whose potential contribution is simply not large enough in relation to the size of the problem.
Money	Of those technologies which have potential for near-term deployment with reasonable conversion efficiencies in relation to available natural resources, and which do not pose insurmountable operational problems, and unacceptable environmental impacts, and which can contribute significantly to satisfying human needs, eliminate those technologies which—at this point in time—appear to be unacceptably expensive in the first instance to those industrial and commercial entities which are expected to deploy the technology and ultimately to the society which must pay for it.

It is hard to imagine a more stark presentation of the crisis. Terms like "irreversible damage" and "catastrophic" are not normally found in the staid vocabulary of professional scientists.

Present patterns of human activity accentuated by population growth should make even those most optimistic about future scientific progress pause and reconsider the wisdom of ignoring the threat to our planet represented by exponential population growth and unrestrained resource consumption as the developing world strives to achieve higher living standards for an exponentially growing population claiming the right to consume resources at the same rate as the developed world.

The optimism of those who think that our science and technology can overcome the constraints of the natural systems in which our human societies are embedded and upon which human civilization depends may have overlooked the rush to egalitarianism in the developing world.

At the United Nations Conference on Environment and Development in 1992, representatives of the developed world governments pledged to save the Earth's forests, prevent global warming, and protect endangered species. They also agreed to a blueprint incorporating environmental considerations into economic development around the world. Unfortunately, little real progress has been made, even though there is credible scientific evidence that environmentally sustainable development offers promising social and economic returns.

While the world merchant powers decry the loss of tropical rain forests, they continue to offer tropical nations no viable economic alternatives to "slash and burn" subsistence agriculture.

Leading economists of the Mercantile World have yet to discover that air clean enough to breathe, water pure enough to drink, and a rich and varied gene pool of plants and animals are no less valuable than biotechnology or "dot com" stocks. Our economists and political leaders seem to have forgotten that all of the money in the world will not buy food from lands without water.

All the genetic engineering from all the laboratories of the world will not provide five or six billion human beings much less 10 billion with sufficient food, clothing, shelter, and health care to prevent war, pestilence, and famine from riding roughshod over the peoples of the earth. Human beings cannot eat and drink stocks, bonds, and the paper currency of nations.

Those who earnestly tend the land, husband our natural resources, and manage the processes of nature, whether in the fields or in the forests or even in the marble halls of government and academe, are the stewards of society and the conservators of civilization. They must be fairly compensated for their unique efforts with the goods and services produced by the rest of humanity.

The world leaders among our trading partners in Asia, the Pacific, and the European community as well as our own freely elected leaders must learn to share. We must share with the peoples who live in what industrial society condescendingly refers to as the Third and Fourth worlds.

We must offer the peoples of the Third and Fourth worlds a sufficient share of the goods and services of the industrialized world to represent a real incentive to limit their population growth to the natural carrying capacity of the lands and resources which they will protect.

We must share with them the goods and services necessary to improve their living conditions in return for them protecting the atmosphere and climate for all of us. We must learn to accept the maintenance of tropical rain forests as payment no less valuable than paper money or even gold bullion.

National environmental policy must not stifle an economy which permits its peoples to be upwardly mobile. National environmental policy must support and promote an economy which provides employment sufficient to assure the continuation of traditional family life in established human communities, provide a salubrious and healthful environment for all. National environmental policy must also provide a broad range of recreational opportunities accessible to all.

Troubling Questions for the Social Sciences

The basic question is, "Can contemporary societies hope to learn anything from the ecological dynamics surrounding the growth and subsequent collapse of former civilizations in time to avert similar ecocatastrophes?" This question is rarely asked by professional social scientists in these days of controlled micro-research and heightened academic specialization. Nevertheless, this "mega" question must be answered with clear analysis, widespread debate, and collective understanding.

For several decades in the twentieth century, doing research on questions of large-scale social change and writing "Grand History" to account for society-wide delusions was considered bad form for a professional social scientist. However, this had not always been so.

