Center for the Study of American Business

Are Economic Growth and a Sustainable Environment Compatible?

by Kenneth W. Chilton

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Washington University in St. Louis

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This booklet is one in a series designed to enhance understanding of the private enterprise system and the key forces affecting it. The series provides a forum for considering vital current issues in public policy and for communicating these views to a wide audience in the business, government, and academic communities.

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Introduction

With nearly 6 billion people on Earth and daily warnings in the media of global climate change, threats of species loss, rainforest destruction and more, it is not surprising that many have become concerned about whether human beings threaten "life on earth as we know it." These global-scale challenges raise the issue of how to sustain the environment while providing for the material needs and wants of Earth's growing population.

This concern grew during the 1970s and 1980s, culminating in the 1992 Earth Summit in Rio de Janeiro. The report providing the springboard for Earth Summit was the United Nations Commission on Environment and Development's *Our Common Future*. It was also the document that popularized the term "sustainable development"—an attempt to reconcile the need to provide for economic development with the desire to preserve (sustain) the earth's natural heritage.

Our Common Future (also known as the Brundtland Report after the chair of the Commission, Gro Brundtland) defined sustainable development as the ability of humanity "to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."[1] This definition has been widely embraced but is not easily put into practice. Taken to the extreme, it could be interpreted to mean that no non-renewable resource can be used by this generation or, for that matter, any succeeding generation.

This paper attempts to examine the problem of reconciling economic aspirations with environmental concerns, primarily from an economist's perspective. The first section outlines the tenets of two economic camps grappling with this issue—ecological economists and mainstream (market) economists. The second portion examines some of the sustainability concerns of ecologists and biologists. In particular, it briefly reviews two measures of humanity's environmental footprint and discusses what may be some of the root causes for these concerns. Next, previous prophecies of some prominent environmentalists are reviewed and an economic explanation is offered for their poor track record. The fourth section goes beyond the concerns of the sustainable development movement to examine the implications of their policy prescriptions. How feasible are these solutions? Do they really address fundamental

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causes? The final section reviews the findings and returns to the question raised in the title, "Are economic growth and a sustainable environment compatible?"

Ecological Economics versus Mainstream Economics

Ecological Economics

Ecological economics has sprung up as a response to the challenge to reconcile economic aspirations with global ecological concerns. Ecological economists see mainstream economics as unresponsive to the environmental and social spheres of life. They tend to side with environmentalists who criticize mainstream economics for its unrealistic assumptions of perfect competition, perfect information, free trade, and individual rationality.[2]

Two of the leading ecological economists, Herman Daly and Robert Goodland, offer an alternative definition of sustainable development as "development without growth in throughput of matter and energy beyond regenerative and absorptive capacities."[3] Daly and Goodland elaborate that "environmental sustainability...seeks to improve human welfare and social sustainability by protecting the sources of raw materials used for human needs and ensuring that the sinks for human wastes are not exceeded."[4]

This principle of holding the use of resources to their regenerative capacity and the wastes from human activities to the capacities of ecological sinks (air, water, and land) to absorb them leads to the concept of carrying capacity. The ecological economist's definition of carrying capacity is "the maximal population size of a given species that an area can support without reducing its ability to support the same species in the future."[5] The species in question is *Homo sapiens* and the area of concern is Earth. Will we humans so foul our own nest that we threaten our very survival?

Economic growth (at least in developed nations) is, in general, anathema to ecological economists. In their view, economic growth—producing greater amounts of products and services by increased use of resources—threatens the environment. Economic *development* is considered a more neutral term. It is an expansion in the qualitative value added by economic activity that does not increase the use of resources.

Though we will return to policy prescriptions later, it is instructive to see where this notion of sustainable development leads. According to Goodland and Daly, "Poor, small, developing economies need both growth and development. Therefore, the rich countries, which are responsible for most of today's global environmental

damage...and whose material well being can sustain halting or even reversing throughput growth, must take the lead....[M]ore growth for the South must be balanced by negative throughput growth for the North if environmental sustainability is to be achieved."[6] Thus, not only intergenerational equity with regard to access to natural resources is in view, but also contemporaneous equity between developed and developing nations.

Mainstream (Market) Economics

Only a very brief discussion of the principles of mainstream or market economics will be presented here. Economists may be offended by this simplistic rendition of their science, but other readers will likely be relieved.

Mainstream economics focuses first and foremost on attempting to describe how a market economy works. The emphasis is on how scarce resources are efficiently allocated to meet consumer desires through market-determined prices and private property rights.

The criticism leveled at mainstream economics regarding its simplistic assumptions would not ruffle the feathers of such an economist. These assumptions keep the market model simple, allowing the implications of the model to be analyzed. Of course, the proof is in the pudding—does this stylized depiction of consumers and markets lead to useful predictions about how the real economy works?

Market economists are not oblivious to the idea that the economic marketplace does not capture all environmental costs that result from production of goods and services.

Regardless of the assumptions of perfect competition, perfect information, free trade, and individual rationality in the idealized model, a capitalistic economy does efficiently allocate scarce resources to the goods and services most desired by consumers. The price system sends signals on the strength of consumer demands and on the scarcity of resources—throughputs, as Goodland and Daly call them—needed to address those demands. High-priced throughputs will flow to those applications most highly valued by the marketplace. Private property protections afforded in a capital-

istic system are critical to furnish the rewards necessary to motivate individuals to employ their resources—intelligence, skills, finances—to create new products and services or to improve on processes that produce current economic outputs.

Market economists are not oblivious to the idea that the economic marketplace does not capture all environmental costs that result from production of goods and services. Indeed, pollution is one form of "externality" widely discussed in mainstream economics literature. Because no one owns the rights to the air, for example, air polluters do not have to pay for the privilege of using this sink. As a result, air pollution could reach levels that might harm public health and the environment.

But the activities of actors in real economies are proscribed by rules set down by political agents. Air quality in nearly all democratic political systems is protected, to one degree or another, by regulatory action or by injunctive relief in the courts.

The activities of actors in real economies are proscribed by rules set down by political agents. Air quality in nearly all democratic political systems is protected, to one degree or another, by regulatory action or by injunctive relief in the courts.

The idea is to make polluters internalize the external costs of pollution. Whether regulations require companies to install pollution abatement equipment explicitly or whether the threat of injunctions causes such investments, pollution sources begin to include their costs for purchasing and operating such equipment in the prices they charge for their products.

Another method of internalizing pollution costs is to impose a tax on pollution sufficiently high that it is cheaper for pollution sources to install pollution abatement equipment than to pay the tax. The advantage of this approach—a Pigouvian tax (named after economist A.C. Pigou)—is that it doesn't lock in abatement technology the way that command-and-control regulation does. A polluting firm can reduce its tax liability by devising any type of solution that reduces emissions. Calculating the correct level of the tax is challenging, but pollution taxes are used in many developed econo-

mies, most successfully in the Netherlands.

Ecological environmentalists are not necessarily swayed by mainstream economists' solutions to these market failures. They argue that the environment is so complex that no such internalization of the true costs of environmental degradation is possible. Indeed, one ecological economics textbook states:

> The conflict between economic activity and environmental quality is not merely the result of "market failure," or of the fact that real-life market economies are not perfectly competitive. The economy-environment conflict ultimately arises from the *impossibility* of economic markets to place ecologically meaningful values on the functions and attributes of the biophysical world.[7] (Emphasis added.)

The disagreement between ecological economists and market economists seems based on the differences in their central focus. Ecological economists are primarily concerned with ecology and see the economy as negatively impacting the environment. Mainstream economists focus on the economy and view its impact on ecology as an external cost that needs to be taken into account in economic decision making. They do not see economic activity as the inherent enemy of the environment.

How Large is Humanity's Footprint on the Earth?

The debate between ecological economists and market economists would be of little consequence if the impacts of human activities on ecological systems were believed to be relatively small. But a variety of sources believe that the human footprint on Mother Earth is large and growing.

While the voices have become louder since the late 1960s, concern for the fate of humanity and the planet date from the late 1700s. In 1798, Thomas Malthus, an English clergyman and economist, predicted that population growth would soon outstrip agricultural production, producing starvation and disease. Malthus reasoned that the survivors would be destined to an existence of bare subsistence.

Another English economist, William Stanley Jevons, believed that coal supplies would soon run out (in 1865), bringing industrial progress to a grinding halt. Jevons wrote, "Our present happy progressive condition is a thing of limited duration."[8]

Ecological economists Herman Daly and Robert Goodland assert: "[W]hat is not contestable is that the current modes of production prevailing in most parts of the global economy are causing the exhaustion and dispersion of a one-time inheritance of natural capital, such as topsoil, groundwater, tropical forests, fisheries, and biodiversity."[9] This statement may be more contestable than Daly and Goodland think, especially if the allegations are directed at the economic activities of developed nations. But this important debate over the source of ecological problems will have to unfold gradually as this study progresses.

