Economic Growth and the Environment: Alternatives to the Limits Paradigm

BY CARLOS DAVIDSON

What is the relationship between an expanding human economy and environmental quality? For most biologists, environmentalists, and ecological economists, the dominant paradigm for understanding the interactions between the economy and the environment is the concept of limits. The idea is that there are biological and physical limits to economic growth beyond which both ecological and economic collapse would occur. In this view, limits are seen as absolute constraints on economic activity, not just as a point beyond which economic growth results in environmental destruction. This concept of limits is a common theme, from limits on arable land (Malthus 1836), to energy and material limits (Meadows et al. 1972, 1992), to the economic scale and thermodynamic limits of ecological economists (Daly 1979, 1996). Although the limits concept has successfully been used to mobilize concern for environmental issues, the concept is problematic (Norgaard 1995). In this article, I argue that the concept of limits is ecologically and economically not useful and politically hinders the cause of conservation. I also propose metaphorical and analytical aspects of an alternative view.

Clearly, current human activities are causing environmental destruction at a scale and pace unprecedented in human history (Wilson 1988, 1992, Reid and Miller 1989). Moreover, any specific natural resource is finite and therefore there are absolute limits on its use. In addition, biological and physical systems underlie all economic activity and form constraints to which the human economy must adapt. However, I argue, contrary to the limits perspective, that biological or physical limits are seldom actually limiting to economic growth, such that reaching limits causes economic collapse or even stops growth. In most cases, the human economy is extremely adaptable and ways are found to adapt and continue to expand. Furthermore, in most cases, continued economic growth results not in ecological collapse but rather in continuous environmental degradation without clear limit points.

Whether or not environmental destruction is conceived of in terms of limits has important political implications. The limits perspective tends to focus on aggregate numbers of resources, consumption, and population and obscures the underlying causes of environmental destruction. I believe that examining the social structures of production and consumption offers greater hope for understanding and changing environmental destruction than does an analysis based on limits.

My arguments against the concept of limits build on and are in part similar to the arguments of Sagoff (1995). However, our approaches differ in key aspects. Sagoff, along with technological optimists (e.g., Simon 1981) and neoclassical economists (e.g., Nordhaus 1992), tends to discount the existence of environmental destruction and its negative impact on human welfare and to believe that new technology will allow the economy to expand without damaging the environment. My critique of limits, by contrast, is predicated on the assumptions that environmental destruction is real and that increases in the scale of the economy will contribute to greater environmental damage.

Traditionally, the term economic growth (or expanding economic scale) refers solely to the monetary value of output (i.e., gross domestic product, or GDP), which is not directly related to material use or waste production (e.g., $1 spent cutting timber, controlling pollution, and restoring a marsh all show up equally in GDP). However, I use the term to mean greater use of materials or increased waste production. I follow Daly (1996) in distinguishing economic growth (i.e., increased use of materials and waste) from economic development, which may provide for increased human welfare without increased use of materials or waste. I use the term environmental quality in its broadest sense to include biological diversity, resilience, and aesthetic, recreation, refuge, and ecosystem service values to humans.

Alternative metaphors for environmental destruction

The relationship between economic activity and environmental quality is extremely complex. It is difficult to define, let alone meaningfully measure, the size of the economy or environmental quality. Consequently, our understanding of the interaction between the economy and the environment is primarily conceptual. Basic conceptual assumptions often take the form of metaphors (or conceptual models). Metaphors are not merely in the words we use but in the very concepts; therefore, they can shape the way we think and act (Lakoff and Johnson 1980). Often, we are not even aware of the content and