The French social historian Fernand Braudel is the exception to the trend toward micro-specialization (Braudel, 1972–74; Braudel, 1973a and b; Braudel, 1981). He drew upon and extended the *Annales* school of social research in France and focused his attention upon what he termed *"l'histoire de la longue durée*—"long-term" or "large-scale" history. This corresponds to what we refer to here as "Grand History." Braudel drew the attention of social scientists back to the "big questions" of the persistence and transformation of cultural forms in the face of constraint throughout history. For example, much of the research by the American sociologist, Immanuel Wallerstein, and his associates and students on "world-systems theory," has been undertaken at the *Fernand*

Braudel Center for the Study of Economies, Historical Systems and Civilizations, established at the State University of New York at Binghamton in tribute to Braudel's lifelong work.

A century ago Grand History was still a flourishing pastime. It was especially popular among the elite classes of the reigning imperial powers of nineteenth-century Europe. Much of modern social science can trace its foundation to the early attempts at grand socio-historical synthesis that sought to discover the origins of social forms and customs from kinship, to marriage, to religion, or the state.

In accord with the over-arching metaphor of evolution which dominated nineteenth-century thought, the nineteenth-century scholars of social form sought to account for human history in one or another unilineal scheme of progressive transformation—a succession of putative "stages" through which they thought humankind had developed to its present state.

Most notable of these grand theories of the stages of human progression were those of Lewis Henry Morgan (Morgan, 1985), Fustel de Coulanges (de Coulanges, 1870), Henry Sumner Maine (Maine, 1866), and Karl Marx himself (Marx and McLellan, 1980).

The trouble with these early, ingenious, and intricate schemes was that they were largely conjectural. Apart from the allusions to classical texts and the odd reference to travelers's accounts, evidence for the grand assertions of these armchair theorists was scanty. They had, in effect, engaged in the writing of "pseudo-histories," the specifics of which had far more to do with the particular social theories that each thinker was seeking to forward than they did with any verifiable circumstances in the remote or recent past.

Early twentieth-century social science abandoned the historical mode of explanation in order to distance itself from the embarrassing excesses of conjectural pseudo-history, although a few masterful European intellects continued to pen broad historical narratives, working feverishly to write what might be called "total" or "totalizing" histories of the world.

Oswald Spengler's *Decline of the West* (Spengler, 1926–28) and Arnold Joseph Toynbee's magisterial 12-volume *A Study of History* (Toynbee, 1934–1961) were perhaps the two most famous attempts to try to integrate the newly available historical evidence of the twentieth century within an over-arching scheme of historical interpretation. The scope and grandeur of these works were on the scale of the work of Edward Gibbon, *The History of the Decline and Fall of the Roman Empire* (Gibbon, 1776), a century and a half earlier and their sweep of historical generalization was every bit as grand.

These works and other big surveys (Durant and Durant, 1935) were fascinating reading for the general public. Professional historians and social scientists, however, generally avoided them, preferring instead to undertake more precise and delimited research on subjects where the historical documentation or social data were better "behaved" or could be more adequately "controlled." Grand History—if engaged in at all—was something to be done in private, on one's own time, or perhaps at the end of a career when colleagues might forgive a doddering mind a wistful glance over the shoulder at the big picture.

In the feverish specialization that characterized American academe during the post-war boom of economic and educational expansion, big questions were studiously avoided. Interdisciplinary work was regarded with suspicion, as it might detract from both the growing budget demands and the disciplinary loyalty that was expected within each academic department. The big questions were shunned. Instead, individuals advanced their academic careers through hyper-specialization. As one scholar observed, it was commonly acknowledged that an academic discipline was simply "a group of scholars who had agreed not to ask certain embarrassing questions about key assumptions" (Cohen, 1989).

