Environmental Economics: Theory, Application, and Policy

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CHAPTER 19

ECOLOGICAL ECONOMICS: AN EMERGING ALTERNATIVE TO ENVIRONMENTAL ECONOMICS

BY JON ERICKSON

Given the generally traditional focus of this text on environmental economics, it is useful to examine the foundation of economic theory and its application to the environment. The chapter begins by contrasting neoclassical economic analysis of the environment with the synthesis of philosophy, ecology, and economics that is evolving under the umbrella of ecological economics. We then examine climate change to illustrate the growing dissatisfaction with a neoclassical approach to analyzing environmental problems; the discussion emphasizes the usefulness of communicating across disciplines. Next follows an introduction to alternative paradigms to economic growth, including limits, sustainable development, and coevolution. The chapter concludes with a historical perspective on the transition between economic paradigms.

The Environment and the Economic Tradition

Adam Smith's *The Wealth of Nations* in 1776 marked the dawn of modern economic thought;[1] his work was founded on two fundamental tenets of self-interest and natural liberty. In criticizing the mercantilist economy of his time, Smith argued for a reduction in the role of government intervention.[2] The market economy was seen as just and amenable to the individual self-interested pursuit of happiness. The aggregate of these self-interested pursuits, in turn, would maximize social welfare and thus the wealth of nations.

There was some dissent about what came to be known as classical economics. Jeremy Bentham, John Stuart Mill, David Ricardo, and Thomas Malthus questioned the selfishly rational tone of economics during its formative years, demanding that economics address issues of the common good. The social utilitarians, typified by Mill's *Principles of Political Economy*,[3] wanted to move economics beyond its growing focus on personal utility and markets and toward social concerns.

Nevertheless, the closing of the 19th Century marked the beginning of the neoclassical era in economics, and the mainstream emphasis in economics continued to follow the tradition of self-interest. Economics quickly became grounded in marginal analysis, descriptive rather than prescriptive, and scientific in nature. Faith in markets was preeminent, and only isolated cases of market failure justified government intervention or any social tinkering. A. C. Pigou in his *Economics of Welfare* briefly brought environmental considerations into the arena of welfare analysis.[4] His work developed the concepts of negative and positive externalities arising from economic activity. However, accounting for externalities was still within the realm of self-interested rationality.

The Keynesian period of economics emerging from the Great Depression of the 1930s established economics as the policy tool for promoting economic growth through government intervention.[5] Social concerns such as unemployment and inflation came into focus under Keynes, but environmental considerations continued to be excluded. After World War II, the negative externalities of economic growth began to show significant impact on water, air, and land resources. Yet even as the environmental movement became rooted in the U.S. collective conscious, neoclassical economics paid little attention. As noted in Chapter 4, the American Economic Association's 1969 *Readings in Welfare Economics* by Kenneth Arrow and Tibor Scitovsky made no reference to the environment. The notable exceptions to this exclusion were developments in the area of natural resource economics. In particular, Ciracy-Wantrup's *Resource Conservation: Economics and Policies* helped define the field of resource economics,[6] evolving from turn-of-the century resource conservation movements. His advocacy of safe minimum standards predated by two decades this concept's use in environmental policy.

Environmental economics didn't come into focus as a discipline until the early 1970s. Its development was primarily a reaction to significant environmental policy initiatives in the United States, including the Air Quality Act of 1967, the National Environmental Policy Act of 1969, the Clean Water Act of 1972, and the Endangered Species Act of 1973. At the same time, environmentalism as a social movement was typified by the first Earth Day on April 22, 1970. Both government policy and social concerns stemmed from Malthusian predictions of environmental catastrophes and an environmental movement finding popularity among the general public.

Environmental economics eventually became a full-fledged academic concern with the establishment of the Association for Environmental and Resource Economists in 1978. Environmental considerations quickly found their place in the tradition of benefit-cost analysis. External social costs and values were also logical extensions of the neoclassical tradition. As has been described in Chapters 2–6, the scope and breadth of topics involving environmental economics also called for modifications in discounting theory, value of life and risk estimates, and methodological developments to value nonmarket goods.

Environmental Economics: Running on Faith

While environmental variables were necessary and useful modifications to neoclassical theory, environmental economics continues to depend on the basic assumptions and priorities of market and welfare theory as reviewed in Chapters 1 and 6. These foundations emphasize the concepts of allocation and optimization, and the neoclassical assumption of continuous growth in material living standards. In environmental economics, if a numerical human benefit can be assigned to an environmental amenity, then it too can be allocated and optimized as with any other market good. The field of environmental economics has from the start both followed and questioned this neoclassical faith.

Environmental amenities, however, are also basic security goods. For instance, the supply and allocation of dependable food, clean water, diversity of species, and protection from the harmful effects of climate change are 'goods' that will determine the course of humanity in the 21st Century and beyond. To this extent, environmental economics is important in its scope. Placing a value on these nonmarket goods attempts to represent positive environmental values alongside traditional market goods in resource allocation decisions.

However, even with adjustments to economic optimization and corrections for environmental market failures, the assurance of these goods for current and future generations is largely left to the fate of Adam Smith's 'invisible hand.' Over two hundred years after *The Wealth of Nations*, self-interest and natural liberty remain central to the study of neoclassical economics. We maximize profits and minimize costs. Individual liberties and the right to consume dominate economic theory.

The basic security goods, however, may not be guaranteed in a "winner takes all" individualistic society. What will remain for future generations is that which isn't utilized by current consumption. Many contemporary students of economics are interested in alternatives to anthropocentric science, economy, and society. As did the generation of classical economists before them, today's students search for moral truths in economics.

This chapter accepts the importance of environmental economics but questions its neoclassical foundation. Should environmental questions be viewed in terms of absolute constraints or as incidental outcomes of cost-benefit analysis? What roles do ethics and religion play? Should the physical laws of thermodynamics be considered with the social laws of economics? And ultimately, how are we to view ourselves—as endpoint of a deterministic evolution, or just a beat in the metronome of geological time? Similar questions first challenged the classical economists and have recently found a home in the new discipline of ecological economics.

The Evolution of Ecological Economics

Perhaps most central to the study of economics is a long-standing preoccupation with the human condition. John Kenneth Galbraith, in his historical analysis of economic thought, traces its beginnings as far back as the writings of Aristotle, more than two millennia ago. A central theme in Galbraith's reconstruction is that "economic ideas are always and intimately a product of their own time and place; they cannot be seen apart from the world they interpret."[7]

In Richard Norgaard's analysis, the 20th-Century pursuit of human advancement rested unconditionally on a faith in science and technology—a belief in progress through modernity.[8] This belief holds that as problems—externalities—arise, they can ultimately be solved through human ingenuity and technological innovation. In essence: we can always produce more and more with less and less; we can replace what's exploited through substitution; we can sidestep inconvenient transition and conservation through adaptation.

Dispelling the faith in modernity is perhaps the outstanding feature of the new assault on the neoclassical tradition. Ecological economics reflects what Norgaard summarizes as prudence, pluralism, and process.[9] Prudence shuns the strong optimism of the technological 'fix.' Pluralism calls for the use of many disciplinary perspectives in formulating ideas, a realization that there is always more than one approach to problem-solving. Process draws attention away from the endpoint (i.e., an optimal solution) and places it on the path to pluralistic solutions. In this light, ecological economics cannot be defined as a traditional discipline. It incorporates methodological pluralism and an ever-changing social process.