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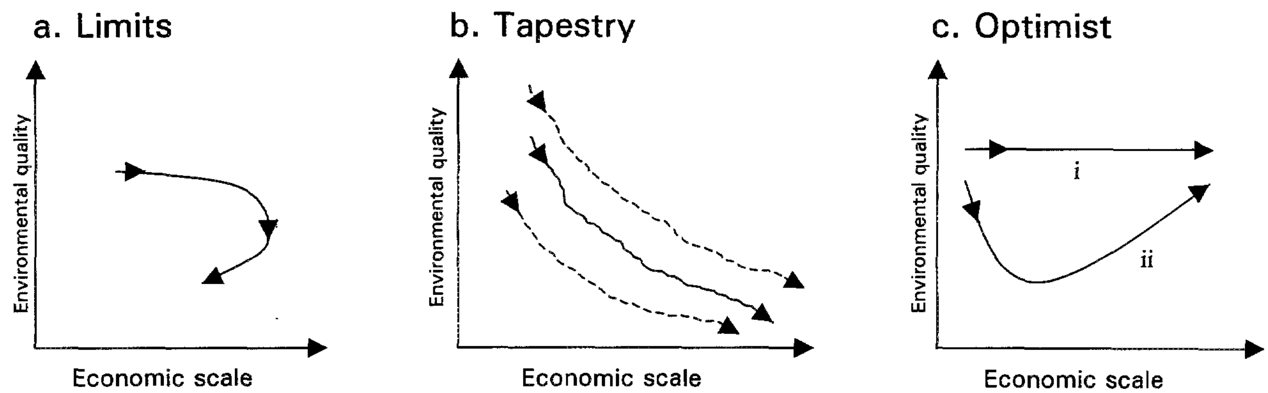

Figure 1. Alternative conceptual models of the relationship between economic scale and environmental quality. (a) Limits model. (b) Tapestry model. (c) Optimist model. The arrows indicate the direction of time. The vertical line in (a) indicates a limit. The dashed lines in (b) represent different socioeconomic arrangements to the solid line and indicate that at any economic scale there may be different levels of environmental quality, depending on the structure of production and consumption. The technological optimist, or neoclassical economic, model predicts either (i) no environmental destruction or (ii) destruction only until the economy reaches a critical level of affluence, after which environmental quality improves with further economic growth.

power of our metaphors.

What is meant by ecological limits to economic growth can best be seen in the rivet metaphor developed by Paul and Anne Ehrlich (1981). In this well-known metaphor, an airplane is analogous to Earth. Each act of environmental destruction (loss of a species, in the original metaphor) is like pulling a rivet from the plane's wing. The wing has lots of rivets, so nothing happens when the first few rivets go. But eventually and inevitably, as more rivets are pulled, the wings break off and the plane crashes. In a related metaphor, environmental destruction is likened to speeding toward a cliff in a car. If the car does not stop, it will eventually go over the cliff. Figure 1a presents a graphical representation of these limits metaphors.

Three essential aspects of the rivet and cliff metaphors shape thinking about environmental problems. First, the transition from no effect to effect is abrupt. That initial changes have little effect contributes to a false sense of security and unwillingness to recognize limits and change course. Second, when limits are reached, the results are catastrophic—the plane crashes, the car goes over the cliff. Limits theorists generally predict that, if limits are reached or exceeded, there will be an ecological collapse which will in turn force a collapse of the human economy (in Figure 1a, both economic scale and environmental quality collapse when limits are reached). Limits are seen as absolute constraints on economic activity, not just as points beyond which economic growth results in environmental degradation. For example, Ludwig (1996) writes, "Either we will limit growth in ways of our choosing or it will be limited in ways not of our choosing" (p. 16). The third essential component of these metaphors is that, in the event of a catastrophe, everyone suffers and therefore everyone has a clear self-interest in avoiding a crash.

The limits concept has been heavily criticized by neoclassical economists who believe that technical change will allow the economy to overcome all resource constraints and expand indefinitely (Nordhaus 1992). The basic neoclassical conceptual model, however, predicts either no environmental destruction or destruction only until the economy reaches a certain level of affluence (Figure 1c; Grossman and Krueger 1993); because of this prediction and others, this model has been criticized by ecological economists (e.g., Daly 1996).

A metaphor based on a tapestry provides a more accurate and useful view of the relationship between economic activity and the environment than either the limits metaphors of rivets and cliffs or the technological optimist model of neoclassical economics. Tapestries have long been used as metaphors for the richness and complexity of biological systems (e.g., the tapestry of life). As a metaphor for environmental degradation, each small act of destruction (akin to removing a rivet) is like pulling a thread from the tapestry. At first, the results are almost imperceptible. The function and beauty of the tapestry is slightly diminished with the removal of each thread. If too many threads are pulled—especially if they are pulled from the same area—the tapestry will begin to look worn and may tear locally. There is no way to know ahead of time whether pulling a thread will cause a tear or not. In the tapestry metaphor, as in the cliff and rivet metaphors, environmental damage can have unforeseen negative consequences; therefore, the metaphor argues for the use of the precautionary principle. The tapestry is not just an aesthetic object. Like the airplane wing in the rivet metaphor, the tapestry (i.e., biophysical systems) sustains human life.