The Refocus upon Macro-historical Process

Although hyper-specialization of social science has proved dysfunctional for our understanding of the current global circumstance, it still persists. Much of the institutional momentum that drove hyper-specialization and the reward structure that produced disciplinary myopia since the 1950's is still very much with us in the universities today.

Those who established their careers in this earlier period are now in the process of selecting their professional successors, so it is hardly surprising that powerful forces still persist that work to perpetuate this narrow outlook and tunnel vision. For purely intellectual reasons, if not for structural ones, it is now becoming more and more apparent that disciplinary boundaries and the departments that enshrine them often function as a threat to productive synthesis.

Social scientists must begin once again to ask the large questions about macro-historical and meta-historical processes: How do societies, cultures, and civilizations emerge? What enabled past civilizations to flourish? Why did they prove to be so ephemeral—lasting at most, a few hundred years? Can anything be learned from the sadly repetitive syndromes of growth, expansion, and collapse that have characterized one civilization after another?

New and scientifically meaningful statements can now be made about the circumstances surrounding the emergence, efflorescence, and subsequent collapse of ancient civilizations. Advances in scientific techniques

have generated new data which have, in turn, fueled yet other questions, launching a renewed interest in subjects long thought to be relegated to the realm of pure speculation.

Macro-historical questions—those dealing with transformations over long-term periods—can now be meaningfully addressed. Similarly, meta-historical questions—those dealing with the controlled comparison between civilizations—can be posed with new vigor.

Natural Science, Social Science, and Historical Ecology

Emerging from this process is a new level of understanding about historical ecology and human affairs. The stark distinction between "natural" science and "social" science has begun to fade as insights from each field are used to further the understanding of the other. What is emerging might be referred to as the natural history of human cultures or the historical ecology of social formations—an understanding of human cultures in the full context of their socio-ecological evolution.

Historical ecology has emerged as a powerful new field for research synthesis. It yields valuable insights in the realms of 1) climate change and its impact in human history; 2) the origins and ecological impact of urbanization; 3) paleopathology and historical epidemiology; 4) the ecology of colonialism; and 5) the complex circumstances contributing to the collapse of ancient civilizations. Each of these subject areas of historical ecology deserve attention in the context of considering sustainability of energy and water for succeeding generations.

While it is not possible to summarize in one short paper all the scientific evidence emerging from the study of past civilizations over broad time horizons, it is possible to highlight some of the major ways in which joining the perspectives, insights, and methods of both the natural sciences and the social sciences are placing the study of human history and civilization in the context of the ecosystems upon which they depended.

1) Climate History and Human Affairs. New technology has enabled scientists to reconstruct regional and localized climate sequences for periods stretching back as far as hundreds of thousands of years. As more and more dispersed data are being acquired and correlated, the broad shape of previous climate is being clarified.

The results of climate research suggest several empirical generalizations that seem both simple and profound. Perhaps most sobering is the observation that, in the past, local and regional climates have changed dramatically over relatively short periods of time as a result of natural processes independent of human activity. These radical shifts have resulted at times in massive, costly, and sometimes traumatic disruption to the infrastructure and patterns of human livelihood in cities, regions, and entire civilizations.

Some climates—particularly those in the Mediterranean region and the Middle East—have experienced climate fluctuations with major social consequences. More disconcerting still is the realization that large portions of human society have become *even more*—not less—vulnerable to regional climatic perturbation (Bryson and Murray, 1977). This observation may seem counter-intuitive because of many popular myths about the nature of social evolution in human groups.

For a long time in academic circles and popular understanding, the whole combination of changes known as the "agricultural revolution" was thought to have *liberated* humankind from direct dependence upon nature and its seemingly random fluctuations. We now know that this was not so.

The whole package of socio-ecological changes associated with the agricultural revolution may have changed the scale and scope of human dependence on nature, but it did not *liberate* the human species— much less human society and human civilization— from nature in any meaningful sense.

