Chapter 12

Economics without Continuing Growth

12.1 Dissenting voices

Neoclassical economics is commonly dubbed "mainstream" because of its dominance in the economics departments of most major English-speaking universities.[1] These departments provides faculty for many smaller universities and colleges, as well as professional staff for large numbers of businesses and governmental bodies. Given that mainstream economics is premised on the desirability of continual growth, this accounts for the widespread assumption within the economic establishment that growth is necessary for a healthy economy (section 11.1).

But while neoclassical economics was building up its hegemony, its path was never entirely free from dissonant voices. Some objected to what was perceived as an excessive use of mathematics in economic theory, and others to the general methodology of establishing a social science on an axiomatic basis. Yet others expressed concern that axiomatic economics had little to say about disparities in wealth between rich and poor nations, or about the growing income gap between management and labor.

The most insistent challenge to mainstream economics, however, is probably that issued by an increasingly influential group of economists and ecologists going under the general title "ecological economics." Their charge is that the mainstream is systematically oblivious to the ecological impact of economic activity.[2] The main purpose of this chapter is to gain an overview of this relatively new approach to economics, with particular attention to its message regarding economic growth.

By way of preparation, we shall look at several well-known antecedents of this ecological approach in the late 1960s and early 1970s. Included are Kenneth Boulding's "The Economics of the Coming Spaceship Earth," E.F. Schumaker's *Small is Beautiful*, and the highly influential (and controversial) Club of Rome study *The Limits to Growth*. This is the business of section 12.3. The survey of antecedents continues in section 12.4 with a brief survey of Nicholas Georgescu-Roegen's scholarly *The Entropy Law and the Economic Process*, to which ecological economics is primarily indebted for its theoretical foundation. In section 12.5, we turn to this new branch of economics itself, reserving its central message about growth for examination in section 12.6. The chapter ends in section 12.7, with an attempt to identify some relevant shortcomings of this otherwise very helpful approach.

Before embarking on this agenda, however, it will be useful to look briefly at a recent offshoot of mainline economics called "environmental economics," which is sometimes confused with its ecological counterpart. As a tributary of the mainstream, environmental economics is not in a position to call continued growth into question. It nonetheless puts forward some useful proposals for mitigating the ecological damage caused by free-market activity.

12.2 Environmental economics

Through most of its history, neoclassical economics viewed environmental resources such as clean air and fresh water as essentially limitless in supply. While it was recognized that resources like these contribute significantly to human well-being, the general perception that they are free and unlimited led to their having no market value. A consequence is that they did not figure in the theoretical models by which economists studied the dynamics of the free-market system.

A further consequence is that environmental factors did not play a role in the operation of actual markets. Thus there were no market mechanisms for factoring pollution and other environmental by-products of production into the pricing of commodities. In economic parlance, this means that harmful environmental effects of production were treated as *externalities.* The main thrust of environmental economics is to make externalities of this sort part of the pricing process and then to allow the market to assign them costs in monetary terms.

From the perspective of environmental economics, the fact that externalities like these previously had no role in the pricing process was viewed as a *market failure*. By one definition at least, a market failure occurs when the market concerned does not reflect the full social costs of goods or services it provides (http://glossary.eea.europa.eu/EEAGlossary/M/market_failure). When this happens, the goods and services in question are said to be allocated inefficiently, meaning that consumers would be unwilling to buy extra units of a commodity at a price reflecting its true social cost (http://www.answers.com/topic/inefficiency). Another way of characterizing environmental economics, accordingly, is that it advocates the correction of market failures pertaining to the costs of environmental resources.

Although pollution is a major concern among environmental economists, there are other kinds of externalities that figure in their discussions as well. One is the environment's ability to absorb potentially disrupting by-products of industrial activity, for example the ability of vegetation to absorb carbon dioxide. Another broad category of externalities is the earth's stock of mineral resources that are subject to depletion. Because of this relatively broad range of interests, the branch of economics in question is sometimes labeled "environmental and natural resource economics."[3]

Various measures have been proposed for factoring environmental costs into the pricing process of the free-market system. One obvious approach would be to regulate the emission of polluting by-products, with the imposition of taxes or fines when maximum thresholds are exceeded. Even if such regulations were enacted, however, they would be difficulty to enforce, given a general antipathy to financial disincentives in a free-market context. There are other measures that rely upon more effective motivations.