However, the tapestry metaphor differs from the rivet and cliff metaphors in several important aspects. First, in most cases there are not limits. As threads are pulled from the tapestry, there is a continuum of degradation rather than any clear threshold. Each thread that is pulled slightly reduces the function and beauty of the tapestry. Second, impacts consist of multiple small losses and occasional larger rips (nonlinearities) rather than overall collapse. Catastrophes are not impossible, but they are rare and local (e.g., collapse of a fishery) rather than global. The function and beauty of the tapestry are diminished long before the possibility of a catastrophic rip. Third, there is always a choice about the desired condition of the world—anywhere along the continuum of degradation is feasible, from a world rich in biodiversity to a threadbare remnant with fewer species, fewer natural places, less beauty, and reduced ecosystem services. With the rivet and cliff metaphors, there are no choices: no sane person would choose to crash the plane or go over the cliff. This difference is key for the political implications of the metaphors. Finally, in the rivet or cliff metaphors, environmental destruction may be seen primarily as loss of utilitarian values (ecosystem services to humans). In the tapestry metaphor, environmental destruction is viewed as loss of utilitarian as well as aesthetic, option, and amenity considerations. (See Sagoff 1995 for a critique of conservation strategies that focus too narrowly on utilitarian values.)

Actual environmental destruction: limits or continuums?

How useful are the rivet and tapestry metaphors in describing actual experiences with the relationship between economic growth and environmental destruction? This question can be examined by looking at the variety of biological and physical limits to economic activity that have been proposed by ecologists, environmentalists, and ecological economists. In this article, I discuss five types of possible limits: input limits, limits on waste assimilation, entropy/thermodynamic limits, limits on human use of the products of photosynthesis, and limits attributable to the loss of biodiversity. The limits metaphor is a statement about the nature of both biophysical and human economic systems; therefore, limits need to be analyzed from both natural and social science perspectives. And, because human economies transport both inputs and wastes across the globe, the issue of biophysical limits to economic activity is best examined at a global scale.

Input limits. Until recently, input limitations received the most attention. Malthus (1836) predicted that limited arable land would restrict the size of the human population through food shortages and starvation. Meadows et al.'s (1972) limits-to-growth models focused on a broader array of inputs but retained the basic Malthusian message: limited natural resources must limit human population and economic activity. Similarly, in *The Population Bomb*, Ehrlich (1968) predicted that hundreds of millions of people would starve to death in the 1970s from absolute food shortages. These predictions of absolute limits to the size of the economy due to resource exhaustion have repeatedly not been borne out. For example, despite over 150 years of predictions to the contrary, food production has consistently kept up with population growth. Between 1950 and 1985, total production of major food crops increased by more than 160%, more than matching population growth (Brown 1995). Millions of people starve or are malnourished every year, but not because of an absolute shortage of food (see Amartya Sen's [1981] classic *Poverty and Famines*).

Predictions of economic limits imposed by limited resources generally fail because they are based on the assumption that limits can be calculated according to current resource use and current resource stocks. This simple view of a limit is attractive but deceptive. Consider the example of cars, steel, and iron ore. A limit on the number of cars that may be produced cannot be calculated based solely on the amount of steel in a car and the size of known iron ore reserves. Car production depends on the amount of ore that is available from known reserves with current technologically and economically feasible extraction methods, the efficiency with which ore is converted to steel, the amount of steel required in a finished car, the efficiency with which the steel is used in producing cars, usage of steel for other products, and the rate of steel recycling. Any and all of these factors can and do change.

Production in capitalist economic systems is sufficiently flexible in substituting inputs that the scale of economic activity is not likely to be limited by input constraints any time soon. For example, in the 1970s, when energy prices in the United States increased dramatically, so did energy efficiency in manufacturing. Between 1973 and 1988, total energy use in US manufacturing declined by 13%, at the same time as output (value added) increased by 52% (Schipper and Meyers 1992). Even specific inputs do not appear to be as limiting as was once commonly thought. For example, between 1976 and 1996, proven reserves of crude oil increased by 65% and reserves of natural gas increased by 140% (OPEC 1997). Ultimately, the amount of any single input, such as oil, is limited, and even current levels of natural resource use have resulted in substantial environmental destruction (e.g., the collapse of fisheries and widespread deforestation). However, neither the fact that quantities of specific resources are limited nor the fact that resource use results in environmental destruction means that economic activity as a whole is limited by input constraints.