The actual discipline of ecological economics wasn't officially recognized until the establishment of the International Society for Ecological Economics (ISEE) in 1988. The work of economists such as Nicholas Georgescu-Roegen, Kenneth Boulding, Herman Daly, and Richard Norgaard, together with ecologists such as Robert Costanza, Robert Goodland, Howard Odum, and Paul and Ann Ehrlich, laid the foundation for a disciplinarily inclusive society. Some of its premises were an awareness of biophysical principles that limit economic activities and of the interactive evolution of natural and social systems through time, and an abandonment of absolute faith in progress through growth.

The incorporation of biophysics into economics is attributed to Georgescu-Roegen. Essentially, he argues, the economic problem is one of entropy, from the second law of thermodynamics. Only a finite amount of low-entropy energy can exist in a finite system, and low-entropy energy "continuously and irrevocably dwindles away."[10] Also, from the first law of thermodynamics, matter or energy can neither be created nor destroyed. In terms of the economic process, matter and energy enter as low-entropy inputs and exit as high-entropy waste. These concepts, generally omitted from traditional flow and stock diagrams in economic theory, have contributed to a better understanding of relative versus absolute scarcity, the importance of scale, and the limits to a fossil-fueled economy.

Again, echoes of classical economists such as Malthus[11] can be found in these warnings of absolute constraints to economic growth. Neoclassical economics, in contrast, has been more concerned with relative scarcity. Oil, minerals, and other geologically scarce low-entropy resources are not economically scarce as long as supply meets demand through equilibrium price mechanisms. In fact, as Chapter 9 emphasizes, real oil prices have recently been at the lowest level in history. So how, the neoclassical economist argues, can oil be scarce? Shouldn't scarcity be reflected through increasing demand followed by increases in equilibrium prices over time?

The ecological economics perspective, however, recognizes the importance of absolute scarcity, or limits on production over time.[12] In terms of intertemporal production possibility frontiers and intergenerational equity, absolute scarcity of natural resources and environmental systems ultimately defines economic wellbeing. David Ricardo, the classical economist, also spoke of long-run limits to economic growth and the finality of a stationary state in which natural resources and technological fixes are exhausted.[13]

Scale also matters. However, the aggregate size of global consumption and production is not of interest in the neoclassical formulation. The ecological economic perspective, in contrast, views human economies as a subsystem of their larger ecosystems. Healthy ecosystems breed healthy economies, and the appropriate scale of economic activity is considered essential to maintaining ecosystem health. An optimal scale requires that an economy's throughput—the flow from raw materials, to commodities, to waste—remain within the ecosystem's regenerative and absorptive capacity.[14]

Working through these complications and interconnections between economy and environment requires a certain degree of "systems thinking." Again, this is in contrast to a neoclassical reductionist methodology where explanation of economic phenomena calls for a Newtonian mechanization[15] and simplification of parts. Most notable in promoting a systems approach is the lifetime work of Kenneth Boulding. The most often-cited work of Boulding is his seminal article, "The Economics of the Coming Spaceship Earth," first published for Resources for the Future in 1966.[16] In this work and elsewhere[17] Boulding laid the groundwork for viewing economics in terms of 'open' and 'closed' systems. Boulding emphasized the laws of thermodynamics and warned against what he termed the "cowboy" doctrine of limitless growth.[18] In contrast, he considered:

> *The closed economy of the future might similarly be called the "spaceman" economy, in which the earth has become a single spaceship, without unlimited resources of anything, either for extraction or for pollution. . . .* [19]

Studying systems dynamics also requires an evolutionary framework of long-term, interdependent changes. Boulding and others created what has come to be called evolutionary economics, a precursor to much of the work in ecological economics today. (This subject is taken up separately later in the chapter.)

Herman Daly is another visionary in the development of ecological economics. While not quite as pessimistic as Georgescu-Roegen, Daly has most significantly argued the merits of a 'steady-state' economy and rejected the ideology of continuing growth. To Daly, a steady-state economy exists where throughput is held constant, and allocation among competing uses is allowed to vary in response to market forces. This approach is quite different from the classical 'stationary state,' which postulates that an absence of growth could only be the result of resource exhaustion or a technological freeze. In the steady-state economy, growth is capped before complete exploitation. Attention is drawn away from quantitative growth and placed on qualitative improvement, what Daly calls 'sustainable development.'[20] During his tenure at the World Bank, he advocated lending and restructuring policies based not on quantitative growth but on this view of sustainable development.

For instance, he recommended qualitative change through population control, redistribution of wealth and income, technical improvements in resource productivity, and a realization of the interconnectedness of the global community.

This global community includes both human and nonhuman species, which necessarily adds a component of spiritual and religious thinking beyond the usual constraints of economics. Daly has written with John Cobb (a theologian) on the need to move away from an anthropocentric society and toward biospheric thinking.[21] They argue that the human species is morally obligated to protect all species.

At one extreme on this philosophical spectrum is the Gaia hypothesis. First championed by James Lovelock in 1979, this theory transforms the discussion of social purpose into global spiritualism, arguing that Planet Earth functions as one organism. Human activity, in our anthropocentric pursuit of utility, will necessarily affect the planet. But earth's global systems will ultimately maintain balance. The social movement spawned by such hypotheses, often called 'deep ecology,' takes the position that "we humans have no special rights, only obligations to the community of Gaia."[22]

Clearly, ecological economics covers a wide range of ideas. It has mainly grown out of the economics community, from economists with a classical rather than neoclassical orientation. Of course, many contributions to this new discipline have been made by such ecologists as Paul and Ann Ehrlich, Garrett Hardin, and Robert Costanza (the first president of the International Society for Ecological Economics), as well as physicists, chaos theorists, environmentalists, and experts from other disciplines worldwide. In addition to Daly, today's most influential ideas in ecological economics include Costanza's work in defining and promoting the organizational aspects of ecological economics; Norgaard and Gowdy's development of a coevolutionary approach to the economy-environment interface; the work of Cleveland et al., which tightens the debate on biophysical limits to growth; and the new international emphasis on sustainability, developing each country's perspective on growth and intragenerational (i.e., within a generation) equity.[23]

The teaching of ecological economics is beginning to make some inroads. The first textbook on ecological economics has been published,[24] and the first Ph.D. degree program in Ecological Economics was established at Rensselaer Polytechnic Institute in Troy, New York.

Other reviews of ecological economics are of interest. Krishnan et al. completed a comprehensive survey of the field's literature. Sahu and Nayak prepared a comparison of ecological economics with neoclassical environmental economics, contrasting the primary differences in paradigm, scarcity perception, problem-solving orientation, and range of integration. Turner et al. have also helped define the ecological economics perspective.[25] To clarify these distinctions, the next section invokes the example of the economics of climate change.