Many ecologists and biologists have been making sincere efforts to find measures of humanity's impact on the planet. Their analyses are generally less emotionally charged than those of environmentalists and ecologists concerned with influencing public policy. This information is important for increasing public awareness of environmental problems.

A recent article in *Science* by Stanford biologist Peter M. Vitousek et al. provides several measures of human impacts on ecosystems.[10] The abstract for the article reads:

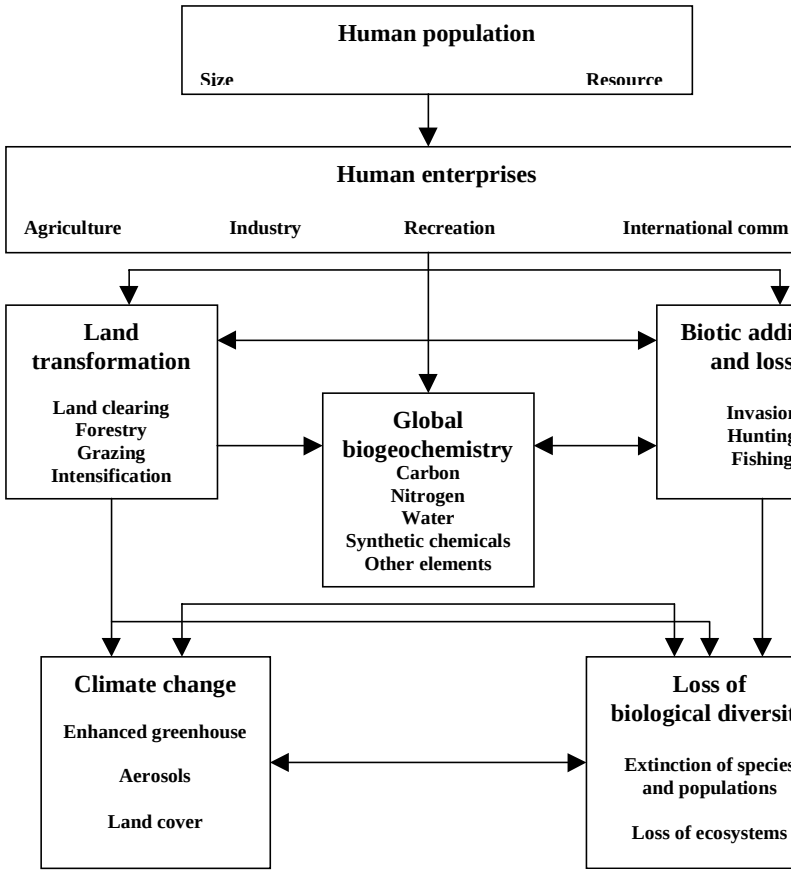
> Human alteration of Earth is substantial and growing. Between one-third and one-half of the land surface has been transformed by human action; the carbon dioxide concentration in the atmosphere has increased by nearly 30 percent since the beginning of the Industrial Revolution; more atmospheric nitrogen is fixed by humanity than by all natural terrestrial sources combined; more than half of all accessible surface fresh water is put to use by humanity; and about one-quarter of the bird species on Earth have been driven to extinction. By these and other standards, it is clear that we live on a human-dominated planet.

Vitousek and his co-authors offer a simplified diagram of how humans affect the Earth's ecological systems. Population size and resource use, operating through agriculture, industry, recreation and international commerce, transform the land, change the global distribution of species and alter global bio- and geochemistry (see Figure 1).

The intent of their paper, say the authors, is to "explore how large humanity looms as a presence on the globe." The article "is not intended as a litany of environmental disasters ... nor is it intended either to downplay or to celebrate environmental successes ..."[11] Likewise, the papers that derive the measures that Vitousek cites and

Figure 1

A Model of Humanity's Direct and Indirect Effects on Earth Systems



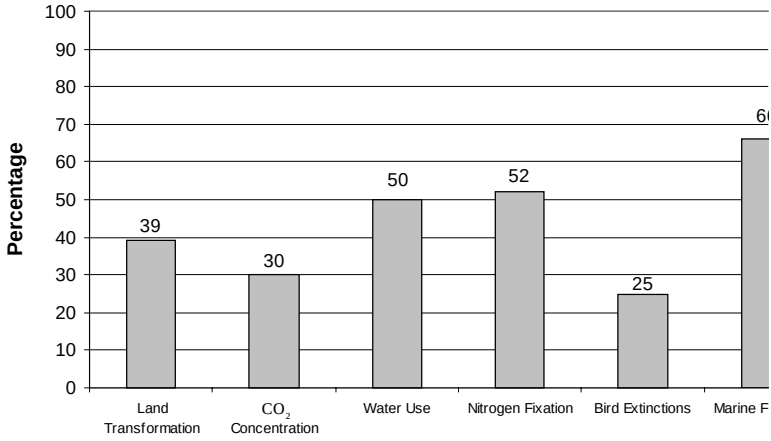
Source: Vitousek et al., "Human Domination of Earth's Ecosystems," *Science* 277 (1997), 494.

discusses are serious attempts by responsible scientists to determine the scope of human impacts on the rest of creation.

Figure 2 is a composite of these findings. Clearly, it is an eclectic set of measures, ranging from the percentage of land transformed (actually the fraction of the land's biological production used or co-opted), to the increase in greenhouse gas concentrations due

Figure 2

Human Dominance or Alteration of Several Major Components of the Earth System



Notes: Column 1. Percentage of the land's biological production used or dominated.
Column 2. Percentage of the current atmospheric CO_2 concentration that results from human action.
Column 3. Percentage of accessible surface fresh water used.
Column 4. Percentage of terrestrial N fixation that is human-caused.
Column 5. Percentage of bird species on Earth that have become extinct in the past two millennia, almost all of them as a consequence of human activity.
Column 6. Percentage of major marine fisheries that are fully exploited, overexploited, or depleted.

Source: Adapted from Vitousek et al., "Human Domination of Earth's Ecosystems," *Science* 277 (1997), 495.

to anthropogenic sources, to the fraction of bird species on Earth that have become extinct in the past 2,000 years. While the percentages are large enough to make one pause, the significance of each of these measures cannot be ascertained without more detailed analysis. Rather than bog down the reader with an examination of each measure, a subset will be discussed. The following pages elaborate on the concept of human appropriation of the products of photosynthesis and examine human impacts on biodiversity.

Human Appropriations of the Products of Photosynthesis

One of the most cited papers attempting to provide a sense of humanity's footprint on the Earth also had Peter Vitousek as lead author (Paul and Anne Ehrlich and Pamela Matson were co-authors). This 1986 *BioScience* article was titled, "Human Appropriations of the Products of Photosynthesis."[12] The authors acknowledge that "the information presented cannot be used directly to calculate Earth's long-term carrying capacity for human beings because, among other things, carrying capacity depends on both the affluence of the population being supported and the technologies supporting it."[13] Yet, this is how these estimates are largely used by many ecological economists, environmentalists, and policy-active ecologists and biologists.

Indeed the authors themselves draw rather sweeping conclusions. They write: "The co-option, diversion, and destruction of these terrestrial resources clearly contributes to human-caused extinctions of species and genetically distinct populations .... This decimation of biotic resources will foreclose numerous options for humanity because of the loss of potentially useful species and the genetic impoverishment of others that may survive."[14] Are these implications really warranted based on the analysis?

If only the organic material directly used by people or domestic animals, both terrestrial and aquatic, is included, Vitousek et al. estimate that humans use about 3 percent of the biosphere's annual products of photosynthesis—net primary production (NPP). If the NPP co-opted by humans—the amount directly used plus pasturelands and forest plantations—is the measure, then 19 percent of NPP is appropriated by humans: 31 percent of land-based and 2 percent of aquatic NPP. The highest estimate includes NPP co-opted and *potential* NPP lost due to human activities. That estimate is 25 percent overall—39 percent of land NPP and 2 percent of aquatic products of photosynthesis. The figure most frequently quoted is the nearly 40 percent of land-based NPP that includes even forgone net primary production—what NPP might have been if humans had *no* impact on the environment.

Even the intermediate case, which includes direct use and co-optation, amounting to 31 percent of land-based NPP, paints a rather distorted picture. To be sure, pasturelands, city parks, residential lawns, and tree farms do not support as diverse flora and fauna as virgin forests or grasslands, but they are not biologically sterile either.