Waste absorption limits. In the 1980s, as the specter of aggregate material or energy shortages diminished, thinking on limits turned to the issue of waste absorption. Problems of waste absorption are potentially much more difficult to address than input constraints because pollution has the potential to cause irreversible and irreparable environmental harm and because there can be long time lags in detecting adverse affects. Furthermore, although economic incentives may at times encourage substitution for depleted inputs, economic incentives often also discourage reduction of pollution and encourage firms to locate in areas with lax environmental regulations (Daly 1996). For all of these reasons, environmental degradation caused by waste production is a difficult ecological, technical, and social problem. However, the problem is not well illuminated by the concept of limits.

A limit for waste absorption analogous to the limits posited for inputs implies that only so much of a pollutant can be released in the environment before the environment will no longer absorb the waste, resulting in drastic negative consequences that ultimately curtail further dumping of wastes and that limit economic activity. However, it is difficult to find documented cases that fit the waste absorption limit model. Although release of wastes often causes environmental destruction and may also have nonlinear effects (e.g., trophic cascades and algal blooms), catastrophic threshold points are seldom observed. Moreover, despite the protestations of industry, curtailing wastes often does not entail significantly limiting economic activity. If the environmental impacts of pollution tend to be gradual and continuous, then the concept of a limit for wastes has little meaning. Consistent with the tapestry metaphor, limit points and catastrophes are not ruled out, but they are probably rare. Carbon dioxide emissions and global climate change may be the best example of possible limit points for waste absorption. Although rising carbon dioxide levels may cause a continuum of impacts due to warmer temperatures and rising sea levels, there may also be catastrophic thresholds. For example, global warming could trigger large-scale changes in ocean circulation patterns that could in turn cause large and abrupt changes in climate (Broeker 1997). Past changes in ocean circulation patterns may have been responsible for the sudden ends of earlier interglacial periods.

This argument against the idea of waste limits is not that of the technological optimists, who deny that pollution is a serious problem. Clearly, pollution is causing massive environmental destruction and affecting human well-being. For example, widespread emissions of toxic chemicals may be responsible for soaring cancer rates. Industrial chemicals are found in the bodies of wildlife in even the most remote parts of the globe (Colborn et al. 1993). However, the fact that pollution is causing environmental degradation does not necessarily mean that there are catastrophic limit points. If there is a continuum of adverse effects, humans have to decide how much pollution we are willing to emit and what levels of environmental impacts we can live with. However, there may be no threshold point at which we must stop to avoid spiraling destruction.

Entropy and primary productivity limits. Herman Daly (1979, 1996) has developed a limits analysis that combines input and waste limits into constraints on throughput and the scale of the economy. Throughput is the total volume of material and energy flowing through the economy, starting as inputs and leaving as waste. Unlike Meadows et al. (1972) in *The Limits to Growth*, Daly does not assert that we are running out of material inputs. He recognizes the flexibility of production and does not want to tie limits to the use of any specific resource for which there may be substitutes. Instead, building on work by Georgescu-Roegen (1971), Daly appeals to limits on aggregate throughput based on thermodynamics and entropy, for which there is no substitution escape. The idea is that the earth and sun constitute a closed system. The total amount of matter and energy in the system is fixed and constant; however, there is a continuous, irreversible decline in the level of entropy. Humans use low-entropy energy from the sun and fossil fuel stocks and release high-entropy wastes. Early human societies relied primarily on energy from the sun; industrialized economies now depend primarily on the limited stock of fossil fuels.

Although entropy or thermodynamic limits are, theoretically, absolute, they are meaningful only if the human economy has a chance of approaching the limit. To be useful, the idea of entropy limits needs to be at least roughly quantifiable. What are the limits, and what is the size of the current global economy relative to those limits? Daly attempts to quantify these limits by referring to an analysis by Vitousek et al. (1986) of human use of net primary productivity (NPP). NPP is the solar energy captured by plants and other photosynthetic organisms minus that used by the organisms themselves for respiration. Vitousek et al. (1986) estimate that humans currently "appropriate" 25% of potential total global NPP and 40% of potential terrestrial NPP. Daly (1996) concluded that humans are therefore only 80 years away or less (two population doubling times) from appropriating the entire NPP, which he contends would be a biological disaster.