Climate Change

The global externalities of climate change, mainly due to anthropogenic emissions of greenhouse gases (GHG) from fossil fuel use and land conversion, may become one of the most significant environmental challenges of our time. The impacts of a rapid climate change have been discussed by physical, biological, and social scientists for over two decades.

The purpose here is to review the popular neoclassical approach to policy regarding climate change, and to compare this with the alternative interdisciplinary perspective of ecological economics outlined in the last section.

The neoclassical approach involves framing the climate change problem in a benefit-cost analysis, similar to traditional, local analysis of air or water pollution. The questions posed include: Should economies invest now in the hopes of averting future damage from such potential problems as increased storm severity, higher sea levels, and intercontinental drought? Or do we wait, adapt as necessary, and hope for the best? Further complicating matters is the fact that, as Chapter 18 explains, a warmer climate could be a boon rather than a problem in some areas. For example, some agricultural regions may benefit from longer growing periods. It is also possible that increased concentration of carbon dioxide in the atmosphere could benefit plant growth through improved photosynthesis and water use efficiency—a "CO_2 fertilization effect."[26] From the economist's standpoint, the challenge is to categorize both the cost of limiting current emissions and the benefits of reducing the future climatic impact.

The previous chapter recognized William Nordhaus's significant contribution to this daunting task. His analysis of the economics of climate change asks us to count all the benefits and costs before we irrationally pursue growth-limiting prescriptions. A sense of the economic rationality of his work is evident in a sampling of titles: "To Slow or Not to Slow: The Economics of the Greenhouse Effect," "An Optimal Transition Path for Controlling Greenhouse Gases," and *Managing the Global Commons: The Economics of Climate Change*.[27] The central questions to this body of literature are: Can society rationalize averting global climate change at the expense of economic growth? Must an either-or decision be made?

A critique of the mechanics and sensitivity of the Nordhaus model has been taken up by others.[28] The focus here is on the philosophical foundation of the analysis—questioning the rationality of *Homo economicus*.[29] To do this, one need only focus on the first equation in the Nordhaus model: the utility maximization specification. The problem, represented in Equation (19-1), is to choose the optimal level of investment [I_t] and control rate [CR_t] in GHG abatement over time in order to maximize U, global utility. Utility is assumed to depend on world population [N_t], the natural logarithm of per capita consumption [c(t)], and a social discount rate [ρ].[30]

$$\underset{\{I_t, CR_t\}}{\text{Max U}} = \sum_{t=1}^{H} \frac{N_t * [\ln c(t)]}{(1+\rho)^t} \qquad (19\text{-}1)$$

The variable of per capita consumption [c(t)] seems intuitively appealing—if each person in the global economy is able to consume more in each time period, then we're all better off. There is a flaw, however, in this intuition. Per capita consumption is merely an average, and an average can be boosted by increasing consumption of a below *or* above average person. In other words, the distribution of consumption has no value. If the average is boosted by increasing consumption of the top 5 percent income class, then global utility is improved, but perhaps at the expense of global welfare.

The vast difference between rich and poor, or between rich and working class, is apparent between countries and within them. In writing about the United States, Michael Yates notes that as working class Americans struggle to make ends meet, the rich are wealthier now than at any time since World War II.[31] Yates cites Kloby in reporting that between 1963 and 1983, wealth rose by 9.7 percent for the richest 0.5 percent of all families, while the poorest 90 percent experienced a 6.7 percent decline.[32] In *The State of Working America*,[33] Mishel and Bernstein found that the difference between rich and poor is increasingly dramatic. Between 1977 and 1990, average real family income fell for the poorest 60 percent of all families, while it increased by 33 percent for the richest 20 percent, and increased by over 95 percent for the wealthiest 1 percent. The decline in income of the lower percentiles of the wealth distribution is just recently starting to pull the average family income down, while the purchasing power of U.S. weekly earnings is currently no higher than it was in 1967.[34]

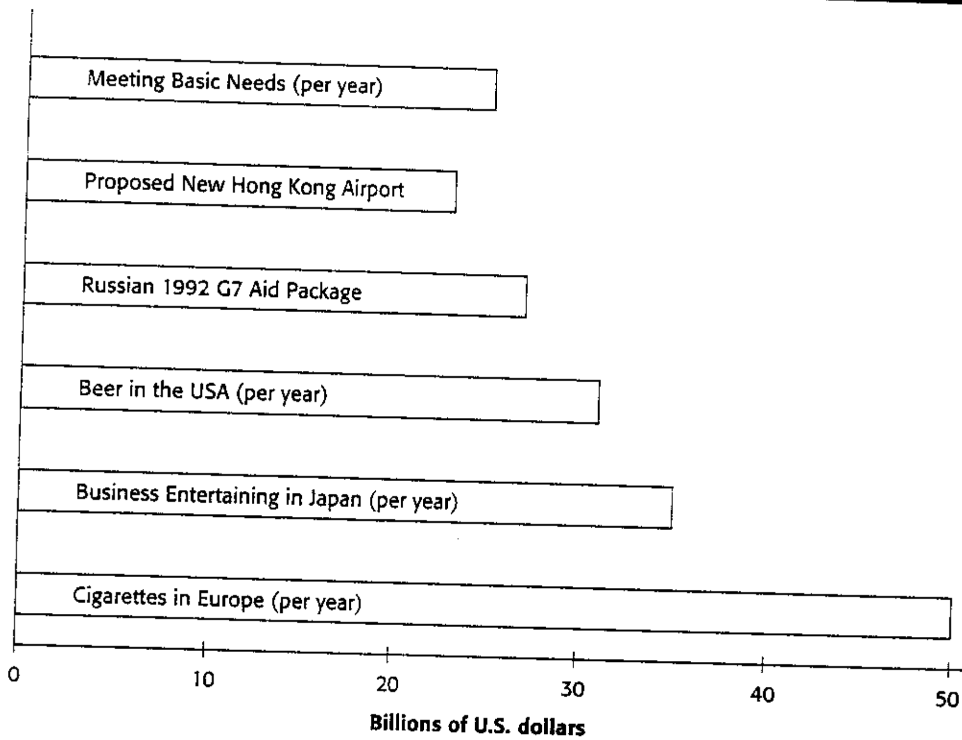
Certainly there is much dissatisfaction with the rich getting richer and the poor getting poorer. Is this an appropriate model of global utility? Superficially, perhaps a better model would be maximizing the minimum, as proposed by John Rawls in *A Theory of Justice*.[35] (See Chapter 5.) This means increasing global utility by improving the living standards of poorer groups. For instance, one of three children is born every day into absolute poverty. Absolute poverty is defined by the income level below which a minimum nutritionally adequate diet (plus essential nonfood requirements) is not affordable.[36] To improve the well-being of those in absolute poverty without altering the quantitative scale of the macroeconomy would require a redistribution of resources.