One such is the implementation of pollution quotas, with permits that can be traded on the open market. When tradable quotas of this variety are available, a firm can compare the cost of reducing its own pollution with that of buying permits from another company capable of accomplishing the same reduction more efficiently and then make the choice it finds less costly. As already observed in section 8.5, a sulfur dioxide trading program of this sort has been in place since 1995 and to date has proved at least moderately successful.

Another market-based approach is to provide tax incentives for installing pollution control equipment (such as smokestack scrubbers; section 8.2). An added economic advantage of this approach is the considerable money to be made in manufacturing the equipment involved. According to one source, profits in the pollution-control industry topped three billion dollars in 2004, with growth to 15 billion projected for 2015 (http://www.environmental-expert.com/resulteachpressrelease.asp?cid=5122&codi=7253).

A further approach often associated with environmental economics is the use of cost-benefit analysis to compare the value of specific sites in providing essential ecological services (e.g., storm and flood protection) with that of their being exploited for other purposes. It is not unusual to find that currently undeveloped areas in various parts of the world are economically more valuable if left in their natural state. According to recent report out of Cambridge University,[4] for example, proposed logging of a certain forest in Malaysia would cut its economic value by 50 percent.

Although particular approaches like these have obvious merits on their own, the fact that environmental economics remains dependent on its neoclassical roots compromises its credibility as a path to ecological survival. One problem noted above is that it leaves unchallenged the doctrine that economic growth is tantamount to social improvement. Bringing environmental costs and benefits into the pricing process is not enough by itself to keep an economy from expanding to the point where it overwhelms its ecological support system.

Also problematic is the methodological requirement that qualitative states of the environment be measured in economic (hence quantitative) terms. Apart from the grossest kind of approximation, there is no way in which an intact ozone layer—or a normally functioning Gulf Stream, or an optimal level of CO_2 in the atmosphere—can be assigned a credible dollar value. One cannot help suspecting that if realistic prices were put on these basic ecological resources then free-market enterprise itself would end up being priced out of existence.

Ecological economics avoids these problems by dissociating itself from the mainstream paradigm. This parting of the ways was gradual, and seems not to have emerged as a fait accompli until sometime in the 1980s. To appreciate the significance of this departure, let us trace out the origins of ecological economics in the 1960s and 1970s.

12.3 Antecedents of ecological economics

Public concern about environmental problems was galvanized by conservationist Aldo Leopold's *A Sand County Almanac* (1949) and biologist Rachel Carson's *Silent Spring* (1962). Among economists, the most prominent pioneer in this movement was probably Kenneth Boulding, author of "The Economics of the Coming Spaceship Earth" (1966). Boulding's status as a respected member of the profession is indicated by his having been elected President of the American Economics Association in 1968.

Boulding's "Spaceship" article has become famous for its contrast between the "cowboy" or open economy (in the sense of open system; section 1.6) and the "spaceship" economy that is essentially closed. As he explained the metaphors, a cowboy is symbolic of the "illimitable plains" and is also associated with reckless and exploitative behavior, while a spaceship symbolizes the planet earth "without unlimited reservoirs of anything, either for extraction or pollution." In the cowboy economy, he goes on the say, both production and consumption are regarded as good things, and the success of any economy is measured in terms of raw materials cycled through the system and discharged as waste products (which he labels "throughput"). In the spaceman economy, by contrast, the primary concern is with maintaining stocks (e.g., of raw materials and pollution sinks), and success is a matter of achieving maximum human good with a minimum of throughput.

Boulding is aware that most economists will find "very strange" the idea that production and consumption are not good things in themselves. Another departure from traditional economics is his explicit use of concepts from thermodynamics.[5] As he puts it, there is "no escape from the grim second law of thermodynamics," especially with respect to our rapidly depleting supply of fossil fuel. Boulding also makes effective use of the contrast between entropic and negentropic (section 2.7) processes (he uses the term 'antientropic'). He illustrates the former by the diffusion of once concentrated materials over the earth's surface, the latter by the concentration of previously diffuse materials. Similar concepts are employed by later writers on ecological economics.