By domesticating selected plants and animals and basing the society and culture on this radically narrowed range of species, humans effectively narrowed their ecological "niche-width." Henceforth humans were all the *more* subject to the localized perturbations of nature since relatively minor fluctuations could be devastating for the radically narrowed range of tolerance that characterized the domesticated plants and animals when compared to the wild species.

In effect, human groups became tied to an ecological niche defined by the environmental tolerance of their own domesticated plants and animals. By mastering the skills of plant and animal breeding and the cultivation of larger crops than an individual required, humans had become slaves to agricultural production and victims of crop vulnerability.

Because humans and their domesticated plants and animals need a continuous supply of water, changes in the amount of rainfall, or shifts in the periodicity or spatial distribution of rainfall have proven to be one of the most powerful limits to human social organization. Average global-climate measures are not particularly significant because the determinative questions in human affairs have been not so much the mean annual parameters of the system as a whole, but rather the particular performance of localized weather regimes.

Paleopathological evidence of pre-historic foraging populations suggests that they suffered from severe nutritional stress periodically, due most probably to drought. The incidence of severe or chronic malnutrition increases in absolute terms with the emergence of urban-based agriculture.

2) Urbanization: New Patterns of Dependence on Nature. One highly adaptive short-term response to the

fluxes of production caused by variable weather conditions in agricultural ecosystems was for human groups to hyper-produce storable agricultural commodities during favorable growing seasons as a safeguard against times of climatic duress. Desiccatable grains such as barley, wheat, rice, and sorghum proved most amenable to this kind of accumulation.

But once again, by favoring the production of these select few domestic species, human society was not liberated from nature but rather became all the more subject to its cycles and variations. The storage of food may help protect the population against seasonal shortages or crop failure. But these advantages may be outweighed by the greater vulnerability that domestic crop species often display toward climatic fluctuations, plant disease, or other natural hazards (Cohen, 1989).

One of the reasons why this increased *collective* vulnerability to variations in natural process has not been widely recognized or commonly understood is that the social adaptations accompanying the agricultural revolution masked the collective costs of the transformation. In effect, new social hierarchies made it possible to distribute nutritional stress in a highly differential manner.

Elite groups, upon whom we have depended for accounts of the past and whose skeletal remains have been most carefully preserved, were not among those who were most severely affected by the new patterns of vulnerability. It was the peasants and commoners who probably suffered most severely when natural perturbations diminished food supplies.

Until recent paleopathological techniques made it possible to examine the collective plight of peasants and commoners, our archeological samples have been skewed in favor of the experience of societal elites. Therefore, it is hardly surprising that for those classes that benefited most from the new social arrangements conditions of life improved. For these groups there may well have been a sensation of being "freed" from dependence upon nature, but it would be a major conceptual error to mistake their experience for that of their society as a whole.

Considered in intervals of decades and centuries, the social groups that proved most successful under this new structure were those that could 1) mobilize the labor necessary to over-produce foodstuffs during favorable times; 2) devise effective mechanisms of storage and distribution for deferred consumption; 3) defend and protect *both* their arable land and their accumulated food stocks; and 4) organize labor to construct and maintain artificial environments that served to buffer or regulate fluctuations in water supply so as to deliver it to the simplified range of domesticated plants at optimum times for growth and reproduction. Successful response to each one of these selective pressures created a powerful positive feedback loop that favored the rapid growth of hierarchically organized urban societies.

Soon cities established a major new epoch in the ecological experience of the human species. The intricate dynamics of urban-rural relationships have restructured natural landscapes for millennia ever since the advent of the first urban centers in the ancient world.

The urban-rural dynamic is predicated upon an asymmetrical exchange between cities and their supporting countryside. In terms of the flow of matter and energy, cities can be said to be parasitic upon their surrounding countryside. Yet although they ultimately depend upon agricultural surpluses generated in outlying rural areas, urban-based elites with no direct experience with agricultural production repeatedly gain inordinate influence over, and control of, production decisions in rural areas.