However, there are a number of serious problems with the NPP argument. First, human use of NPP is not an appropriate metric to assess possible entropy or thermodynamic limits. Entropy represents a theoretical limit to the economy because it encompasses all available energy. NPP, on the other hand, represents only a small fraction of even just the solar energy available on Earth. An entropy or thermodynamic limit to the economy implies that total human energy use is in danger of exceeding energy availability. Yet solar energy flow to Earth is many thousands of times greater than current global energy use (Dunn 1986). Although Daly (1996) appeals to entropy and thermodynamic limits, his NPP argument is more akin to earlier input limitation scenarios. The argument that NPP is an input limit suffers from the same flaws as other input limit arguments. Unlike entropy, total NPP is not fixed and may be increased in agriculture. More important, other inputs can be substituted for the products of primary producers: direct solar energy can be used instead of firewood, and adobe, concrete, or steel can be used instead of wood for building materials.

In addition, Vitousek et al.'s (1986) estimates for human appropriation of NPP have been widely misconstrued as direct consumption figures and then used inappropriately to argue that NPP is an input limit to the economy (e.g., Goodland 1992). Appropriation of NPP in Vitousek et al.'s analysis is the sum of three separate categories: direct human use, co-opted NPP, and forgone NPP. Human consumption or direct use of NPP in the form of food, animal feed, timber, and fiber accounts for only 5.3% of appropriated NPP and only 1.4% of total NPP. Vitousek et al. (1986) measured NPP in petagrams (1 Pg = 10^{15} g) of organic material. Total global NPP was estimated to be 224.5 Pg and direct human use 7.2 Pg. The bulk (65.5%) of appropriated NPP comes from the co-opted category, which includes material "that is used in human-dominated ecosystems by communities of organisms different from those in corresponding natural ecosystems." (It should be noted that Vitousek et al. include direct use within the co-opted category; for clarity I have maintained them as separate.) Thus, the entire NPP from the world's croplands (15 Pg) was counted as co-opted, even though direct use in terms of crops harvested is approximately only 1.8 Pg (Vitousek et al. 1986). Similarly, the entire NPP (9.8 Pg) from human-created pasture lands (e.g., human-created savannas in Africa and cleared pastures from forests in Latin America) is counted as co-opted, even though livestock consume only 0.7 Pg of NPP on these lands (Vitousek et al. 1986).

If NPP is envisioned as an input limit for the economy (Daly 1996, Ludwig 1996), then including co-opted NPP is inappropriate for assessing current human use. It is as if one counted all the water behind dams as co-opted, added the volume to that directly consumed, and, based on the total, asserted that there is a water shortage. Co-opted NPP is not consumed. Most of the NPP counted as co-opted flows to nonhuman organisms—albeit an altered set of organisms. Although it is clearly not desirable, there is no reason why humans cannot co-opt NPP production on all lands (resulting in 100% appropriation). Indeed, this may have already occurred, because to some degree humans have probably altered most of the planet (Vitousek et al. 1997).

The third component of NPP appropriation is forgone NPP, the loss of potential NPP due to land conversion. Vitousek et al. (1986) conclude that forgone NPP is 17.5 Pg, or 7.2% of total potential NPP (actual global NPP plus forgone NPP). However, roughly half of estimated forgone NPP results from the questionable assumption that the NPP of agricultural lands is less than that of the natural systems they replaced. Indeed, one of Vitousek et al.'s (1986) principal sources of global NPP data assumes just the opposite (Olson et al. 1983).

Although Vitousek et al. (1986) do not claim that products of NPP for human use are in danger of running out, they do suggest that human appropriation of NPP is leading to species extinctions because the vast majority of species must exist on the NPP that remains after human use. However, NPP appropriation probably does not provide a useful measure of human impact on the biosphere or threats to species' survival. Moreover, as an index of human impact on the environment (Vitousek et al. 1986) or of the size of the human economy (Arrow et al. 1995, Daly 1996), NPP appropriation may produce perverse results. For example, because NPP appropriation treats all human-altered lands as a loss, paving over a highly diverse traditional agricultural field does not show up as an increase in NPP appropriation. Instead, it only shifts the NPP of the agricultural field from the co-opted to the forgone category. In addition, increased carbon emissions and global warming may already be causing dramatic increases in NPP (King et al. 1997, Myneni et al. 1997), which would lead to a smaller percentage of NPP appropriated by humans and wrongly indicate a reduction in human environmental impact.