The much maligned but highly influential volume *The Limits of Growth*, by Donella H. and Dennis L. Meadows, Jorgen Randers, and William W. Behrens III, was first made public in 1972. As far as a methodology is concerned, the genius behind the work was Jay Forrester, found of the computer simulation technique known as System Dynamics and then Professor in MIT's Sloan School of Management. In bare essentials, the computer model ("World 3") used in the "Limits of Growth" study was a system of several dozen interdependent variables that could be either altered or held constant in order to explore their effects on each other. The primary contribution of the volume's authors, all of whom had extensive experience in the study of complex systems, was to select the variables to be manipulated and to make educated guesses about how they might be empirically related.

Variables were selected to represent five areas of major global concern: industrialization, population growth, food shortage, depletion of nonrenewable resources, and environmental degradation. Runs of the mode based on estimates of then existing trends predicted that natural resources would soon be exhausted, that pollution was about to reach life-threatening levels, that massive famine was only a few decades away, and that catastrophic collapse of the whole system would occur by 2050. Ultimate collapse in the model could be delayed by holding one or a few of the key variables constant (e.g., population or the use of natural resources). Given the systematic interconnections among variables, however, the only way to avoid eventual collapse involved arresting or reversing existing trends in all five areas. Piecemeal approaches focusing on population control or food production in isolation would not assure a sustainable future, and might even backfire.

Needless to say, *The Limits of Growth* received scathing reviews from mainstream economists. Not only were its results radically at odds with the doctrine that continual growth is necessary for a healthy economy; no less disconcerting to the reviewers was that the methods of computer simulation employed in the study were fields apart from the mathematical models favored by mainstream economists. One might surmise that the appearance of this study was a defining moment in the fixation of mainstream orthodoxy; henceforth to take this kind of study seriously was to invite excommunication from the fold.

Despite this derision from the mainstream, however, by the year 2000 *The Limits to Growth* had sold over three million copies in at least 31 languages.[6] Its importance lies not in the accuracy of its predications, which were not intended to be definitive in the first place, but rather in its having alerted the world to reasons why economic growth cannot continue indefinitely. In this manner it helped clear the way for the distinctly unorthodox approach represented by ecological economics.

Other trail-breaking works by economists during this period were E.F. Schumacher's *Small is Beautiful: Economics as if People Mattered* (1973) and Herman Daly's *Steady-State Economics* (1977). The title of Schumacher's book reflects his ideas that large organizations should operate like networks of smaller groups and that the technology used by such groups should be "intermediate" in the sense of designed for the job-satisfaction of self-employed workers. For Schumacher, quality of work-experience is a basic economic good, to be stressed even at the expense of economic growth.

Daly's book also argues for a de-emphasis of economic growth. In place of the standard economic model focusing on the flow of products to consumers and the return flow of income from consumer to producer, which ignores the economy's dependence on environmental resources, Daly advocates a model focused on the throughput (Boulding's term) of low-entropy resources resulting in high-entropy by-products. His basic idea is that an economy is sustainable only if it maintains a stable balance (steady state) between the natural resources it consumes and those the environment can replenish at a sustainable rate. Daly was a student of Nicholas Georescu-Roegen, whose contributions we consider in the following section.

Among important contributions from outside the field of economics were ecologist Howard T. Odum's *Environment, Power, and Society* (1971) and geophysicist Earl Cook's *Man, Energy, Society* (1976). Odum's book was an application of general systems theory to the interaction between ecological and economic systems in particular. One of its basic themes is that all wealth stems from the environment and that the value of commodities ought to be based on the energetic resources needed to produce them (rather than on, e.g., the consumer's willingness to pay). Cook's book is a thoughtful and sober examination, against the backdrop of the Second Law of Thermodynamics, of the various forms in which human society appropriates energy from the natural environment and of the inefficiencies with which that energy is often put to use.