Urbanized elites came to exercise this power for a series of strategic reasons relating to their functional role in exchanging, storing, or distributing produce; their managerial role in mobilizing periodic labor corvées; their adjudicative role in settling disputes; their ceremonial role in presiding over religious activities; or their military role in defending strategic territory or possessions. The particular combination of roles played by various urban elites in different cultures varied considerably, but their overall relation to rural populations was strikingly similar.

As long as these powerful urban elites recognized and respected the natural limits of the ecosystems which supported the rural populations upon which they ultimately depended, periods of stable production could endure. Sadly, however, urban-based decisions concerning rural areas were frequently made with little knowledge or understanding of the limits of rural production systems.

The long-term results could be repeatedly catastrophic, engendering cycles of urban growth and collapse, which in turn left whole geopolitical regions and regional ecosystems permanently transformed and, in the human scale, irreparably damaged.

3) Paleopathology and the Natural History of Disease. There has been another major and enduring ecological consequence of the urban revolution. The evolution of cities afforded new opportunities for the growth, transmission, and chronic persistence of pathogens that came to use humans and their domesticated plants and animals as hosts.

By congregating in cities and engaging in intense local interaction combined with periodic long-distance exchanges with other cities, humans created the ideal conditions for the evolution and expansion of various kinds of viruses, bacteria, parasites, and pests.

As with common myths about agriculture "freeing" humankind from the domination of nature, so too it is in the study of disease. It should not be blithely assumed that the health of human populations has simply improved in some sort of uniform or progressive manner since the emergence of sedentary agriculture, the evolution of social complexity, and the elaboration of systematic scientific theories about natural process.

To be sure, the development of the microbial theory of disease and the creation of a petrochemical-based pharmacopeia in the late nineteenth century has

transformed the ecology of human existence in our time, but this change is quite recent in human history and may well prove to be ephemeral in the long run.

New evidence from archeologists seems to support the conclusion that many forms of degenerative and lethal diseases have not been reduced over the course of human history but have actually emerged along with the growth of civilization. Our misunderstandings have stemmed largely, as in the case of nutrition, from the problem of relying too much upon evidence from the remains of the privileged classes (Cohen, 1989).

4) Historical Ecology of Colonialism. In biological terms, the notion of colonization has long been understood as a particular type of biological process having to do with the arrival of exogenous species in new environments or the radical simplification of existing environments and the subsequent restoration of plant and animal communities over time.

Forest fires, volcanoes, and receding ice sheets all create circumstances that allow for the colonization of newly created or radically altered environments by invading life forms. Biologists have studied the processes of plant and animal colonization quite independently of human involvement or intention since time of Darwin. Social scientists are beginning to examine the insights of these biological studies to analyze colonizing episodes in human history.

The results of this new approach to human history are often quite disturbing. Although humans many be very powerful agents in the biological processes that constitute colonialism, they rarely understand the scope or magnitude of their complex role as they act. It is only years, decades, or centuries later that the underlying patterns of biological, ecological, and social interaction become strikingly apparent (Crosby, 1972, 1986).

With a new sensitivity to historical epidemiology, historians have begun to focus upon the ecology of colonialism in considerable detail. The progression of human colonial enterprises—especially those that emerged from the expansion of Europe since the Renaissance—is often well documented from a socio-political point of view. Colonization efforts often had to be justified to royal sponsors, state treasurers, or joint stock companies. However, the effort to give an ecological account of colonial phenomena is relatively recent.

In broad terms it now seems clear that although colonial episodes can frequently be quite profitable in economic terms, they are often likely to be ruinous to local environments in ecological terms. The nature of the colonial enterprise determines the character of the devastation involved (Weiskel, 1987, p. 275–288; 1988, p. 141–171; 1989, p. 98–103; Weiskel and Gray, 1992, chapters 2–4).