Mark Sagoff, senior research scholar at the University of Mary-

land Institute for Philosophy and Public Policy, points out that rising population and economic growth do not necessarily portend greater co-optation of biotic resources. He writes:

> Between 1950 and 1989, the global output of major food crops rose by 160%, more than keeping pace with world population. Most of the increase is attributed to improved yields, not to the use of more land. *As a result of greater yields, the United States now idles 50 million acres of farmland in conservation reserves, and the nation is far more forested than a century ago, while remaining a major net food exporter.* Other industrialized nations, also net agricultural exporters, have seen farms revert to forest.[15] (Emphasis added.)

It simply is not possible to predict the impact of humanity on biodiversity from these gross estimates of our co-optation of net primary production.

To proceed to the next step—to predict serious effects on humanity—is even more unwarranted. When the authors conclude that biotic resources are being "decimated" and that this decimation will, in turn, "foreclose numerous options for humanity" because of species loss and "genetic impoverishment" of surviving species, they are engaging in hyperbole. Biodiversity may be threatened by human activities, but one must examine this question more directly to assess the level of threat and its causes.

Threats to Biodiversity

Numerous efforts have been made to estimate the level of threat to other species sharing the planet with *Homo sapiens*. One of the most recent is by Stuart Pimm and Thomas Brooks, presented at the Biodiversity Forum in Washington, D.C., in October 1997.[16] Their paper attempts to answer three questions: (1) How many species will we lose? (2) Will these losses occur across the globe, or are some areas more vulnerable than others? and (3) How quickly will species disappear—do we have years, decades, or centuries to mitigate our current actions?

Pimm and Brooks caution that "many important justifications for protecting biodiversity emerge from populations, not species" and that their estimates for species loss "must be substantial underestimates of these effects on populations."[17] They also acknowledge that the vast majority of species that ever lived are

now extinct. So the real question is, "How much faster than one would expect are species going extinct?"

The two biologists first set about comparing current extinction rates with historic rates. Fossil records indicate that species persist for 1 million to a few million years. There are 1.5 million named species; therefore, one would expect to see one or two species become extinct each year.

It simply is not possible to predict the impact of humanity on biodiversity from these gross estimates of our co-optation of net primary production.

"Within small subsets of species, we would expect to wait longer to see just one extinction—a little less than a century [for a single species] for the 10,000 species of birds for example," write Pimm and Brooks.[18] In the last 2,000 years, the 10,000 bird species have suffered "one or a few" extinctions annually. Thus, humanity has increased the bird extinction rate by a factor of several hundred. These extinctions have been concentrated in islands in the Pacific. Pimm and Brooks estimate that, "over the last few thousand years, humans eliminated over 10% of the world's bird species and locally over 90% of them."[19] Note that Pimm and Brooks' estimate of bird species loss is about half that reported in Vitousek et al.'s 1997 roundup of measures of human domination of ecosystems, providing some perspective on the uncertainty about current extinction rates.

According to Pimm and Brooks, these extinction rates are similar to extinction rates for other types of animals and plants. "Surveys of many groups of plants and animals uncover rates of extinction at least several hundred times the rate expected on the basis of the geological record. These groups are very diverse in their natural histories and evolutionary origins. With high statistical confidence, they are typical of the many groups of plants and animals about which we know too little to document their extinction," say the two biologists.[20]

Pimm and Brooks suggest three general ecological principles that make species vulnerable to extinction:

An Alternative Assessment of Biodiversity and Species Loss

Recent estimates of the total number of species range from 7 to 20 million, out of which we believe a good working estimate is about 13 to 14 million. Only about 1.75 million species have been described scientifically, of which slightly under a fifth are plants or vertebrates (see Table 1). Even for the 1.75 million species described there is no comprehensive listing.

Northern temperate forests have changed dramatically in North America and Europe as a consequence of intensive logging, exploitation, and replanting, often with introduced species, over the last several hundred years. In terms of total area, forest and woodland communities have decreased globally by about 15% since pre-agricultural times. Northern temperate forests are currently relatively stable in total area. In the early to mid-1980s, humid tropical forests were losing approximately 10 million hectares, or just under 1% per year globally, although there is good evidence that rates of forest conversion in parts of Central and South America have declined since. Dry tropical forests may have lost even more area.

If recent rates of loss of closed tropical forest (about 1% globally per year) were to continue for the next 30 years, the equilibrium number of species in the forest, as calculated by species-area techniques, would be reduced by approximately 5 to 10%. These potential extinctions would not be immediate: it could take decades or even centuries to reach the new equilibrium number of species.

These estimates do not take into account the potential effects of fragmentation, increases or reductions in the rate of deforestation, or the potential effects of mitigative measures that might be taken in the interim that could retard or even prevent extinctions, such as the setting aside of protected areas which include "hotspots" or concentrations of species' diversity.

Excerpted from *Global Biodiversity Assessment: Summary for Policy-Makers*. United Nations Environment Programme (Cambridge: Cambridge University Press, 1995) pp. 16, 18, 21, 25.

Table 1

Approximate Numbers of Species in Major Groups

(in thousands)

Group	No. of described species[1]	Est. total no. of species in group	% of species known	Group	No. of described species[1]	Est. total no. of species in group	% of species known
Vertebrates	45	50	90.0%	Algae[2]	40	400	10.0%
Plants	270	320	84.4%	Nematodes	25	400	6.3%
Molluscs	70	200	35.0%	Fungi	72	1,500	4.8%
Crustaceans	40	150	26.7%	Viruses	4	400	1.0%
Protozoa[2]	40	200	20.0%	Bacteria	4	1,000	0.4%
Insects	950	8,000	11.9%	Others[3]	115	250	46.0%
Arachnids	75	750	10.0%	**Totals**	**1,750**	**13,620**	**12.8%**

Note: 1. Estimated number of described species that are accepted today.
2. The Protozoa and Algae are interpreted here in a broad sense.
3. Mainly little-known animal groups.

Source: Table 1, *Global Biodiversity Assessment: Summary for Policy-Makers*, United Nations Environment Programme (Cambridge: Cambridge University Press, 1995), p. 18.

- Many species have very small range sizes, relative to the average range size.
- Species that have small ranges are typically less abundant than species that have large ranges.
- Species with small ranges are often geographically concentrated, resulting in "hot spots of endemism."

These principles lead to the conclusion: "Many species are rare and local and so at particular risk from humanity's impact. Such species are not spread evenly; extinction will be geographically clumped, like broken eggs in a dropped basket."[21]

Not surprisingly, then, the fraction of species that will become extinct depends primarily on whether policies protect range-restricted species. The good news, say Pimm and Brooks, is that vulnerable species are concentrated, so saving them requires relatively little area. The bad news is that many of these are areas with rapidly growing human populations in less-developed countries with little wherewithal to protect species.[22]

Many species are rare and local and so at particular risk from humanity's impact. Such species are not spread evenly; extinction will be geographically clumped, like broken eggs in a dropped basket.

The next challenge is to answer the question of how long we have to solve the problem of species loss due to habitat reductions—fragmentation. Working primarily with data on forest bird populations, the two biologists predict: "Fragments lose half the species they are going to lose in about 50 years. In a century, they will lose 75% of their species."[23] Given that 10 percent of the world's 10,000 bird species are threatened with habitat loss and fragmentation, some 500 species will become extinct in 50 years, or a rate of 1,000 extinctions per million species a year. They consider this a conservative estimate for other groups of species because it assumes that habitat destruction will freeze at current levels, whereas tropical deforestation is accelerating.[24]

The *worst-case scenario* is that only 5 percent (the current global percentage of land protected in nature preserves) of the world's

tropical forests will be protected. If, as Peter Raven (director of the Missouri Botanical Garden) has suggested, these tropical forests contain as many as two-thirds of all the planet's species, then using the species-to-area relationships that Pimm and Brooks have developed suggests that the Earth would eventually lose half of these species—one-third of all species.[25]

It appears that the current best estimate of future species loss lies somewhere between 1,000 extinctions per million species a year (assuming habitat loss is frozen at its current state) and the worst-case scenario of "eventual loss" of one-third of all species (if only 5 percent of critical habitat can be protected). Both ends of this range are very rough estimates and could be criticized by some as being too optimistic or by others as too pessimistic. (See the box, "An Alternative Assessment of Biodiversity and Species Loss," to obtain added perspective on the projected dimensions of species loss.)

Pimm and Brooks answer their original three questions as follows:

1. How many species will we lose? *Somewhere between one thousand species per million annually and one-third of <u>all</u> species eventually.*

2. Will these losses occur across the globe, or are some areas more vulnerable than others? *"Nature has put her eggs—species with small geographical ranges, which typically have relatively low densities—into a few baskets, the hot spots."*[26]

3. How quickly will species disappear? *"Very soon: we can expect to see widespread extinctions in fragmented habitats within 50 years...."*[27]

Policy Implications. One of the most important findings of research on biodiversity is that the key to protecting large numbers of sensitive species is to protect critical ecological hot spots. Various authorities have attempted to identify these areas. Table 2 lists 24 global biodiversity hot spots identified by Conservation International (CI).