12.4 The conceptual reorientation due to Georgescu-Roegen

Kenneth Boulding may have been the first prominent economist to have applied the Second Law of Thermodynamics explicitly to the economic process (section 12.3), but his use of the principle involved little technical sophistication. Other attempts to make this principle relevant to economics were made by physical scientists, including Frederick Soddy and Earl Cook as previously noted, but their works were seldom read by mainstream economists. Within the field of economics proper, the first technically rigorous treatment of the Second Law and its economic implications came with Nicholas Georgescu-Roegen's *The Entropy Law and the Economic Process* (1971).

Georgescu-Roegen (G-R) was born in Romania, received a doctoral degree in mathematical statistics from the Sorbonne, and came to the U.S. in 1934 where he studied economics under the influence of Joseph Schumpeter at Harvard. He subsequently moved to Vanderbilt University, where he gained a reputation among mainstream economists for his work on mathematical models of consumer preference and market equilibria. When he turned his mathematical skills from mathematical modeling to thermodynamics and its economic applications, the shift was perceived as a revolt against the mainstream to which he himself had made substantial contributions.

G-R's departure from neoclassical economics can be described in terms of what, following Schumpeter,[7] might be called a conflict of preanalytic visions. The preliminary conception of a functioning economy that stands behind the standard neoclassical approach posits an isolated system in which exchange value of one or another sort is passed back and forth between firms and households. More concretely, an economy is conceived as a closed loop in which products are exchanged for money, which then underwrites the generation of more products, and so on indefinitely. The system is isolated in the sense of being cut off from its environment. No account is taken either of raw materials and energy coming into the system or of the resulting waste products discharged back into the environment.

In place of the familiar producers and consumers, G-R substituted what amounts to a one-way flow beginning with resources taken from the environment and ending with a discharge of wastes.[8] The one-way flow is roughly equivalent to the quantity termed 'throughput' by Boulding and others. In G-R's own terms, it consists of "an input flow of low entropy" joined to "an output flow of high entropy."[9] So-called "low entropy" is what we have been calling "negentropy" (section 2.7; G-R also uses this term occasionally), and "high entropy" is energy or structure too far degraded for further use.

Another way of getting at the disparity between G-R's approach and that of the mainstream has to do with their respective postures toward classical (Newtonian) mechanics. The equations of classical mechanics have no temporal parameters, which is to say that the processes they apply to are theoretically reversible. The equations would apply even in a world where, so to speak, time ran in the opposite direction. This ties in with the atemporal character of the neoclassical flow model, with exchange value circulating endlessly between producer and consumer. In G-R's way of thinking, by contrast, the economic process is essentially temporal and not mechanical.[10] Because of the Second Law, it is physically impossible for the economy to reverse itself and to begin operating so as to convert a high-entropy input into a low-entropy output.

A concrete result of G-R's entropy flow model (low entropy in, high entropy out) is his rejection of the neoclassical notion that increases in capital can make up for decreases in natural resources. According to the standard conception, economic output is a joint function of given quantities of capital, labor, and natural resources, such that a greater quantity of one factor can compensate for a lesser quantity of another.[11] In G-R's analysis, this notion trades on a confusion between funds and flows. Whereas natural resources constitute flows passing through the economy, both capital and labor are funds (agencies) that transform resources into products. In terms of a favorite analogy of Herman Daly's, to think that capital can effectively substitute for resources is like thinking that the same house could be built with half the lumber by using twice the number of saws.[12]

G-R is generally recognized as the theoretical progenitor of ecological economics (although he seems not to have used the label himself). Within the last few decades, ecological economics has emerged as a major source of dissent against mainstream orthodoxy.

12.5 Ecological economics (EE)

EE took on a distinct identity with the founding of the International Society for Ecological Economics in 1987 and the establishment of a journal bearing its name in 1989. Founding editors of the latter were Robert Costanza and Herman Daly (author of *Steady-State Economics* mentioned earlier), who had collaborated previously in editing a special issue of the biology journal *Ecological Modelling* (1987) on topics germane to the emerging field of EE. This volume still serves as a useful introduction to the field, along with several more recent books explicitly directed to that purpose.[13]

This new field is interdisciplinary in the following sense. Whereas mainline economics is concerned with the operation of economic systems, and mainline ecology with that of ecosystems, EE is concerned with the *interaction* between systems of these two different sorts. Moreover, the manner in which it addresses this interaction is distinct from the way in which the interdisciplinary science of biophysics, for example, addresses biological phenomena from the perspective of physical theory. Strictly speaking, EE is neither the application of mainline economic theory to ecological phenomena (environmental economics is closer to this description) nor the application of ecological theory to economic phenomena (this is closer to bioeconomics[14]).