For example, UNICEF estimates that an investment of $25 billion per year over a decade could control the major childhood diseases, halve child malnutrition, reduce child deaths by 4 million a year, bring safe water and sanitation to all communities, provide basic education for all children, and make family planning universally available. In comparison, as Figure 19.1 demonstrates, the United States spends over $30 billion per year on beer. Of the $40 billion a year spent by Western industrialized nations on bilateral aid, a mere 10 percent is earmarked for meeting these most basic human needs.[37]

Comparing a pack of cigarettes or a can of beer with a polio vaccination introduces a second fundamental problem in modeling global utility on per capita consumption: no distinction is made between welfare and specific goods. In the global maximization problem, a $100 pair of sneakers has the same value as $100 worth of rice. In welfare terms, however, rice should be much more valuable than the latest athletic shoes. If the global economy had only one hundred more dollars to spend, which good would provide more global welfare? This has long been recognized as the "diamond and water paradox."

In a narrow sense, the concepts of consumers' surplus and consumers' value from Chapter 1 resolve the paradox by measuring economic welfare as the monetary value of the area under the demand curves. Nevertheless, the fundamental problem is the measurement of utility in monetary terms.

FIGURE 19.1 Opportunity Cost of Meeting Basic Human Needs[38]



So, in contrast, a more prudent model of climate change economics would not choose a GHG control rate that resulted in the inundation of a poor Bangladesh while a rich Manhattan adapts and remains unscathed behind a sea wall. Rather, a prudent model might start with a decision to protect the people of Bangladesh, to realize this future cost and compare it with the current cost of abatement. Focusing on a safe minimum standard shifts emphasis away from an optimal solution and concerns itself with the process of achieving risk- and welfare-oriented goals.

The science of climate change also provides an ideal case study of the benefits of interdisciplinary work and a focus on *process* rather than optimal *outcomes*. Working to understand the social, economic, and biophysical dimensions of climate change has been a dynamic social process, not a charted optimal path. As Norgaard explains, "When astro-physicists, dealing in microns and microseconds, come together with evolutionary biologists, dealing on continental scales over millennia, there must be some softening of traditional disciplinary mortar."[39] These multidisciplinary efforts have been the breeding ground for ecological economics and its evolution.

A New Paradigm: Limits, Sustainable Development, Coevolution

There is a growing sense among economists and ecologists that human consumption of world physical resources has grown too large. Yet we have become so accustomed to equating increased consumption with progress that as a society we know no other way. Two U.S. presidential elections were won on very strong growth platforms, despite a vice president who had written about our "Dysfunctional Civilization" and "disharmony in our relationship to the earth, which stems in part from our addiction to a pattern of consuming ever-larger quantities of the resources of the earth. . . ."[40]

Table 19.1 offers examples of per capita waste and consumption by the average U.S. citizen. An average 150-pound person is annually creating 287 times his weight in carbon dioxide emissions, 13 times his weight in solid waste, and consuming 48 times his weight in coal. At these rates, and with a growing population, our current and future ecological impact looks significant. The dogma of economic growth raises an unavoidable question: can the earth support a society of tens of billions of U.S. consumers?

Most striking is our impact on global biodiversity. Richard Leakey and Roger Lewin in *The Sixth Extinction* argue that we are living in a tragically unique time in evolutionary history:

> *Dominant as no other species has been in the history of life on Earth,* Homo Sapiens *is in the throes of causing a major biological crisis, a mass extinction, the sixth such event to have occurred in the past half billion years.*[41]

Only five times before has mass extinction run its course over such a brief geological instant.[42] The current rate of species extinction is controversial, with estimates ranging from 17,000 to 100,000 species lost per year. However, an extinction

TABLE 19.1 A Sample of the U.S. Per Capita [illegible]

	Annual per Capita	*Units*
Waste		
CO_2 emissions	43,064	pounds
SO_2 emissions	181	pounds
Solid waste	2,000	pounds
Consumption		
Motor gasoline	460	gallons
Coal	7,219	pounds
Vehicle miles traveled	9,006	miles
Replacement		
Fertility rate	2.1	children/woman

rate of 30,000 a year is 120,000 times above what is considered normal: one species lost every four years.[44]

Limits to Growth

The major cause of such mass extinction has been our quantitative growth, or economic scale, and our resulting consumption of ecosystem space. Global deforestation is most alarming. Leakey and Lewin reviewed two independent studies by the World Resources Institute and the United Nations Food and Agriculture Organization, each reporting deforestation rates in the range of 80,000 square miles per year. At this rate, tropical forests may be reduced to 10 percent of their original cover early in the 21st Century.[45]

Contemporary arguments for an absolute limit to this unprecedented human growth began with the report of The Club of Rome's Project on the Predicament of Mankind. As explained in Chapter 10, the Meadows group constructed a computer model of exponential growth in population, industrial capital, food production, nonrenewable resource consumption, and pollution, within geologically and geographically defined physical and social limits. Assuming the then-current rates of exponential growth, they found "the limits to growth on this planet will be reached sometime within the next one hundred years" and that the "most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity."[46]

The Meadows work highlighted physical, environmental, and social limits to growing material consumption as the causes of projected societal collapse. Unfortunately, the physical limits hypothesis (i.e., limits in energy and mineral resources, fresh water, and arable land) became the most popular forecast of their larger body of work. Under their exponential index scenario, the world's reserves of copper, lead, mercury, natural gas, petroleum, tin, and zinc were all predicted to be depleted within the seven-year period 1985–1992.[47] However, through changes in demand, increased recycling, substitution possibilities, and discovered geological reserves, limits to 20th Century growth imposed by absolute scarcity were largely avoided. For this reason, the "Limits to Growth" hypothesis has more often than not been rejected by mainstream economists.

However, this rejection ignores the other half of their story: limits to our environmental and social resources. In 1972, the Meadows group warned that, if resources proved sufficient for continued economic expansion, economic collapse would follow environmental catastrophe. As evidence, consider that the waste-assimilating capacity of our atmosphere and oceans cannot absorb the CO_2 emissions from 600 million automobiles and other energy uses, increasing the probability of dramatic global climate change.

On the social front, demand for education, health services, and political stability continues to be greater than our ability to provide it to much of the global citizenry. The 1993 *Human Development Report* found for all developing countries (about 77 percent of the world's population) a 40 percent secondary school enrollment ratio, and 72 percent, 68 percent, and 55 percent of the population with access to health services, safe water, and sanitation, respectively.[48]

Twenty years later, Meadows et al.[49] produced a sequel to the original report, correctly emphasizing indications that global pollution, social instability, and absolute scarcity would ultimately limit our energy and materials use. While the first report alluded to the possibility of altering exponential growth rates and obtaining ecological and economic sustainability, the 1992 work concluded that society would now have to contract, particularly in materialistic consumption, in order to come back within sustainable limits. Table 19.2 illustrates worldwide growth in selected activities between the publication of the reports.

The Limits to Growth argument stems from the ecologists' concept of carrying capacity: a finite boundary to economic expansion, resource extraction, and social stability. Clearly, if there is any truth to the ecologist's vision of limits to the human "waste" line, then the traditional economic paradigm of growth must be discarded.