Many of the names on this list are unfamiliar to the average person. And these "spots" can be rather vast. What CI refers to as Mesoamerican Forests includes almost all of Central America and southern Mexico. Within this broad region, some areas have already been set aside. Nearly 25 percent of Costa Rica is under some form of protection and 10 percent of Panama is protected.[28]

Costa Rica and Panama have joined forces to create La Amistad

Table 2

Global Biodiversity Hot Spots

1. Tropical Andes
2. The Mediterranean Region Complex
3. Madagascar and Indian Ocean Islands
4. Mesoamerican Forests
5. Caribbean
6. Indo-Burma
7. Atlantic Forest Region
8. Philippines
9. Cape Floristic Province
10. Eastern Himalayas
11. Sundaland
12. Cerrado
13. Southwestern Australia
14. Polynesia and Micronesia Island
15. New Caledonia
16. Darien/Choco/Western Ecuador
17. Western Ghats and Sri Lanka
18. California Floristic Region
19. Western Cape/Succulent Karoo
20. New Zealand
21. Central Chile
22. Guinean Forests of West Africa
23. Wallacea
24. Eastern Arc Mountains, Coastal Forest

Source: Conservation International web site at http://www.conservation.org/hotspots/priority.htm.

Bi-National Park and Biosphere Reserve. The core of La Amistad is a 667,000-hectare conservation area. The reserve is home to more than 10,000 species of plants, 30 to 40 percent of which are exclusive to this area.[29]

Conservationists became concerned with the threats to La Amistad from forest fires and agricultural conversion of forests surrounding the park. As a result, Conservation International teamed up with the Tropical Science Center in Costa Rica and FUNDESPA, a non-governmental organization in Panama, to establish the AMISCONDE project (AMISCONDE is an acronym for the Spanish words meaning friendship, conservation, and development). The project set up an easy credit system, managed by local farmers, to establish soil conservation projects and profitable, environmentally friendly products and businesses.

Hundreds of acres of land not suitable for agriculture have been reforested, and other cleared lands have been left to regenerate naturally. Luis Murillo, former AMISCONDE director in Costa Rica, credits the project's success to efforts to involve local residents in all activities.[30]

Government ownership of vast tracts of land in developing nations does have its downside, however. Government management of multiple-use resources will serve political interests, which may not always coincide with what is best for citizens. It is unlikely,

however, that private ownership alone could be relied upon to protect such vast expanses of sensitive ecological hot spots. Nonetheless, ultimate protection of biodiversity cannot be assured unless the material needs of indigenous peoples are also met, and this often means providing and enforcing property rights.

A survey article on "Development and the Environment" in the March 21, 1998, issue of *The Economist* highlighted the economic development and conservation challenges facing poor nations with rapidly growing populations.[31] For example, the Brazilian Amazon shrank between the 1960s and the early 1990s because government policy intentionally promoted settlement of the region. The policy was meant to provide a safety valve for the growing concentrations of landless poor in Brazil's coastal areas.

The government encouraged colonization by building roads and schools. Land ownership required that the settlers develop the land, i.e. clear it or lose title. Rainforest land loses its fertility after a few years of agricultural use, so farmers would clear new parcels of land as previously cleared space lost its productivity. As a result, deforestation was accelerated by colonization. Brazilian authorities also offered tax breaks to companies for development of the region, leading to large cattle ranches and more deforestation.

Though it may seem crass, it behooves policymakers and those who wish to influence environmental policy internationally to be clear about the reasons for preserving species.

As the cost of these policies became more obvious (and environmentalist pressure increased), the government changed its policies. Landowners were prohibited from logging more than 50 percent of their land; this limit was then lowered to 20 percent. Nonetheless, according to satellite data, deforestation in the Brazilian Amazon reached an all-time high in 1995 of 29,000 square kilometers out of 5 million square kilometers (less than 1 percent). In 1996, 18,100 square kilometers were lost. The Brazilian government estimates that 80 percent of the timber in the region is harvested illegally. Furthermore, Indians, squatters,

and loggers often use fire as a weapon against each other. Ownership rights are tenuous at best.

Plantation forestry can be as profitable as logging virgin timber, and has the advantage of selecting the most profitable species to cultivate. Without secure property rights, however, plantation forestry has no chance of success. Fires or encroachment by squatters could easily destroy any investment in trees that would take 20 years to mature. *The Economist* article concludes: "The sort of policies that might help developing countries to reduce their rate of deforestation are also the sort of policies that are likely to promote economic growth: upholding the rule of law, securing property rights, weeding out corruption and reducing subsidies."[32]

Significance of Biodiversity. Though it may seem crass, it behooves policymakers and those who wish to influence environmental policy internationally to be clear about the reasons for preserving species. Often, "biodiversity prospecting" to discover new pharmaceutical products has been offered as a fundamental reason to protect rainforests and other critical habitat.

Aspirin, quinine, and several cancer-fighting drugs such as vincristine, vinblastine, and taxol are derived from higher plants. About one-third of all prescription drugs are derived from 250,000 species of higher plants.[33]

A recent study by economists at Resources for the Future (RFF) attempts to calculate an economic value for species preservation based on their potential for developing new drugs to benefit mankind. The researchers build upon the work of others who have tried to make this evaluation but failed to take scarcity into account. If beneficial chemicals can be derived from a number of similar species, rare variant sources are of far less value than supposed.

The RFF study values "the marginal species on the basis of its incremental contribution to the probability of making a commercial discovery."[34] Using fairly generous assumptions about the expected return to new product research and discounting future revenues at a 10 percent annual rate, the researchers calculated the maximum possible value of the marginal species at slightly less than $10,000.[35]

Applying the widely used model from ecological literature of the relationship of species extinction to habitat destruction (incorporated by MacArthur and Wilson in their theory of island biogeography), the RFF economists calculated values for habitat preservation in 18 biodiversity hot spots. Because the number of endemic plant species vary in these hot spots, the maximum

amount that pharmaceutical firms would, theoretically, be willing to pay to preserve a hectare of land in each of them also varies. These values range from nearly $21 a hectare in western Ecuador to $2 in Tanzania to just 20 cents a hectare in the California Floristic province (see Table 3).

As the authors of this report correctly point out, their findings do not imply that we should not be concerned about loss of biodiversity. Rather, they find that the amounts that pharmaceutical companies might be willing to pay to preserve habitat for biodiversity prospecting purposes are not likely to make a significant difference in policies affecting these critical areas.

The RFF study is not beyond criticism, of course. In particular, some take umbrage with the 10 percent discount rate used because of its dramatic lowering of the payoffs from long-term research. Given that the objective of the analysis is to estimate the value of plant biodiversity to pharmaceutical firms, not to nonprofit or public institutions, the discount rate used is not unreasonable.

An unpublished paper by David Pimentel estimates the value of over-the-counter, plant-based drugs at $84 billion annually. Pimentel also suggests that ecotourism is worth another $500 billion a year.[36]

The rejoinder to these estimates from one of the RFF authors, R. David Simpson, is that "it is the marginal value—the value of doing a little more of something—that determines economic behavior."[37] There are many useful materials to be drawn out of tropical rainforests and many potentially attractive spots to be visited by ecological tourists. But this is bad news for valuing a particular biological hot spot. The existence of many substitute sites for pharmaceutical prospecting or ecological tourism means that the value of any single site, at the margin, is low.

Simpson does not conclude, however, that biodiversity is not worth protecting. The world's wealthier people view biodiversity as an asset that is becoming more scarce, largely because they can afford to be concerned about such things. "It is up to us, then to put up the money to make conservation attractive to the poor," says Simpson.[38]

In an article for *BioScience* on carrying capacity and ecological economics, Mark Sagoff cites biologist E.O. Wilson's view that destruction of biodiversity is the crime for which future generations are the least likely to forgive us. Sagoff says, "The crime would be as great or even greater if a computer could design or store all the genetic data we might ever use or need from the destroyed species.