One of the most alarming phenomena associated with the ecology of colonialism is the "plant genetic collapse" syndrome—a patterned sequence of biological transformations that leads to the radical simplification or total extinction of indigenous animals and plant genetic material. Rarely is it the explicit intention of human groups in charge of colonial efforts to destroy or render extinct local species, yet it is equally rare for them to avoid doing so in practice.

The process often involves displacing local varieties of foodstuffs in favor of exogenous or putatively "improved" crop varieties which show exceptional economic promise. Local agricultural plant varieties—many of which represent specific adaptive advantages for pest resistance or extreme weather tolerance—can become extinct simply through the neglect of the peasant communities that have found the newly introduced varieties more desirable or immediately profitable under new market conditions.

Ecological imperialism is quite similar to economic imperialism. In both, there is a flow of energy and material from the less organized system to the more organized one. Both economic imperialism and ecological imperialism may also be masked by the same euphemisms and economic metaphors, such as "progress" and "development."

In the context of the current forms of international aid this kind of progressive biological impoverishment can be the net result of even the most noble assistance programs. In some instances, aid programs seek to extend the cultivation of plant varieties that have been selected specifically to grow best in petro-intensive environments with artificial fertilizer subsidies and the concomitant application of herbicides and pesticides.

In the short run, provided that all the required petroleum and petrochemical inputs are continuously available, the crop in question may do quite well for several years. In the longer run, however, the topsoil and ground-water systems may be significantly altered. Moreover, even when the new petro-intensive cultivars prove entirely successful with minimal off-farm impact, the local populations that grow them are henceforth committed to purchasing petroleum inputs. As petroleum becomes more expensive, their operating costs are bound to increase, sometimes beyond the level that they can afford in order to stay in farming (Rappaport, 1971).

Finally, with such highly specialized systems installed for the newly "improved" varieties, farmers lose the flexibility necessary to respond to changing weather and climate conditions. Irrigated rice can only be sustained if irrigation systems have water to run through them. If the rivers or rains fail, farmers are often forced off the land all together, either into famine centers and refugee camps or off to the urban centers in search of other employment. Once peasants in this circumstance have left the rural regions for the cities, there is a high probability that their farming skills and their expertise concerning local crops and cropping techniques will be lost forever.

Third World urban centers are growing at rates that outstrip the already high national population growth rates of the regions in which they are located. Many of these

cities in places like Africa can only be sustained with constant food subsidies from western agricultural surpluses.

The cumulative effect of the innumerable local transformations resulting from the ecology of colonialism has been to force Third World agricultures to focus on producing cash crops for export while these same countries have become dependent upon higher and higher levels of imported foodstuffs.

The industrialized countries for their part are correspondingly addicted to a pattern of foodstuff overproduction and export to earn foreign exchange, while they continue to import cash crops from tropical countries. The impact of this global economic food cycle on the soils, forests, water quality and water supply has been, in many cases, devastating to local ecosystems in *both* the Third World and in the rural areas of the industrialized world.

The future biological stability of such a radically simplified and hypercoherent global food system is by no means assured. The anthropocentric trend toward redesigning all local ecosystems primarily to meet short-term *human* needs may have ethical implications, but the issue is ultimately not a matter of morality or even of *Realpolitik*. It is one of biological viability.

5) The Decline of Ancient Civilizations. The accelerated deterioration of colonial ecosystems in the contemporary world has encouraged some historians to re-examine long-abandoned questions about the decline and fall of ancient civilizations.

While "decline and fall" speculations in the past were heavily grounded in ideological and philosophic argument, now historians come armed with new scientific data and computer models to interpret that data and simulate the circumstances surrounding the collapse of specific civilizations. General climate models have been used to clarify the agro-climatological conditions of past civilizations as they enter their collapse phases (Hosler et al., 1977).

Certain suggestive insights emerge from the whole range of recent studies on the collapse of ancient civilizations.