Joel Cohen (as discussed in Chapter 10) has thoroughly reviewed the debate over limits to population growth in his book *How Many People Can the Earth Support?*[50] While the answers to this question range from less than 1 billion to more than 100 billion, he finds that more than half fall between 4 and 16 billion. With a

TABLE 19.2 Worldwide Growth in Selected Human Activities and Products[51]

	1970	*1990*
Human population	3.6 billion	5.3 billion
Registered automobiles	250 million	560 million
Km driven/year (OECD only)		
by passenger cars	2,584 billion	4,489 billion
by trucks	666 billion	1,536 million
Oil consumption/year	17 billion bls	24 billion bls
Natural gas consumption/year	31 trillion cu ft	70 trillion cu ft
Coal consumption/year	2.3 billion tons	5.2 billion tons
Electric generating capacity	1.1 billion kW	2.6 billion kW
Electricity generation/year, by nuclear power plants	79 tWh	1,884 tWh
U.S. soft drink consumption/year	150 million bls	364 million bls
U.S. beer consumption/year	125 million bls	187 million bls
U.S. aluminum consumed/year for beer and soft drink containers	72,700 tonnes	1,251.900 tonnes
Municipal waste generated/year (OECD countries only)	302 million tonnes	420 million tonnes

Abbreviations:

km = kilometer(s)
OECD = Organization for Economic Cooperation and Development
cu ft = cubic feet
kW = kilowatt
tWh = terawatt-hours
bls = barrels
tonne = one metric ton (2,205 pounds or 1,000 kilograms)

current global population of over 6 billion and growth of nearly 100 million per year, we are entering an era of tremendous population demands on our planet's finite carrying capacity.

Optimal social scale does not enter into the calculus of economic growth. More "stuff" in the long run is always preferred. In fact, environmental worries are addressed, in the neoclassical tradition, through improvements in efficiency. Environmental impact, in the most general sense, equals population times per capita consumption times efficiency of consumption. As Bill McKibben notes:

> *We have tended to focus on the efficiency issues (in this equation)—new technologies, better cars, recycling, and so on—because they are politically and emotionally the most palatable: they allow us to avoid the question of our place on the planet, they offer us the possibility of extending our current patterns of use for at least another generation or two.*[52]

In contrast, the Limits to Growth literature offers a paradigm of absolute constraint, the possibility of a society sustained within a supportive ecosystem, but likely at the expense of political and emotional palatability.

Sustainable Development

Sustainable development has also been considered a defining paradigm from ecological economics for a post-consumerism global economy. (This is the subject of the next chapter, by Richard Bishop and Richard Woodward. The theory of sustainable use was introduced in Chapter 6 and applied to agriculture and forestry in Chapters 13 and 14.) Sustainable development means many things to many different people. Its present popularity in government, business, academic literature, and the popular press, however, has done more to dilute the concept than support it.

Table 19.3 illustrates a range of perspectives on sustainable development. The interdisciplinary approach comes closest to matching the Limits to Growth paradigm. The Nobel Laureate Robert Solow perhaps best summarizes the neoclassical perspective on sustainable development; he calls it a matter of intergenerational equity—providing to our children and grandchildren ad infinitum opportunities similar to those our generation enjoyed. Equity is the ability to maintain current levels of material consumption into the future. Given human and natural capital depreciation, as well as nonrenewable resource depletion, this version of sustainable development requires each generation to invest in capital stock and environmental resources, i.e., growth.

Contrasted with the limits to growth paradigm, 'sustainable' and 'growth' uttered in the same phrase seem contradictory. Substitution of new products or improvements in efficiency may allow continued economic growth in the near term, but the jury is still out on the environmental and social limits to this growth. Because of these conflicting goals and the political unwillingness to recognize limits, sustainable development has not yet become a real guiding principle.

From an institutional perspective, Howarth and Norgaard conclude: "If development is not sustainable, it is because the institutions through which the present provides for the future have not evolved in consonance with changes in social and economic structures, technology, and population pressure."[53] This perspective

[illegible] Perspectives on Sustainable Development[a]

Perspective	*Sustainable Development As:*	*Key Concepts*	*Source*
Academic - interdisciplinary	". . . sustainable scale of economic activity within the ecological life-support system."	Carrying capacity, sustain welfare, environmental quality	Arrow et al., 1995 (page 521)
Academic-neoclassical economics	". . . [endowing future generations] with whatever it takes to achieve a standard of living at least as good as our own and to look after their next generation similarly."	Intergenerational equity, capital investment	Solow, 1992 (page 15)
Business	". . . integrat[ing] environmental considerations into our operations and into our long-range planning. . . ."	Sustainable growth	Kennedy, 1992 (page 2)
Development agency	". . . a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base."	Sustainable technological progress, no absolute limits, intragenerational equity	World Commission, 1987 (The Bruntland Report) (page 1)
Government	". . . policies that encourage economic growth, job creation, and effective use of our natural and cultural resources."	Good economic policy protects the environment and good environmental policy strengthens the economy	White House, 1993

places demands on intergenerational equity while recognizing a social evolutionary process, the subject of the next possible paradigm.

Lessons from Coevolution

The father of modern theories of evolution is Charles Darwin.[55] Jones suggests "classical economics as the scaffolding for evolutionary biology" with the writings of Thomas Malthus, Adam Smith, and others influencing Darwin.[56] (This is ironic given the current tendency to apply paradigms from evolutionary biology to the problems of economics.)

In studying social evolution, a particularly useful subsection of evolutionary biology is coevolution. It is a process of "evolutionary change of two closely interacting species where the fitness of the genetic traits within each species is largely governed by the dominant genetic traits of the other."[57] Coevolution accounts for change through selection, trial, error, and the survival of what proves fit. In a social context, it envisions social and biological systems evolving together along a random, but deterministic, time line within physical environmental constraints—"random" because what changes will occur are unknown; "deterministic" because change will certainly occur.

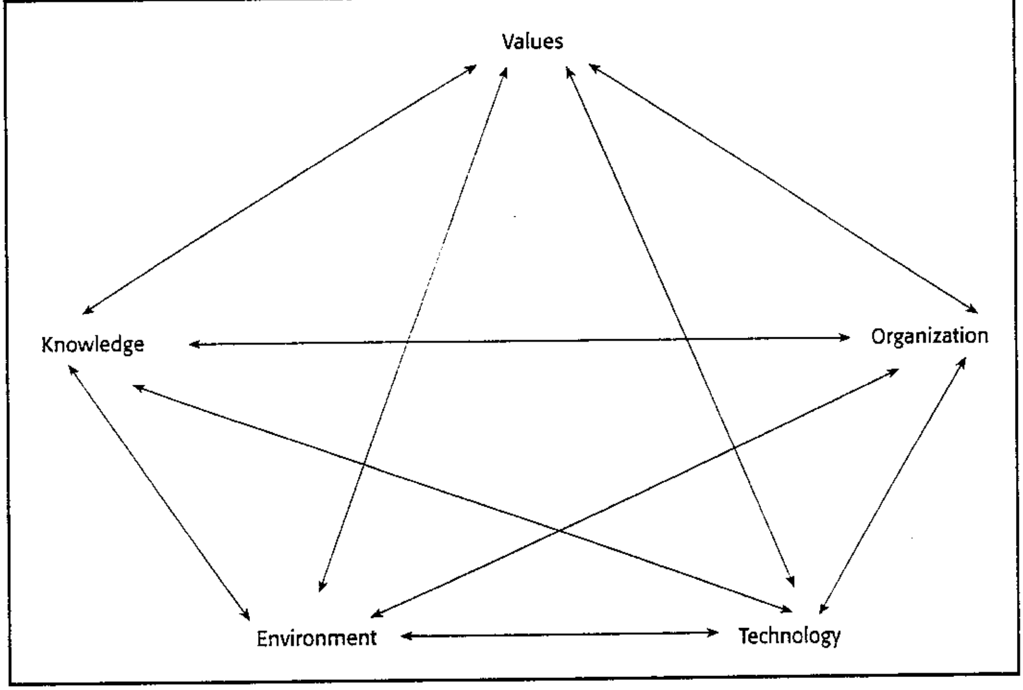
Under this paradigm there are no universal truths. In fact, coevolution promotes the virtues of diversity as a proving ground for functionality. In turn, "what works" is itself always changing.