Table 3

Theoretical Maximum Willingness of Pharmaceutical Firms to Pay to Preserve a Hectare of Land in 18 Biodiversity Hot Spots

Hot Spots	Present Forest Area (1,000 ha)	Number of Plant Species	Proportion of Plant Species Endemic to Region	Endemic Plant Species per Hectare	Maximum Willingness to Pay
Western Ecuador	250	8,750	0.25	0.00875	$20.63
Southwestern Sri Lanka	70	1,000	0.50	0.00714	$16.84
New Caledonia	150	888	0.89	0.00527	$12.43
Madagascar	1,000	3,550	0.82	0.00291	$ 6.86
Western Ghats of India	800	4,050	0.40	0.00203	$ 4.77
Philippines	800	3,595	0.44	0.00198	$ 4.66
Atlantic Coast Brazil	2,000	7,500	0.50	0.00188	$ 4.42
Uplands of Western Amazonia	3,500	15,383	0.25	0.00110	$ 2.59
Tanzania	600	1,600	0.33	0.00088	$ 2.07
Cape Floristic Province of South Africa	8,900	8,600	0.73	0.00071	$ 1.66
Peninsular Malaysia	2,600	5,799	0.28	0.00062	$ 1.47
Southwestern Australia	5,470	3,630	0.78	0.00052	$ 1.22
Ivory Coast	400	2,770	0.07	0.00048	$ 1.14
Northern Borneo	6,400	6,856	0.39	0.00042	$ 0.99
Eastern Himalayas	5,300	5,655	0.39	0.00042	$ 0.98
Columbian Choco	7,200	9,212	0.25	0.00032	$ 0.75
Central Chile	4,600	2,900	0.50	0.00032	$ 0.74
California Floristic Province	24,600	4,450	0.48	0.00009	$ 0.20

Source: R. David Simpson, Roger A. Sedjo, and John W. Reid, "Valuing Biodiversity for Use in Pharmaceutical Research," *Journal of Political Economy* 104, no. 1 (1996), 181.

The reasons to protect nature are moral, religious, and cultural far more often than they are economic."[39]

Summary

Examination of humanity's footprint on the earth indicates that our effect on the environment should not be ignored. The measures offered by Vitousek and his fellow authors do not, in and of themselves, tell us how threatened the planet is because of our presence, however.

If wealthy people in developed countries wish to protect these hot spots of biodiversity, they must find ways to provide economic benefits from protection.

As we analyze the causes of species loss and the prospects for the future, we find that the key ecological areas of concern are primarily in nations whose economies are still developing. If wealthy people in developed countries wish to protect these hot spots of biodiversity, they must find ways to provide economic benefits from protection. The residents of these developing nations will not accept ecological colonialism but, rather, must benefit more from preservation policies than they do from exploitation of their ecological heritage.

Failed Doomsday Prophecies

Numerous environmentalists, ecologists, biologists, and social scientists have made bold (and gloomy) assessments of the effects of human activities on the planet. And they have not been shy about offering global policy prescriptions.

From the late 1960s through the 1980s, a number of books forecast serious problems for humanity and the planet. Paul Ehrlich's *The Population Bomb* (1968), Donella and Dennis Meadows' *The Limits to Growth* (1972), the *Global 2000 Report to the President* (1980) and the UN Commission on Environment and Development's (the Brundtland Commission's) *Our Common Future* (1987) all warned of impending global calamities. The 1992 United Nations Conference

on the Human Environment ("Earth Summit") in Rio de Janeiro brought policymakers from around the globe together to consider what should be done to forestall these disasters.

Ehrlich's *Population Bomb* proclaimed, "The battle to feed humanity is over. In the 1970s, the world will undergo famines—hundreds of millions of people are going to starve to death."[40] The book's predictions turned out to be extremely inaccurate.

Limits to Growth intoned in 1972: "If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial society."[41] So far, there is no indication that the predicted collapse is likely to occur.

The gloomy forecasts…contrast sharply not only with present conditions, but also with projections from the United Nations' World Health Organization (WHO).

The *Global 2000 Report* was constrained somewhat by its mission to make its predictions coincide with the turn of the millennium. One of its dramatic predictions was that population would increase faster than world food production, so that food prices would rise by between 35 percent and 115 percent by 2000. As pointed out earlier, so far food production has outpaced population growth. In fact, the world food commodity price index actually has *fallen* by 50 percent during this period.[42]

The Brundtland report *Our Common Future* (1987) comes up with the scariest scenario:

> Nature is bountiful, but it is also *fragile* and *finely balanced*. There are thresholds that cannot be crossed without endangering the basic integrity of the system. Today we are close to many of these thresholds; we must be ever mindful of the risk of endangering the survival of life on earth. Moreover, the speed with which changes in resource use are taking place gives little time in which to anticipate and predict unexpected events.[43] (Emphasis added.)

This reference to undefined thresholds that cannot be crossed is not specific enough to be helpful in devising solutions to these vague threats to survival of life on Earth. Moreover, the speed with which resource use is changing is a plus in many cases, such as the use of fiber optics and satellites instead of copper cable in telecommunications. Cell phones and TVs using satellite reception may enable some developing nations to leapfrog traditional deployment of cables and telephone wires and poles to establish their communication systems.

The gloomy forecasts just cited contrast sharply not only with present conditions, but also with projections from the United Nations' World Health Organization (WHO). WHO cannot be dismissed as some Pollyannaish group by any means, but its *World Health Report 1998* is quite optimistic about world health in the next century:

> The 21st century offers a bright vision of better health for all. It holds the prospect not merely of longer life, but superior quality of life, with less disability and disease. As the new millennium approaches, the global population has never had a healthier outlook.[44]

The report says there is "an unmistakable trend towards healthier, longer life" and credits this trend to "the social and economic advances that the world has witnessed during the late 20th century." Food supply has more than doubled in the past 40 years; per capita real gross domestic product has increased by a factor of 2.5 in the past 50 years; and adult literacy rates have increased 50 percent since 1970.[45] WHO forecasts average worldwide life expectancy, currently 68 years, to reach 73 years by 2025—a 50 percent increase in life expectancy from 1955's average of 48 years.[46]

Why Have So Many Sustainable Development Proponents Produced Faulty Forecasts?

Focus on the Physical. Biologist Garrett Hardin, famous for his "Tragedy of the Commons" essay, writes:

> In drawing up plans for the future, natural scientists focus on the earth's resources. Since the earth is of finite size, the quantity of resources must also be finite. Every time we draw on useful materials, we must reduce the supply. How could it be otherwise?

> Science and common sense agree in this conservative conclusion."[47]

Hardin's view of a resource-limited Earth does appear to be common sense. At least it does until we begin to examine what we really mean by resources.

Focusing on physical resources as limits to economic growth and to material well-being is the root source of the failed predictions of the doomsayers. In economic terms, a resource is really a service, not a thing. A person who wishes to start her car doesn't care whether the lead for her battery comes from a lead mine, or is recycled, or, indeed, if the energy storage source is a lead-acid battery or some other storage device. She only wants the device to be reasonably priced and to reliably and safely provide the service of starting her car.[48]

Focusing on physical resources as limits to economic growth and to material well-being is the root source of the failed predictions of the doomsayers.

But even mainstream economists can be attracted to the common-sense notion that resources are fixed, at least until they examine the evidence. In 1979, economist William Baumol wrote, "Neither reduced demand nor expanded exploration can make our finite resources limitless."[49]

After examining the data on resource scarcity, he came to a different conclusion. A decade later, Baumol wrote:

> Measured in terms of their prospective contribution to human welfare, the available quantity of our exhaustible and unreproducible natural resources may be able to rise unceasingly, year after year. Rather than approaching exhaustion with continued use, their *effective* inventories may actually be growing and may never come anywhere near disappearance."[50] (Emphasis added.)

The effective stock of a natural resource can be increased in four primary ways. The first is to improve techniques for finding

the resource. Methods for locating oil and gas have significantly improved in the past two decades, for example. The second is to decrease waste when extracting or using a material. The third is to substitute other physical materials to provide the same service. For example, added insulation can reduce the amount of natural gas needed to heat a home in winter. The fourth way to increase the effective stock of a resource is to recycle it. Properly motivated individuals will explore all of these alternatives. A capitalistic economy includes the price signals and the private payoffs that produce this motivation.

Decreasing Scarcity. A fundamental tenet of market economics is that a persistent decrease in the price of any good indicates that its supply is increasing relative to its demand—its effective stock is increasing. In terms of average wages, the 1990 prices for all natural resources in the United States were only 50 percent of what they were in 1950 and just 20 percent of the 1900 price.[51]

Table 4 shows the trends in real prices (constant 1997 dollars) for selected minerals from 1980 to 1997. Gold, silver, sulfur, and tin lead the pack with prices declining by more than 70 percent over the period. Zinc declined the least—just 6 percent—followed by natural gas with a drop of 18 percent. (Zinc prices appear to fluctuate substantially from year to year—although not included in the table, the 1996 price was 20 percent lower than the 1997 level.) Prices, thus, tell a tale of *decreasing* scarcity of mineral resources, contrary to the common-sense expectations of Garrett Hardin.