- The decline and collapse of civilizations seem to involve syndromes of accelerated deterioration caused by multiple feedback processes; and
- In times of crisis among ancient cultures, the urban-based elites seem to have failed to perceive the crisis at hand and may have actually contributed to systemwide collapse by blindly pursuing fallacious partial remedies to systemwide problems or simply by projecting their own special interests as those of the general public.

Material circumstances and ecological constraints played a fundamental role in leading past civilizations into decline, but other "ideological" factors were also important as the syndromes of collapse got underway.

It appears that the accelerating nature of complexity in the system as a whole exceeded the perceptual apparatus of the elites that were supposed to act as regulators or governors of systemic process. In general systems terms, the information mechanisms necessary to trigger the negative feedback processes that would stabilize the system failed to function properly. In a sense their "science"—that is, their ability to observe, integrate, synthesize, and explain events—lagged behind the quickening pace of the events themselves.

Beyond this, and perhaps of greater significance, the social capacity for cooperation that would have been required in any attempt to reverse the syndromes of decline was itself strained beyond its level of tolerance.

Anthropologists have pointed out that initially a crisis situation can engender improved social cooperation in small-scale groups, but after certain thresholds of heightened or prolonged stress, social groups tend to fragment, as each special interest tries to make the best of a declining circumstance for itself and its immediate allies. Objective perception declines, and efforts at social cooperation collapse (Weiskel and Gray, 1992, chapter 5; and Brady, 1978, p. 1–48). In the process, the special interests of particular groups are frequently set forth in the name of the general interest of the society as a whole.

What drives the system to collapse is a positive feedback loop. In terms of control theory, the elite regulatory apparatus acted to amplify error within the system rather than diminish it.

Drawing upon the Classical Mayan material (Hosler et al., 1977, p. 553–584; Willey and Shimkin, 1973, p. 63–115), John Lowe (Lowe, 1985, p. 98) demonstrated that the Mayan ritual priesthood actually functioned to accelerate the Classical Mayan collapse by reacting inappropriately to declining agricultural production.

As agricultural system output began to decline, the priests sought to extract greater and greater taxes from the peasants in order to undertake heightened sacrificial activity. The self-interested arguments of the religious elites were the most thoroughly dysfunctional for the crisis at hand, yet their ineffective and counterproductive "solutions" were adopted on grounds of systemwide necessity rooted in absolute virtue (Tainter, 1988; Yoffee and Cowgill, 1988).

Government Action Requires High-quality Holistic Science

There must be scientific integrity in the processes of legislative drafting and administrative rule-making that affect natural resources, the environment, and the Earth as a General System. Procedural and substantive due process—guaranteed to all under the Constitution of the United States—must assure the people that the science relied upon by legislators and executives is sound and honest. Machiavelli was a courtier, not a natural scientist.

Earth is a planet, a solid body of minerals surrounded with a thin envelope of fluids—air and water—which sustain our human species and support our human civilization. Scientists have a non-delegable duty to acknowledge these basic truths and confront inadequate, dishonest, and poor science, which ignores or refuses to respect them. The popular literature is filled with inaccuracies and scientifically implausible inferences.

Environmental Law

Environmental law and environmental litigation became recognized elements of our legal system in the spring of 1966 when a suburban New York housewife brought an action on behalf of all the citizens of Suffolk County, New York, not only of this generation, but generations yet to come, seeking equitable relief from a toxic insult to the community ecosystem. The real defendant in that action was not the local mosquito-control commission still routinely using DDT in an attempt to control a mosquito population that had long since become resistant to the chemical, but the broad-spectrum, persistent chemical biocide, 1,1,1-trichloro-2,2-bis-(parachlorophenyl) ethane— DDT itself. The New York State Supreme Court issued a temporary injunction restraining the County of Suffolk from using DDT for mosquito control on August 15, 1966, and continued this "temporary" injunction until December 6, 1967, finally holding that:

> DDT has, by its inherent chemical stability, become a continuing factor in some ecological life cycles so as to profoundly alter them and the environmental equilibrium. Thus, it is reasonably apparent that DDT is capable of and actually has to some extent caused extraordinary damage to the resources of this county. If in no other way, the chemical by its very stability has introduced an element of instability in the general ecosystem. For instance, by reducing a food source of some of the larger wildlife and so reducing the over-all larger wildlife population, lesser elements multiply more quickly. These lower forms are presumably more of a nuisance, assuming they in turn survive. Furthermore, DDT affects wildlife directly. Its ingestion, from whatever source, has the capability, it seems, to disrupt reproductive processes or even more simply act as a poison. It is fairly apparent then that the application of DDT in Suffolk County has and is continuing to have a demonstrable effect on local wildlife, reducing it slowly but surely, either directly across the board or indirectly from the top down, but reducing it nevertheless.
>
> We have a situation where plaintiff has at least minimally sustained a massive effort to validate the allegation that DDT does in fact do biological harm (*Carol A. Yannacone, &c.* v. *H. Lee Dennison, et al.*, 65 Misc2d 545, 1966).

Environmental law has drifted far from its origin in a courtroom on Long Island in 1966. Environmental law must recover its original respect for science and return to its fundamental observation that the "natural law" cannot be separated from natural science.

Environmental regulation should proceed from a clear statement of legislative principles freely arrived at by representatives directly accountable to the people on a regular basis through the electoral process. The implementing procedures developed by agencies which are essentially unaccountable to the people must reflect sound science. Where technology is specified rather than goals, economic damage often follows. There are windfalls and wipeouts in a marketplace that is no longer free.

While human health and safety are supposed to be of paramount concern, much environmental regulation is based upon perceived risk and esthetic values. Actual risks to human health and safety are not clearly identified, much less quantified. Consequently, many environmental regulations address issues of little consequence while diverting public concern and legislative attention from more serious issues.

The ultimate goal of risk assessment in the public interest should be to establish priorities among the issues upon which public funds will be spent and the national economy modified. Risk assessment raises questions which scientists should ask and to which the public must demand answers. "Risk to whom?" "Risk from what?" "What is the magnitude of the risk?" "How does this risk rank in terms of other risks?"

Weighing risks among the options available and committing our limited resources according to the principle of the greatest good for the greatest number of human beings is an obvious goal. Risk-based assessment and risk management should be the cornerstone of all public environmental policy.

Communications

The practice of any profession is a constant effort to communicate with many different groups: those who make up the constituency for your profession; those who need your profession immediately for help; and those who may need it but don't know about it yet.

There is also the concomitant need to communicate to all of human society. The fabric of human society—the very coherence of human society—depends on maintaining Earth or Geo Science as a profession—a community of dedicated individuals sharing custody of, and responsible as stewards for, the unique and special body of knowledge about the earth as a dynamic complex system and an element of a greater universe. Those who do not share your knowledge depend upon you. Those who

are not of your particular scientific discipline, must, of necessity, rely on your inherent intellectual integrity and personal honor as professionals.

During a service at the GSA Presidents Colloquium on Ethics, Dr. James Skeehan, a scientist, a geologist, a teacher, and a Jesuit priest, quoted from the Book of Jeremiah in the Hebrew Bible. For those who may have forgotten your Bible history, Jeremiah was an insensitive, bellicose, belligerent, pugnacious prophet of the Old Testament, singularly lacking in tact or a sense of humor. His mission was basically to irritate his fellow men and in this endeavor he was singularly successful. We do not record much in the way of contemporaneous applause for his message. His message, however, should ring out to everyone, scientists, academics, scholars, and political leaders.

"Woe unto the shepherds who mislead and scatter the flock. You who have not cared for the flock will be punished for your evil deeds" (*Jeremiah* 25:10).

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