Figure 19.2 describes some of the critical interactions of a coevolutionary social system. In direct contrast to modernity, there is no directionality in a coevolutionary model. The 20th Century version of progress starts with a problem, introduces science and the virtues of technological development, and unconditionally expects a solution. Under a science-knows-best paradigm, the solution to unsustainable development is simply to accelerate technological change—not dissimilar to the business, development agency, and government perspectives on sustainable development from Table 19.3.

Coevolution, however, cannot predict or be operationalized as conveniently as a utility maximization problem. This is perhaps not very satisfying. But coevolution sheds light on the complexity of the social-natural-physical system, which in turn provides insight into how to behave as individuals and how to structure our societies. It focuses less on finding the optimal solution than on asking the right questions. How should we take advantage of a coevolutionary process we cannot control? What are the catalysts to coevolutionary processes?

Norgaard explores U.S. pesticide policy as an example of the coevolutionary process. He also examines agricultural development in the Amazon for lessons from a coevolutionary perspective.[58] In the Amazon case, Norgaard argues that the application of Western agriculture and global market theory to a tropical ecosystem and culture has failed completely. On the other hand, traditional knowledge and cultures, which coevolved with this specific ecosystem, have repeatedly proven more reliable. John Gowdy explores hunting and gathering societies, and concludes that they represent perhaps "the most successful lifestyle humans have yet devised."[59] Success is considered in terms of their compatibility with the long-run sustainability of the ecosystem and exemplary egalitarian societal structure. He, too,

FIGURE 19.2 The Coevolutionary Process[60]



argues against the universal applicability of modern market economies, demonstrating that the 'economic man' most often characterized in utility maximization problems is misleading. He believes that humans have not historically exhibited unlimited wants or purely egocentric behavior without altruism or concern for environmental externalities.

By its nature, a paradigm of coevolution cannot be applied to all problems. Norgaard argues, however, that recognizing an underlying coevolutionary process between social and natural systems can be helpful in formulating lessons to help guide social processes. Some lessons include:[61]

1. Experiment on a small scale and monitor the evolutionary chain of events. This is particularly useful in avoiding past mistakes regarding the unforeseen consequences of technology transfer.
2. Experiments with long-term commitments should be avoided. The perfect example here is the set of problems caused by a policy of irretrievable nuclear-waste burial.
3. Diversity in coevolving systems is inherently good; without it, stagnation is likely. Diversity in cultures, ecosystems, and species provides greater opportunity for natural selection to determine what is fit.
4. Emphasize evolutionary processes rather than mechanical fixes. For instance, encourage diversity instead of relying on monotypical technical fixes. This allows great flexibility in responding to new challenges.

5. Cultures first evolved around ecosystems, then around hydrocarbons. Will the next focal point of social evolution be sustainability?

Concluding Remarks: Choices and Change

The very first lesson students of economics learn is that economics is the study of choices.[62] This is perhaps something all economists can agree on, whether they call themselves neoclassical, environmental, or ecological. Traditionally the choices have been framed in terms of how best to employ scarce resources to produce commodities and distribute them for consumption. Within this realm, economics has been very amenable to marginal analysis and the mathematics of optimization, and during the neoclassical age it has become more a science of choice than the instrument of social change originally envisioned by the classical economists.

Choices, however, are increasingly difficult to make. The environmental consequences of our individually rational choices include the prospect of dramatically changing the global climate as well as damaging biodiversity—in essence, resetting the evolutionary clock. The social consequences include a widening of global income disparity, the institutionalization of poverty, and the failure to support an exploding human population. The discipline of environmental economics addresses these consequences, but has been somewhat limited due to a dependence on the consumption-oriented, individualistic growth paradigm of neoclassical economics.

This chapter addresses the broader choice of paradigms. The relatively new discipline of ecological economics was presented as an alternative to environmental economics. More specifically, the paradigms of limits, sustainable development, and coevolution were discussed as alternatives to a market-driven model of economic growth.

The transition to a new paradigm has been discussed for decades, but is slow in coming. John Livingston in *Rogue Primate* concedes that:

> *. . . no one knows how a new paradigm or a new metaphysic, no matter how cogently drafted, is to be gotten into the human bloodstream. You don't legislate things of this kind. You evolve into them, and out of them.*[63]

As evidence of this social evolution, consider the last large-scale shift in paradigm from the mercantilist to the free-market era. Galbraith notes that the mercantilist era that preceded industrialization and competition evolved over a half-century of change. Before the industrial revolution, the wealthy merchant class discouraged competition for fear of bringing prices too low. The success of the state in this era was measured by the success of its merchant class's pursuit of wealth. The welfare of individuals or households was irrelevant.[64]

Even before the shift in paradigm from merchant to individual, the emphasis on profit-seeking behavior was itself a gradual evolution. In premercantilist economic history, wealth was largely viewed with suspicion and its pursuit was felt to be immoral. In fact, early Christian doctrine condemned the use of interest on loans.[65]

Economic thought continues to evolve. In neoclassical economics, the pursuit of wealth gained gradual acceptance. Might the next defining economic concept be the pursuit of sustainability?

Questions for Discussion and Analysis

1. What is ecological economics?

2. List what you believe to be the three most important concepts in ecological economics. Compare your list to that of another student. Do they agree?

3. Do you consider yourself to be either a neoclassical or an ecological economist? Explain.

4. How does the Erickson perspective on climate change in this chapter compare to the Nordhaus perspective in the previous chapter?

5. Consider Chapter 10's review of economic aspects of population growth and resource depletion. Do you think resource exhaustion or pollution will prove to be a more important question? How do you think the author of this chapter would answer the same question?

6. Compare the several definitions of sustainability in Table 19.3.

7. Discuss the major components of the coevolution concept.

8. This textbook includes 18 or 19 chapters that would generally be considered mainstream environmental economics. Do you think that this chapter by Erickson successfully makes the case that ecological economics is an alternative to environmental economics?

9. Assume you wish to join a professional society in economics that publishes research on environmental subjects, but you can only afford to join one of the three! Would it be the American Economic Association, the Association of Environmental and Resource Economists, or the International Society for Ecological Economics?