Biodiversity limits. The original rivet metaphor (Ehrlich and Ehrlich 1981) referred to species extinction and biodiversity loss as a limit to human population and the economy. A wave of species extinctions is occurring that is unprecedented in human history (Wilson 1988, 1992, Reid and Miller 1989). The decline of biodiversity represents irreplaceable and incalculable losses to future generations of humans. Is biodiversity loss a case of limits, as suggested by the rivet metaphor, or is it a continuum of degradation with local tears, as suggested by the tapestry metaphor? In the rivet metaphor, it is not the loss of species by itself that is the proposed limit but rather some sort of ecosystem collapse that would be triggered by the species loss. But it is unclear that biodiversity loss will lead to ecosystem collapse. Research in this area is still in its infancy, and results from the limited experimental studies are mixed. Some studies show a positive relationship between diversity and some aspect of ecosystem function, such as the rate of nitrogen cycling (Kareiva 1996, Tilman et al. 1996). Others support the redundant species concept (Lawton and Brown 1993, Andren et al. 1995), which holds that above some low number, additional species are redundant in terms of ecosystem function. Still other studies support the idiosyncratic species model (Lawton 1994), in which loss of some species reduces some aspect of ecosystem function, whereas loss of others may increase that aspect of ecosystem function.

The relationship between biodiversity and ecosystem function is undoubtedly more complex than any simple metaphor. Nonetheless, I believe that the tapestry metaphor provides a more useful view of biodiversity loss than the rivet metaphor. A species extinction is like a thread pulled from the tapestry. With each thread lost, the tapestry gradually becomes threadbare. The loss of some species may lead to local tears. Although everything is linked to everything else, ecosystems are not delicately balanced, clocklike mechanisms in which the loss of a part leads to collapse. For example, I study California frogs, some of which are disappearing. Although it is possible that the disappearances signal some as yet unknown threat to humans (the miner's canary argument), the loss of the frogs themselves is unlikely to have major ecosystem effects. The situation is the same for most rare organisms, which make up the bulk of threatened and endangered species. For example, if the black toad (*Bufo exsul*) were to disappear from the few desert springs in which it lives, even careful study would be unlikely to reveal ecosystem changes. To argue that there are not limits is not to claim that biodiversity losses do not matter. Rather, in calling for a stop to the destruction, it is the losses themselves that count, not a putative cliff that humans will fall off of somewhere down the road.

The politics of limits

Is the limits metaphor a politically useful way to conceptualize environmental problems? If someone thinks that there is a cliff ahead in the road, she tells the driver, "There's a cliff." If that is not sufficient, she says, "It is a big cliff and we all are going to die if we go over." The limits approach assumes that "if only people understood" (i.e., saw the cliff and how big it is), they would stop their environmentally destructive practices (put on the brakes). After all, if the car crashes, everyone dies. All sane people are assumed to share a common interest in preventing a crash. The hope is that the existence and recognition of ecological limits external to society will force society to stop destructive practices. The limits perspective leads people to focus on pointing out limits and to emphasize the catastrophe that awaits if the limits are transgressed. As a consequence, writing about environmental degradation often has an apocalyptic tone.

Environmentalists have often predicted impending catastrophes (e.g., oil depletion, absolute food shortages and mass starvation, or biological collapse). This catastrophism is ultimately damaging to the cause of environmental protection. First, predictions of catastrophe, like the boy who cries wolf, at first motivate people's concern, but when the threat repeatedly turns out to be less severe than predicted, people ignore future warnings. Secondly, the belief in impending catastrophe has in the past led some environmentalists to support withholding food and medical aid to poor nations (Hardin 1972), forced sterilization (Ehrlich 1968), and other repressive measures. Not only are these positions repulsive from a social justice perspective, they also misdirect energy away from real solutions. And, by blaming poor and third world people for global environmental problems, these views have tended to limit support for environmentalism to the affluent in the first world. Fortunately, environmentalists of widely differing political perspectives, including some leading limits thinkers, now see alleviating human misery and poverty as essential to solving global environmental problems (Athanasiou 1996, Daily and Ehrlich 1996, Ehrlich 1997). In addition to recognizing the need to address poverty and inequality, recent limits writing has reduced its focus on catastrophe.