Moreover, decreasing scarcity of key physical resources is no aberration. Proven world reserves of oil, gas, and coal are estimated to be 45, 63, and 230 years of current consumption, respectively. Probable reserves are forecast to be 114 years for oil, 200 years for gas, and 1,884 years for coal. World oil reserves are over 15 times 1948 levels, when such calculations were first made. World coal reserves have increased 75 percent in just two decades.[52] The only serious threat to producing energy from fossil fuel resources at present seems to be global climate change policy calling for restrictions on their use.

An article in the June 2, 1995, issue of *Science* points to the same factors mentioned earlier as the source for increasing reserves of mineral resources. Major new discoveries resulting from improved methods of locating minerals; improved extraction methods; substitution of ceramics, composites and plastics for some metals; and increased recycling all have served to increase effec-

Table 4

Average Prices of Selected Mineral Products—1980, 1990, and 1997

(1997 dollars)

	1980	1990	1997	% Change 1980-1990	% Change 1990-1997	% Change 1980-1997
Platinum ($/troy oz)	$1250.00	$560.00	$397.00	-56%	-29%	-68%
Gold ($/fine oz)	1140.00	462.00	333.00	-59%	-28%	-71%
Silver ($/fine oz)[1]	17.90	5.78	4.90	-68%	-15%	-73%
Sulfur Crude ($/m ton)	166.99	96.20	38.00	-42%	-60%	-77%
Tin ($/lb)	15.70	4.63	3.81	-71%	-18%	-76%
Copper electrolytic ($/lb)	1.88	1.48	1.07	-21%	-28%	-43%
Lead ($/lb)	0.80	0.55	0.45	-31%	-18%	-44%
Zinc ($/lb)[2]	0.69	0.90	0.65	+30%	-28%	- 6%
Bituminous Coal ($/short ton)[3]	45.60	26.10	18.20	-43%	-30%	-60%
Crude Petroleum ($/bbl)	40.20	24.00	17.20	-40%	-28%	-57%
Natural Gas ($/1,000 ft^3)	2.96	2.05	2.42	-31%	+18%	-18%

Notes: 1. Base year used for silver is 1981.
2. 1996 price for zinc was just $0.52/lb.
3. Bituminous coal data for 1997 not available, data are for 1996.

Source: Derived from Table 1171, *Statistical Abstract of the United States 1998*, (Washington D.C.: U.S. Department of Commerce, October 1998.)

tive inventories and to lower prices. The author, a scientist with the U.S. Geological Survey, concludes, "Contrary to mid-century expectations, mineral supplies, metallic and nonmetallic, are now thought to be adequate for the next 100 years."[53]

Most of the doomsayers also did not foresee the green revolution. Rather than the mass starvation predicted in *The Population Bomb*, per capita food production grew by nearly a quarter from 1961 to 1995. During that period, the world population more than doubled.[54]

The World Bank's 1994 standard fertility projection implies that global population will increase to 9.6 billion in 2050 and to 11.4 billion in 2150. (The latest projection from the United Nations Population Division is that world population in 2050 will lie within the

range of 7.3 to 10.7 billion, with 8.9 billion the most likely number.)[55] If global economic growth continues, per capita food demand will increase faster than population.

Based on the World Bank's 1994 estimate, Indur Goklany, manager of science and engineering at the U.S. Department of the Interior, projects that total supplies of food (using cereals as a surrogate) need to increase 121 percent between 1993 and 2050 to increase global food supplies at the same rate as they increased in the 1969-1991 period. In effect, that would increase per capita food supplies by 28 percent.[56]

To meet the world's food needs without displacing much of nature or inflicting serious amounts of other environmental harms, the world must follow its recent path of economic growth and technological development.

To produce a 121 percent increase by 2050 without increasing cropland would require an average 1.4 percent annual increase in agricultural productivity. The amount of additional cropland needed to meet the rising demands of a growing population is quite sensitive to improvements in productivity. If global agricultural productivity grows by only 1.0 percent a year, nearly 370 million hectares of land would need to be converted to cropland (1.4 billion hectares was devoted to cropland in 1993). If annual productivity growth averages 1.5 percent, cropland would actually *decline* by 77 million hectares. To put these growth rates in perspective, cropland productivity increased at an annual rate of 2.1 percent from 1970 to 1980 and by 2.0 percent a year from 1980 to 1992.[57]

Goklany acknowledges that there are environmental costs to increasing agricultural output, but these are offset by habitat preservation. He points out that, just since 1961, market-driven technology has forestalled the conversion of at least 966 million hectares to cropland worldwide.[58]

To meet the world's food needs without displacing much of nature or inflicting serious amounts of other environmental harms, the world must follow its recent path of economic growth and technological development. Goklany also suggests that freer and

unsubsidized trade is another critical policy feature to ensure efficient movement of food surpluses and capital across borders. Many developing nations will need to reject the notion of food self-sufficiency and concentrate on exports in other economic sectors to pay for food imports.[59]

Summary

The inaccurate predictions of environmental catastrophe are due to a fundamental misunderstanding of the nature of resources. Rather than comprehending how effective supplies of resources are increased because of the rewards and disciplines of the marketplace, many environmentalists have a "spaceship Earth" mentality that sees nonrenewable physical resources as necessarily becoming exhausted as a result of economic growth.

Declining prices and rising reserves of minerals are contrary to the predictions of the ecological pessimists. Increasing abundance of food in the face of rapidly growing population also is contrary to their viewpoint.

The late Julian Simon put the debate over the finiteness of resources in terms of a "closed-system" versus "open-system" worldview. He wrote:

> [A] key difference between the thinking of those who worry about impending doom, and those who see the prospects of a better life for more people in the future, apparently is whether one thinks in closed-system or open-system terms....Malthusian fixed-resources reasoning is simple and fits the isolated facts of our everyday lives, whereas the expansion of resources is complex and indirect and includes all creative human activity—it cannot be likened to our own larders or wallets.[60]

Problems with the Solutions

Ecological economists and environmental activists take an ecocentric, ecology-first view of the ecology-economy nexus. This viewpoint leads them to policy prescriptions that attempt to restrict economic and population growth. At times, the solutions offered by the ecology-first proponents are naive about human behavior. Sometimes their policy recommendations are less benign, calling for governments to severely limit economic and political freedoms.

Ecological Ethics and Heavy-Handed Politics

Recall that Robert Goodland and Herman Daly believe that developed countries must reduce their use of resources and biological sinks for wastes so that developing nations can experience economic growth. They also call for large-scale transfers to the poorer countries, referring to these transfers as burden sharing, and say that developed countries should exact leadership on themselves.

The Brundtland Commission report *Our Common Future* also relies on larger amounts of government control of resources, ranging from energy to outer space.[61] The report recommends that government agencies at every level engage in economic planning and regulation in order to protect the environment. While governments certainly do have important roles to play, many well-intended government policies have proven counterproductive, especially those that ignore human desires to improve material well-being.

The textbook on ecological economics referred to at the beginning of this paper also makes appeals to normative—"ought to"—behavior. It also includes politically correct rhetorical flourishes such as:

> Calls for the ethical treatment of nature are becoming more and more accepted as a result of the growing scientific evidence blurring the distinction between humans and the rest of the animal kingdom.
>
> The ecological ethic of ecofeminism is an ethic of eco-justice, which focuses on the links between social domination and the domination of nature. It sees the roots of the dual oppression of exploited humans and exploited nature and culture established by the scientific revolution, patriarchal religion, and the dominant psychology of a rights-based, rather than a responsibility-based ethic.[62]

Some prescriptions offered by proponents of environmental sustainability are more politically oriented. In 1969, environmentalist Barry Commoner testified before a Senate committee that "nothing less than a change in the political and social system, including revision of the Constitution, is necessary to save the country from destroying its natural environment."[63] In his 1990 book, *Making Peace with the Planet,* Commoner called for a "genuine" socialist state. He wrote: "In a genuine socialist economy, where production decisions—in keeping with that ideology—are supposed to be under social governance and, therefore, could include environmental factors, the conflict [between private production and envi-

ronmental quality] need not arise."[64] One can only surmise that Commoner sets up the ideal of a "genuine" socialist state because, in practice, socialized economies have had much less enlightened environmental regimes than capitalist economies.