Notes to Chapter 19

1. Adam Smith, *The Wealth of Nations* (London: Dent, 1910). First printed in London, 1776.
2. Smith, however, was more concerned with the moral implications of self-interested behavior than he has been given credit for. In his work on the *Theory of Moral Sentiments* (1759), which preceded *The Wealth of Nations*, Smith argues that our conscience (what he calls "the impartial spectator") will also play a role in guiding our decisions. See Robert Heilbroner, *Teachings from the Worldly Philosophy* (New York: Norton, 1996).
3. John Stuart Mill, *Principles of Political Economy*, Seventh Edition (London: Oxford University Press, 1994). First published in 1848.
4. A. C. Pigou, *The Economics of Welfare*, Fourth Edition (London: MacMillan, 1952). First published in 1920.
5. John Maynard Keynes, *The General Theory of Employment, Interest, and Money* (New York: Harcourt, Brace, 1964). First published in 1936.
6. S. V. Ciriacy-Wantrup, *Resource Conservation: Economics and Policies* (California: University of California Division of Agricultural Sciences, 1963). First edition published by the University of California Press in 1952.
7. John K. Galbraith, *Economics in Perspective: A Critical History* (Boston, MA: Houghton Mifflin, 1987).

8. Richard B. Norgaard, *Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future* (London/New York: Routledge, 1994). See also John M. Gowdy, "Progress and Environmental Sustainability," Spring 1994 *Environmental Ethics* 16:41–55.
9. These categories were suggested by Richard Norgaard in a seminar at Cornell University.
10. Nicholas Georgescu-Roegen, "Energy and Economic Myths," January 1975 *Southern Economic Journal* 41(3):347–381, page 359.
11. Thomas Malthus, an ordained clergyman, is known for his writing on absolute limits to population growth. He argued that a fixed amount of land accompanied by an increasing population would lead to diminishing returns and a declining per capita food supply. In turn, standards of living would decline to a level where population would cease to grow. See Thomas Robert Malthus, *An Essay on the Principle of Population*, Philip Appleman. ed. (New York: Norton. 1976). First published anonymously in 1798.
12. See John Gowdy, *Coevolutionary Economics: The Economy, Society and the Environment*, (Boston. MA: Kluwer, 1994), page 8; and John Gowdy and Sabine O'Hara, *Economic Theory for Environmentalists* (Delray Beach. FL: St. Lucie, 1995), pages 48–51.
13. David Ricardo, *Principles of Political Economy and Taxation* (London: Everyman, 1926). First published in 1817.
14. Herman E. Daly, *Beyond Growth: The Economics of Sustainable Development* (Boston. MA: Beacon, 1996), page 27.
15. 'Newtonian' refers to the scientific tradition of explaining phenomena or processes by reducing them to parts and universal rules.
16. Kenneth E. Boulding, "The Economics of the Coming Spaceship Earth," pages 3–14 in H. Jarrett, ed., *Environmental Quality in a Growing Economy* (Baltimore: Johns Hopkins, 1966).
17. See Kenneth E. Boulding, *The World as a Total System* (Beverly Hills, CA: Sage Publications, 1985); and Kenneth E. Boulding, *Towards a New Economics* (England: Elgar, 1992).
18. Boulding used the phrase "cowboy economy" to describe an economy where resources are thought to be limitless, as they perhaps seemed during the European settlement of the western United States. Modern-day cowboys or ranchers, however, are well aware of the limits to resources on a daily basis.
19. Boulding, "Spaceship Earth." *op. cit.* (see Note 16).
20. Daly *op. cit.* (see Note 14), page 31.
21. See Herman E. Daly and John B. Cobb, Jr., *For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future* (Boston, MA: Beacon, 1989). Recall the discussion of 'natural rights' and 'nonhuman value' in Chapters 5 and 15.
22. James Lovelock, *Gaia: A New Look at Life on Earth* (London: Oxford University Press, 1995), page viii. First published in 1979.
23. Robert Costanza, editor, *Ecological Economics: The Science and Management of Sustainability* (New York: Columbia University Press, 1991); Norgaard *op. cit.* (see Note 8); John Gowdy, *Coevolutionary Economics: The Economy, Society and the Environment* (Boston. MA: Kluwer, 1994); Cutler J. Cleveland, Robert Costanza. Charles A. S. Hall, and Robert Kaufmann, "Energy and the U.S. Economy: a Biophysical Perspective," August 1984 *Science* 225:890–897.
24. Robert Costanza, John Cumberland, Herman Daly, Robert Goodland, and Richard Norgaard, *An Introduction to Ecological Economics* (Boca Raton, FL: St. Lucie, 1997). This is a good resource for the book's detailed discussions of "The Historical Development of Economics and Ecology" (pages 19–75) and "Problems and Principles of Ecological Economics" (pages 77–167).

25. Rajaram Krishnan, Jonathan M. Harris, and Neva R. Goodwin, eds., *A Survey of Ecological Economics* (Washington, DC: Island, 1995); Nirmal C. Sahu and Bibhudatta Nayak, "Niche Diversification in Environmental/Ecological Economics," 1994 *Ecological Economics* 11:9–19; Kerry Turner, Charles Perrings, and Carl Folke, "Ecological Economics: Paradigm or Perspective," pages 25–49 in Jeroen C. J. M. van den Bergh and Jan van der Straaten, eds., *Economy and Ecosystems in Change: Analytical and Historical Approaches* (Cheltenham, UK: Elgar, 1997).
26. For a critique, in the spirit of ecological economics, of CO_2 fertilization claims. see Jon D. Erickson, "From Ecology to Economics: The Case Against CO_2 Fertilization," 1993 *Ecological Economics* 8:157–175; and David H. Wolfe and Jon D. Erickson, "Carbon Dioxide Effects on Plants: Uncertainties and Implications for Modeling Crop Response to Climate Change," pages 153–178 in Harry Kaiser and Thomas Drennen, eds., *Agricultural Dimensions of Global Climate Change* (Delray Beach, FL: St. Lucie, 1993).
27. William D. Nordhaus, "To Slow or Not to Slow: The Economics of the Greenhouse Effect," July 1991 *The Economic Journal* 101:920–937; William D. Nordhaus. "An Optimal Transition Path for Controlling Greenhouse Gases," November 1992 *Science* 258:1315–1319; William D. Nordhaus. *Managing the Global Commons: The Economics of Climate Change* (Cambridge, MA: MIT Press, 1995).
28. For instance: Duane Chapman, Vivek Suri, and Steven G. Hall, "Rolling DICE for the Future of the Planet," July 1995 *Contemporary Economic Policy* 13:1–9; Donna Lee and James Roumasset, "Optimizing Global Warming: An Intermediate Approach," presented at the 84th Annual Meeting of the American Agricultural Economics Association, San Antonio, TX, July 28–31, 1996; Neha Khanna and Duane Chapman. "Climate Policy and Petroleum Depletion in an Optimal Growth Framework." Cornell ARME Staff Paper 97-7, November 1997; Robert K. Kaufmann, "The Economic Impact of Global Climate Change: Making Sure the 'DICE' Model isn't Loaded." *Climatic Change*, in press.
29. Literally meaning "economic man," the stereotypical decision-maker in the self-interest model. This nomenclature was first used by Max Lerner in an introduction to Adam Smith's *The Wealth of Nations*, First Modern Library Edition (New York: Random House, 1937).
30. Nordhaus *op. cit.* (see Note 27, 1992).
31. Michael D. Yates. *Longer Hours, Fewer Jobs: Employment & Unemployment in the United States* (New York: Monthly Review Press, 1994), page 11.
32. Jerry Kloby. "The Growing Divide: Class Polarization in the 1980s." September 1987 *Monthly Review* 39(4).
33. Lawrence Mishel and Jared Bernstein. *The State of Working America* (Armonk, NY: M. E. Sharpe, Inc., 1993).
34. Yates *op. cit.*, pages 10 and 11.
35. Rawls proposes a classic thought experiment in which a "veil of ignorance" is placed over each participant, effectively blinding any socioeconomic identity they may have. In setting up an initial situation that is fair, he argues that principles of justice will be chosen that require (1) equal rights to basic liberties, and (2) social and economic inequalities arranged for the greatest benefit of the least advantaged (the difference principle). See John Rawls. *A Theory of Justice* (Cambridge, MA: Harvard University Press, 1971).
36. Calculated from Table 10 (Regional Summaries), pages 98–99 in UNICEF. *The State of the World's Children 1996* (New York: Oxford University Press, 1996).
37. UNICEF, *The State of the World's Children 1993* (New York: Oxford University Press, 1993), Figure 1, page 2.
38. *Ibid.*
39. Norgaard *op. cit.* (see Note 8).