This is not to say that individuals working in the field of EE lack training in these two previously established disciplines. From its founding period to the present, EE has included both economists and ecologists bringing their unique skills to bear on phenomena of shared interest. Thus there are ecological economists without specialized training in economics and others without specialized training in ecology. This underscores the fact that EE as such is not an extension of some previously established discipline (like biophysics is an extension of physics). It is interdisciplinary in the sense of including researchers from different disciplines engaged in a collaborative effort, rather than a merger of the two disciplines involved.

For these reasons, EE not only lacks an overarching theoretical framework but also has no generally shared methodology. In the words of one of its prominent representatives, EE is "a large umbrella under which economists, ecologists, and other scholars" engage in searching for "a better understanding of the interrelations between people and their environment" (R.B. Norgaard, http://environment.harvard.edu/religion/disciplines/economics/index.html). Taken on its own, it is "methodologically eclectic" without integrating models or distinct theoretical paradigms (ibid.).

Given its methodological and theoretical eclecticism, EE is held together by a set of shared attitudes and perceptions regarding economic systems and their natural environments. Probably without exception, anyone identifying with the field would accept G-R's preanalytic vision that an economy is an integral part of a more comprehensive ecosystem.[15] Along with this goes the understanding that an economy takes low entropic resources from its environment, uses up these resources in its internal processes of production and consumption, and discharges the resulting high entropic wastes back into the environment. Another part of this preanalytic vision is an awareness that the environment is limited in its ability to sustain economic activity, with respect both to the low entropic resources it makes available and to its capacity for assimilating high entropic wastes.

Tied in with this conception of a limited physical environment is an understanding that economic growth cannot continue indefinitely. Continuing growth involves taking increasingly greater quantities of resources from the environment and discharging increasingly greater amounts of wastes for the environment to assimilate. Inasmuch as the environment is limited in both respects, continuing growth hastens the time when the economy in question will simply stop functioning.

From this perspective, it seems obvious that there will come a time (if it is not here already) when growth will have to be curtailed for the world economy to continue functioning. But curtailing growth does not require that the economic quality of human life will necessarily diminish. Herman Daly has made this point repeatedly, relying on a distinction between growth and development.[16] Economic growth is a matter of increasing quantities of materials flowing through the economy (which Daly, following Boulding, calls “throughput”). Economic development, on the other hand, is qualitative in character, having to do with increasing economic services achieved with a given amount of throughput.

Daly’s proposal in this regard is that economic planners shift their aim from quantitative growth to what he calls “sustainable development.” For him this means qualitative improvement in economic services, while avoiding levels of quantitative throughput that exceed the carrying capacity of the ecosystem.[17] While not all interested parties believe such a shift in emphasis would be realistic in the long run,[18] Daly at least has pointed out a kind of economic expansion that would not necessarily be environmentally destructive.

Another departure of EE from standard economics is its focus on environmental quality as such, in contrast with environmental economics’ focus on human benefits. As a branch of the mainstream, environmental economics relies on cost-benefit analysis in policy decisions and evaluates costs and benefits in terms of individual (and/or group) utilities and disutilities. This means that factors of environmental quality and impairment are evaluated with respect to human preferences. EE, however, evaluates these factors in terms directly relevant to their ecological functions, such as productivity (of biomass), stability and resilience, and biodiversity. In brief, whereas standard economics focuses on the environment as a source of human services, EE treats ecological systems as having value in their own right.

This illustrates yet another departure of EE from standard economics in that EE, unlike the latter, makes no pretence of being value-neutral.[19] To be sure, proponents of EE often are quite upfront in their concern for justice, equity, and human dignity (e.g., Norgaarrd, loc. cit.). Some even discuss values of an overtly religious nature (e.g., Daly, *Beyond Growth*, chs. 14, 15). EE is also described by its advocates as a context especially suited for taking the needs of future generation into account (Norgaard, loc. cit.), a concern which conventional economics with its emphasis on actual preferences is ill-suited to address.