Herman Daly's focus on halting throughput growth and reducing the load on biological sinks led him to write *Steady State Economics* in 1977. He identified three institutions for attaining and maintaining a steady state economy:

- A distribution institution limiting the degree of inequality in the distribution of constant stocks among the constant population (maximum and minimum limits to personal income and a maximum limit to personal wealth).
- An institution for stabilizing the stock of physical artifacts and keeping throughput below ecological limits (depletion quotas auctioned by the government).
- An institution for stabilizing population (transferable birth licenses).[65]

He justified the distribution institution on the basis of providing moral legitimacy for the marketplace. He wrote, "Without some such limits [on income and wealth], private property and the whole market economy lose their moral basis, and there would be no strong case for extending the market to cover birth quotas and depletion quotas as a means of institutionalizing environmental limits...Exchange between the powerful and the powerless is often only nominally voluntary and can easily be a mask for exploitation, especially in the labor market, as Marx has shown."[66] Daly's distribution institution would also require that all corporate profits be distributed as dividends to stockholders, thus inhibiting private industry's ability to make investment decisions free of government oversight.[67]

Daly calls for a depletion quota for resources in order to control environmental impacts. He writes, "If we limit aggregate depletion, then, by the law of conservation of matter and energy, we will indirectly limit aggregate pollution...[I]t is physically easier to monitor and control depletion than pollution..."[68]

He suggests that the quota for renewable resources should be set at an amount equivalent to some reasonable calculation of maximum sustainable yield. For nonrenewable resources with renewable substitutes, the quota would be set low enough that its resulting price would be at least as high as the price of the nearest renewable substitute. For nonrenewables with no renewable substitute, "the quota would reflect a purely ethical judgment con-

cerning the relative importance of present versus future wants."[69]

Daly's institution for stabilizing population is borrowed from Kenneth Boulding. By global concurrence, governments would issue to every woman a quantity of reproduction licenses that corresponds to replacement fertility—2.1 licenses. The licenses would be freely transferable. A woman who wants more than two children could buy extra licenses.

What should be done to law-breaking parents having unlicensed children? Boulding (and Daly) suggest, "One possibility is to put the children up for adoption and encourage adoption by paying the adopting parents the market value, plus subsidy if need be, for their license, thus retiring a license from circulation to compensate for the child born without a license."[70]

But overpopulation is a relative term…While there are clearly areas of ecological concern, the overall evidence indicates that the current 6.0 billion people, or even the maximum population forecast of about 10.5 billion, do not qualify as overpopulation…

Daly quotes Kingsley Davis's "simple" solution for holding population stable: "Accidental pregnancies beyond the limit [of two per couple] would be interrupted by abortion. If a third child were born without a license, or a fourth, the mother would be sterilized and the child given to a sterile couple."[71]

As outlandish as these proposals may seem, China has basically adopted Kingsley Davis's solution. And so-called voluntary sterilization in many developing nations may be more coerced than we realize. For example, see the case of Celia Durand in the accompanying box.

Presumably benign socialist governments like those envisioned by Barry Commoner would be in charge of administering all of these institutions. There seems to be little danger, fortunately, that Daly's institutions will become a reality. They would probably be very effective at creating steady state economies—steady and impoverished.

Herman Daly is not alone in his calls for population controls, though many prefer to be less specific about the mechanisms for limiting population growth. Garrett Hardin believes that "free-

In Peru, Women Lose the Right to Choose More Children

When a government team held a "ligation festival" to register women for sterilization in La Legua, Peru, Celia Durand resisted.

The 31-year-old mother of three was appalled at the pressure tactics government health workers used to induce women to have tubal ligations. Not only did they go house-to-house to round up candidates, but they paid repeated visits to those who refused to comply.... they reassured the operation was "simple and quick," adding that she could "go dancing the same night."

Even though Mrs. Durand knew that the local health station was equipped with little more than an examination table, pressure from government health workers finally wore her down. On July 4, 1997, she reluctantly underwent surgery. Two weeks later she died from complications....

What was originally sold to Peruvians as an altruistic program aimed at helping poor Peruvian women has evolved into an orchestrated attempt to control reproduction and to meet a goal of fewer Indian children in the countryside.

Excerpted from Steven W. Mosher, "In Peru, Women Lose the Right to Choose More Children," *Wall Street Journal*, 27 February 1998, A15.

dom to breed is intolerable."[72] Paul Ehrlich supports coerced family planning—a device that would be unnecessary if humans would have starved in the numbers forecast in *The Population Bomb*.[73]

And, of course, population control was the theme of the United Nations' International Conference on Population and Development in Cairo in 1994. The conference sought "to forge a new consensus that population concerns should be at the centre of all economic, social, political and environmental activities."[74]

But overpopulation is a relative term; it must be overpopulation because of its effects on resources, arable land, or some measure of ecological carrying capacity. While there are clearly areas of ecological concern, the overall evidence indicates that the current 6.0 billion people, or even the maximum population forecast of about 10.5 billion, do not qualify as overpopulation, based on any of these factors.[75]

Those who look at the data on the progress of mankind reach a more upbeat conclusion than ecology-firsters. Julian Simon may have been the leader of this band. In his 1996 update of his tome, *The Ultimate Resource*, he wrote:

> Adding more people causes problems, but people are also the means to solve these problems. The main fuel to speed our progress is our stock of knowledge, and the brake is our lack of imagination. The ultimate resource is people—skilled, spirited, and hopeful people who will exert their wills and imaginations for their own benefit, and inevitably they will benefit not only themselves but the rest of us as well.[76]

Ultimately, neither rhetoric nor socialistic political solutions can deliver the goods. Normative appeals to the ethics of an ecocentric world view don't change the desires of humans to better their lots in life. It's not realistic to believe that Americans, for example, would be willing to sell their automobiles, move into the urban core and reduce their purchases of consumer goods simply because ecological economists believe this is what they should do. Wealthy westerners, especially Americans, do appear willing to make some financial contributions to protect the environment, but this is because they can afford to do so.

The flaw with genuine socialism is that it thus far has existed only in the minds of political thinkers. Real socialism, as exemplified by the former Soviet Union and its Central European satellites, has wreaked environmental havoc. These disasters range from the destruction of the Aral and Caspian Seas as a result of irrigation projects to severe pollution of Lake Baikal (one of the largest and deepest freshwater lakes in the world) to untreated wastes in half of the cities of Poland, including Warsaw.

Democratic Capitalism: A More Successful Approach

Ecological economists and environmental activists view capitalism as the enemy of the environment. This is not a view that is necessarily informed by the facts, however. Capitalism delivers the material goods and services that consumers want. But to environmentalists, consumption conjures up visions of depleting the spaceship's provisions, thus, it is presumed to be detrimental to the future of all those on board. Nor do environmentalists recognize that profit maximization requires cost minimization, which means that resources are conserved, not wasted, in a market economy.

It was acknowledged at the beginning of this paper that unbounded capitalism in some instances might not protect the environment. Air pollution appears to be costless when no one owns the rights to clean air. But capitalism bounded by a democracy (actu-

ally a republic) does not have to despoil the natural realm. Government regulation or common law redress can force external pollution costs to be internalized into private-sector decision making, albeit imperfectly. Moreover, democratic capitalism generates the wealth (or slack financial resources) needed to make significant investments in environmental protection.

But capitalism bounded by a democracy does not have to despoil the natural realm....Moreover, democratic capitalism generates the wealth (or slack financial resources) needed to make significant investments in environmental protection.

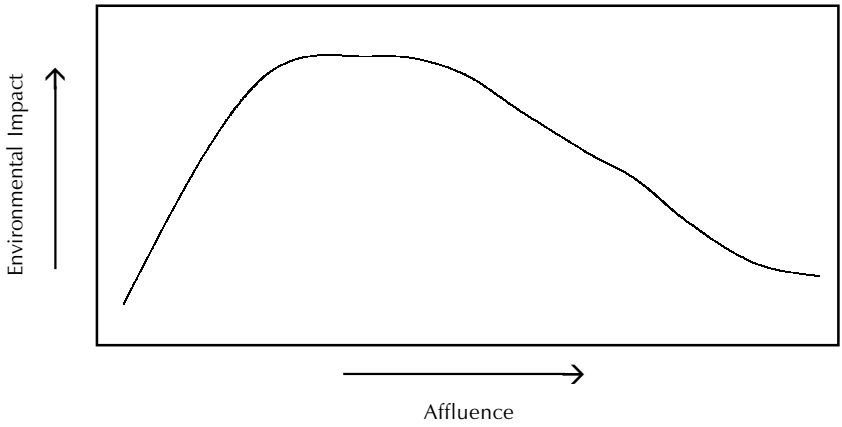
Several analyses support the contention that democratic capitalism is not the enemy of the environment. One of the best-known of these studies is an examination of cross-national data of 14 environmental indicators by Princeton University economists Gene Grossman and Alan Krueger. Their analysis concluded:

> Contrary to the alarmist cries of some environmental groups, we find no evidence that economic growth does unavoidable harm to natural habitat. Instead we find that while increases in GDP may be associated with worsening environmental conditions in very poor countries, air and water quality appears to benefit from economic growth once some critical level of income has been reached. The turning points in these inverted u-shaped relationships vary for the different pollutants, but in almost every case they occur at an income of less than $8,000 [1995 dollars].[77]

Indur Goklany refers to these inverted U-shaped relationships between economic growth and environmental impact as "environmental transitions." He suggests that society is on a continual quest to improve its quality of life. But quality of life is determined by a number of social, economic, and environmental factors.