40. Al Gore, *Earth in the Balance: Ecology and the Human Spirit* (Boston, MA: Houghton Mifflin Co., 1992), page 223.
41. Richard Leakey and Roger Lewin, *The Sixth Extinction: Patterns of Life and the Future of Humankind* (New York: Doubleday, 1995), page 245.
42. Defined when at least 65 percent of marine animal species became extinct. Extreme changes in life's history are most readily inferred from the marine fossil record as these organisms are more likely to become fossilized and thus have provided a more complete fossil record. The Big Five, however, are also evident in the terrestrial record. *Ibid.*, pages 44–45.
43. Notes to Table 19.1:
    a. World Resources Institute, *World Resources 1994–95* (New York: Oxford University Press, 1994). CO_2 in 1991 emissions from Table 23.1, page 363. SO_2 in 1991 emissions from Table 23.5, page 367.
    b. P. William Reidhead, *Environmental Costs and Optimal Unit Pricing for Municipal Solid Waste Services*, M.S. thesis (Ithaca, NY: Cornell University, 1996), page 1. Includes both residential and commercial solid waste for 1989.
    c. U.S. Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035 (96/05), U.S. Department of Energy, Washington, DC, May 1996. Gas statistics from 1995, Table 3.4, page 57. Coal statistics from 1995, Table 6.1, page 87. Per capita calculation assumes a U.S. population of 260.6 million.
    d. U.S. Environmental Protection Agency, *National Air Quality and Emissions Trend Report 1994*, EPA 454/R-95-014, U.S. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC. October 1995, Figure 1.3, page 1–4. 1994 data.
    e. UNICEF *op. cit.* (see Note 37), Table 5, page 88. 1994 data.
    f. Also see Table 10.2 in Chapter 10 on per capita recycling and waste.
44. Leakey and Lewin *op.cit.*, page 241.
45. *Ibid.*, page 237.
46. Donnella H. Meadows, Dennis L. Meadows, Jorgen Randers and William W. Behrens III, *The Limits to Growth* (New York: Universe Books, 1972), page 23.
47. This scenario calculated the number of years known global reserves would last assuming consumption growing exponentially at the average annual rate of growth. *Ibid.*, Table 4, pages 56–60.
48. United Nations Development Program, *Human Development Report 1993* (New York: Oxford University Press, 1993).
49. Donnella H. Meadows, Dennis L. Meadows, and J. Randers, *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future* (Post Mills, VT: Chelsea Green Publishing Co., 1992).
50. Joel E. Cohen, *How Many People Can the Earth Support?* (New York: Norton, 1995).
51. Meadows *op. cit.* (see Note 49).
52. Bill McKibben, *The Comforting Whirlwind: God, Job, and the Scale of Creation* (Grand Rapids, MI: Eerdmans, 1994), page 43.
53. Richard B. Howarth and Richard B. Norgaard, "Environmental Valuation under Sustainable Development," May 1992 *American Economic Review* 82(2):473–477, page 473.
54. K. Arrow, B. Bolin, R. Costanza, P. Dasgupta, C. Folke, C. S. Holling, B. Jansson, S. Levin, K. Maler, C. Perrings, and D. Pimental, "Economic Growth, Carrying Capacity, and the Environment," April 1995 *Science* 268, page 521; Robert Solow, "An Almost Practical Step Toward Sustainability," an Invited Lecture on the Occasion of the Fortieth Anniversary of Resources for the Future, Washington, DC, October 8, 1992, page 15; Robert D. Kennedy (CEO, Union Carbide Corp.), "Sustainable Development: The Hinge of History," Industry Forum on Environment and Development, Rio de Janeiro, May 28, 1992, page 2; World Commission on Environment and Development, *Our Common Future*

(New York: Oxford University Press. 1987); White House, Office of the Press Secretary, "On Earth Summit Anniversary President Creates Council on Sustainable Development," Press Release, June 14, 1993.

55. Charles Darwin, *On the Origin of Species—A Facsimile of the First Edition* (Cambridge, MA: Harvard University Press, 1964). *Origin* was first published in 1859. Although Darwin is most often credited as the father of evolution, Alfred R. Wallace is recognized as a codiscoverer of natural selection. See Stephen Jay Gould, *Ever Since Darwin: Reflections in Natural History* (New York: Norton. 1977), page 25.
56. Lamar Jones, "The Institutionalists and *On the Origin of Species*: A Case of Mistaken Identity," 1986 *Southern Economic Journal* 52(4):1043–1055, page 1043.
57. Norgaard *op. cit.* (see Note 8), page 26.
58. *Ibid.*, page 121. See also Richard B. Norgaard, "Sociosystem and Ecosystem Coevolution in the Amazon," 1981 *Journal of Environmental Economics and Management* 8:238–254.
59. Gowdy *op. cit.* (see Note 12), page 27. See also, John M. Gowdy, *Limited Wants, Unlimited Means: A Reader on Hunter-Gatherer Economics and the Environment* (Washington, DC: Island, 1997).
60. Figure 19.2 is from Norgaard (Note 8). page 27.
61. Norgaard *op. cit.* (see Note 8).
62. For example: Paul A. Samuelson and William D. Nordhaus, *Economics*, Twelfth Edition (New York: McGraw-Hill, 1985), page 4; J. R. Clark and Michael Veseth. *Microeconomics: Cost and Choice* (San Diego, CA: Harcourt Brace Jovanovich, 1987), page 4; Robert H. Frank. *Microeconomics and Behavior*, Second Edition (New York: McGraw-Hill, 1994), page 3.
63. John A. Livingston, *Rogue Primate: an Exploration of Human Domestication* (Toronto, Canada: Roberts Rinehart Publishers. 1994), page viii.
64. Galbraith *op. cit.* (see Note 7), page 38.
65. *Ibid.*, page 22.