Historically, the limits metaphor has been part of a broader environmental and social analysis developed by authors such as Donella and Dennis Meadows, Paul and Anne Ehrlich, and Herman Daly. I refer to this broader analysis as the limits perspective. By focusing on aggregate quantities of natural resources, consumption, and population, the limits perspective depoliticizes our understanding of environmental destruction. What we consume, how much we consume, and how goods are produced are all political decisions that change over time and vary from country to country. Yet in the limits perspective, consumption and production technology are seen as more or less fixed, and significant social change is not even considered a possibility. In the most simplistic analyses, human population growth becomes the only variable in explaining environmental destruction. Similarly, many biologists who write on environmental issues erroneously apply the concept of carrying capacity to human society, and as a result ignore the social and political aspects of resource use. In animal populations, carrying capacity is the maximum population that can be sustained on the available resources in a given area. For human societies, however, carrying capacity has no real meaning unless consumption, technology, and a whole host of social variables are set at fixed levels (Cohen 1995). Viewing technology, consumption, and all social variables as fixed is implicit in the limits perspective, yet these variables are key to understanding the problem (Cohen 1995). For this reason, a recent high-profile statement of the limits perspective (Arrow et al. 1995) suggests moving away from the use of the carrying capacity concept.

The environmental destruction that is decried by the limits perspective is often real, even if it does not result from a transgressed limit, but there is something missing from this perspective. The focus on the cliff and catastrophe means that important political questions are often not asked: Why are we driving so fast? Who benefits from driving in this manner? Who has the right to decide how we drive and why? What views and beliefs support the current arrangements? Who benefits least from the current arrangements and might support change?

An alternative approach

The multiple threads of a tapestry together form a picture. Similarly, to better understand and challenge environmental destruction, it is necessary to examine the multiple factors shaping consumption and production and move beyond the singular focus of the limits perspective on aggregate population and resources. This approach means examining economic structures, social relationships of power and ownership, control of state institutions, and culture. For example, in the limits perspective, urban sprawl in western US cities is viewed as attributable principally or solely to population growth. Although population is an important factor, the limits perspective's focus on population leaves out other, equally important factors: economic incentives for developers to build large houses at low density, real estate interests' dominance of zoning and land-use planning decisions, and government funding for sprawl-inducing freeways instead of urban mass transit. All of these political, social, and economic factors are key for understanding sprawl, and, more important, for doing something about it.

The political–ecological approach is part of a growing body of research by geographers, anthropologists, economists, and biologists that draws on biological and social sciences to understand environmental problems. An excellent example is from Vandermeer and Perfecto (1995), who analyze the political and ecological causes and consequences of deforestation in Costa Rica. Other examples from very different perspectives include a collection by Painter and Durham, *The Social Causes of Environmental Destruction in Latin America* (1994), Richard Norgaard's *Development Betrayed* (1994) about the Amazon, and a recent critical review by Peet and Watts (1996).

Conclusions

The claim that, for the most part, there are not biophysical limits to economic growth may disturb many environmentalists. Dropping the limits/catastrophe paradigm is unattractive if one believes that appealing to people's rational desire to avoid a crash is the only way to motivate change and stop environmental destruction. The tapestry metaphor and the related political–ecological approach may be seen as pessimistic because they suggest that there are no external limits that are going to force a stop to environmental destruction. Without the threat of catastrophic limits, there is no guarantee of a fundamental commonality of interests to stop destructive practices. If environmental degradation is often gradual and continuous rather than catastrophic, then those in power who benefit materially from our current destructive economic system will fight to maintain the status quo.

However, the tapestry metaphor and the political–ecological approach have a hopeful side. Halting destructive processes is a political struggle that requires people to see beyond the aggregate numbers of resources, consumption, and population to understand the political, economic, and social forces responsible for environmental destruction. A political–ecological analysis often reveals that levels of consumption and destructive production processes are not fixed and inevitable but rather the result of political, economic, and cultural decisions that are subject to change. Environmental movements in many countries have been successful in bringing about significant changes, often against powerful political interests. For example, the US Clean Air and Clean Water Acts have greatly reduced air and water pollution. A political–ecological approach can illuminate possible solutions to environmental problems that may be obscured by the limits perspective. Finally, a political–ecological approach ties environmental issues to broader struggles for social justice and points to potential allies for conservation.

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