Figure 3

The Environmental Transition



In the early stages of economic and technological development, a society attempts to improve its overall quality of life by placing a higher priority on increasing affluence. Some environmental degradation will be tolerated because greater affluence provides the means for obtaining basic needs and amenities (e.g., food, shelter, water, and electricity) and thus reduces the most significant risks to public health and safety (e.g., infectious and parasitic diseases, child and maternal mortality).

Eventually, environmental problems move up to a higher priority on the public's list of unmet needs, i.e., environmental quality becomes a more important determinant of the quality of life. Moreover, affluence makes it possible to support additional research and development of new or improved technologies and to purchase these technologies. Technological change and affluence reinforce each other, i.e., they co-evolve.[78] Figure 3 depicts a hypothetical environmental transition.

A 1995 article in *Science* by Kenneth Arrow et al. is often cited by ecological economists as a refutation of the inverted-U relationship between pollution levels and economic growth.[79] The article points out that not all pollutants necessarily follow this pattern. In particular, greenhouse gas emissions like carbon dioxide may continue to increase with income levels. The article sets up a straw man, suggesting that economists like Grossman and Krueger say that the inverted-U shape is independent of political institutions.

Arrow et al. write, "The solution to environmental degradation lies in such institutional reforms as would compel private users of environmental resources to take account of the social costs of their actions."[80] Just so. For these reforms to be embraced, political institutions must take into account the desires of citizens for an improved quality of life and the nation must be sufficiently wealthy and technologically sophisticated to take action.

Of course Grossman and Krueger aren't the only mainstream economists finding a positive relationship between economic prosperity and environmental protection.[81] John Antle and Gregg Heidebrink looked at two very different measures of environmental quality—total land area protected within a nation and rate of deforestation. They found that an environmental transition takes place in these instances also. Beginning at income levels of about $3,000 per capita (in 1998 dollars), deforestation reverses and the land area under government protection also increases.[82]

Summary

The failed forecasts of those who view economic growth as the enemy of the planet should not be dismissed lightly. The focus on physical resources and a closed-system, spaceship-Earth perspective continues to lead to gloomy predictions. These dire forecasts, in turn, lead to policy prescriptions that would restrict economic advancement and private decisions about reproduction.

Meanwhile, democratic capitalism is growing in its global reach. In contrast to the hypothetical benefits offered by "genuine" socialism, democratic capitalism has unleashed an agricultural and technological revolution that has tremendously improved the economic and physical well-being of people around the globe. Rather than being the enemy of the environment, this political-economic system has been a protector of the environment.

Conclusion

The question raised in this paper is, "Are economic growth and a sustainable environment compatible?" A separate discipline, calling itself ecological economics, has sprung up in the last quarter-century that purports to have the answer to this question. Not surprisingly, the practitioners of ecological economics reject many of the basic tenets of mainstream economics. Their focus is on ecology first, and they look upon economic activity as encroaching on this domain.

Ecological economists often are linked to environmental activ-

ists and policy-oriented biologists and ecologists in their belief that humanity has already gone beyond sustainable levels of resource use and utilization of ecological services. They see a zero-sum game in terms of economic growth, where wastrel developed nations must reduce their use of natural capital so that developing nations can enjoy economic growth.

Mainstream economics focuses on efficient allocation of resources to their most beneficial uses. Prices and property rights are key elements of a market system that make it an efficient allocator of resources. The environment is not ignored by mainstream economists but is viewed as external to the normal market process. To protect the environment, the external costs imposed by economic activities must be internalized. Pollution taxes, regulations, and common-law redress are all potential tools for policymakers to utilize to make environmental costs part of market costs.

Even in capitalistic democracies, however, the internalization of pollution costs is imperfect. Politically influential groups can forestall environmental legislation, at least in the short run. These groups are not always recalcitrant big business but often municipalities, farmers, and even agencies of national governments. And government policies are often misdirected, providing subsidies to activities that harm the environment.

The notion of sustainability is widely discussed but poorly defined. In 1987, the World Commission on Environment and Development defined sustainable development as the ability of humanity "to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."[83] This definition is widely embraced, but nearly impossible to put into operation.

Ecological economists believe, almost as a matter of faith, that current modes of production are exhausting and dispersing a "one-time inheritance of natural capital."[84] Ecologists and biologists have been attempting to develop measures of humankind's impact on natural capital.

Two of these measures of human appropriation of ecological resources—the percentage of land-based biological production used or dominated by humans, and human impact on biodiversity—are examined in the preceding pages. The often-quoted figure of human appropriation of 40 percent of land-based products of photosynthesis tells us very little about humanity's impact on natural capital.

Species loss can be shown to be significantly accelerated by human activities. But analysis of this problem reveals that the

greatest impact is taking place, or will take place, in regional hot spots of biodiversity, primarily in tropical rainforests in developing nations. The solution is not to restrict economic growth in developed nations. These "hot spot" areas are being exploited because of the material needs of residents in these countries and as a result of ill-considered government policies. If wealthy citizens of developed nations wish to protect these hot spots of biodiversity, they must find ways to provide economic benefits to indigenous peoples that make preservation preferable to exploitation.

Doomsday forecasts by ecological economists and environmental activists have been woefully inaccurate. Nor are their more recent forecasts more credible. Even the UN's World Health Organization has come to the conclusion, "As the new millennium approaches, the global population has never had a healthier outlook."[85]

The fundamental reason for the poor showing of prophets of gloom and doom is their static focus on physical resources.

The fundamental reason for the poor showing of prophets of gloom and doom is their static focus on physical resources. Their closed-system, spaceship-Earth view of the ecology-economics interface blinds them to the dynamic way that free markets work to increase the effective supplies of resources.

The ecocentric, ecology-first viewpoint of ecological economists and many policy-active ecologists leads them to look upon economic activity as the enemy of nature. Paul Ehrlich calls economic growth "the creed of the cancer cell" (consigning humanity to the role of cancer cell).[86] This low view of humanity's struggle for economic betterment leads to a low view of humanity. The ecology-firsters prescribe heavy-handed government control of economic activity, the ability of individuals to accumulate wealth, the use of resources, and human reproduction. They advocate benign socialism to enforce these controls and to usher in steady-state economics.

Mainstream economics acknowledges that unbridled capitalism could cause significant environmental damage. The prescription,

however, isn't to destroy the incentives to innovate and to take risks, but rather to use the many ways available to incorporate concerns for the environment into economic decision making.

Democratic capitalism has advanced around the globe during the past two decades, proving to be a boon, not a bane, to the societies fortunate enough to have embraced this system. Global per capita real gross domestic product has increased by a factor of 2.5 in the past half century, producing tremendous benefits for *Homo sapiens*. Population has doubled in a little over three decades, but agricultural production has outpaced population growth by about 25 percent. Average worldwide life expectancy has increased from 48 years to 68 years since 1955. The World Health Organization credits this "unmistakable trend towards healthier longer life" to "social and economic advances."[87]

Economic growth is not only compatible with a sustainable environment; it is a prerequisite.

But humanity is not the only winner as a result of the global spread of democratic capitalism. Developed nations have reached the point in wealth creation that enables them to provide environmental protection through technological developments that can, in turn, benefit people and their natural surroundings worldwide.

Ecologists and biologists are providing a valuable service by making everyone more aware of the importance of Earth's natural capital. A deeper appreciation for all of creation cannot but help to enrich our lives. The challenge is to continue to improve the lives of humankind without abusing this heritage.

Most mainstream economists, ecologists, and biologists are not at odds in this pursuit, but they are talking past one another. Though many of the environmental problems identified by natural scientists appear around the globe, their solutions are nearly always dependent on local circumstances. These local solutions require that the parties causing environmental harm be provided with economic incentives to change their behaviors. In rich countries polluters can be forced to bear abatement costs. In developing nations, economic "carrots" likely are a better approach than the regulatory "stick."

The institutions embodied in democratic capitalism appear to provide the best mechanisms for meeting the challenge of providing greater material well-being for people and better protections for nature. Economic growth is not only compatible with a sustainable environment; it is a prerequisite.

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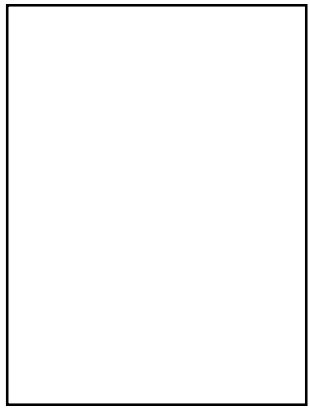

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