This brief discussion is enough to show that, from an ecological perspective, EE's approach to the interaction between economy and environment is clearly preferable to anything mainstream economics has to offer. A resulting question is how, and to what extent, EE can help us find a way out of our current environmental predicament.

12.6 The contribution of EE to our environmental predicament

Our discussion of economics in its various manifestations began in chapter 10 with the observation that mainstream economics is committed to economic growth. Since economic growth generally requires increased energy consumption (ch. 7), and since increasing energy consumption over recent centuries has caused increasing damage to the biosphere (chs. 5 and 6), the influence of mainstream economics impedes the otherwise promising strategy of trying to alleviate our environmental predicament by substantial reductions in energy consumption. What help does EE offer in pursuing this strategy?

In reading the literature of EE, one gets the sense that its advocates are putting it forward as a workable alternative to mainstream economics. One encounters talk specifically about paradigm shifts, like that from classical (Newtonian) to quantum mechanics, suggesting that the paradigms of neoclassical economics are due for replacement by those of its ecological counterpart.[20] Although a shift of this sort clearly would be beneficial to the environment, there are reasons for thinking that such a transition will never actually take place.

These reasons have to do with differences in status between the two types of theory involved. For one thing, in comparison with EE, neoclassical economics is typified by a more or less integrated theory held in place by a relatively uniform paradigm. Although formulated differently by different authors, its dominant paradigm is that of a perfectly competitive market in which all participants make rational and fully informed choices intended to maximize their own interests. As already noted (section 12.5), however, EE is theoretically eclectic and possesses no single paradigm by which its concerns can be integrated. A consequence is that a transition from neoclassical to ecological economics would be less a paradigm shift within the same discipline than a change to another discipline of quite a different sort.

Perhaps a more substantial point of difference is that neoclassical theory has descriptive power that EE lacks. The fact that mainstream economics makes extensive use of mathematical modeling does not prevent it from being an empirical science. Its subject matter covers factual topics pertaining to the distribution of scarce resources within organized societies. While the gap between fact and theory is often considerable, people actually learn things about these topics when they study neoclassical economics. Knowledge gained through this study enables trained economists to find influential jobs in government and business. Mainstream economics is descriptive in that its practitioners are trained to make factual observations about the operation of actual economies.

Given that EE focuses on the interaction between economy and environment, rather than on economies themselves, it does not provide its practitioners with the same kind of factual expertise. The study of EE does not prepare people for economic positions in government and industry. (It is hard to imagine an ecological economist as Chairman of the Federal Reserve Board, for instance.) This is not to deny that ecological economists are knowledgeable in the operation of actual economies; undoubtedly many are. When this is the case, however, it is because of their experience with standard economics rather than their study of EE as such.

As far as its consideration of operating economies is concerned, EE is prescriptive rather than descriptive. Rather than providing information about how economies actually operate, that is to say, it is a primary source of advice about how they *should* operate. To mention two of many proposals by way of illustration, Herman Daly has urged that we (1) stop counting the consumption of natural capital as income, and (2) maximize the productivity of natural capital in the short run and invest in increasing its supply in the long run (http://www.feasta.org/documents/feastareview/daly2.htm). If these and similar proposals were implemented, our environmental circumstances undoubtedly would begin improving as a result. The point to be emphasized, however, is that they are only proposals and that under current circumstances they stand little chance of being implemented.

As matters stand, to be sure, EE has neither the technical expertise nor the political clout to change the economic process in ways it thinks would be environmentally desirable. Take the case of economic growth in particular. EE has been loud and clear in its insistence that upward-spiraling growth is inflicting increasingly severe damage upon the environment. But most governments and financial institutions see growth as essential to full employment and price stability. This means that calls from EE (and elsewhere) for no-growth policies will go largely unheeded. EE can advocate such policies until the end of the day; but as matters stand it lacks the resources to put these policies into effect.

The present section began with the question of how EE might help reduce the quantities of energy consumed by industrialized countries. This boils down to the question of how it can help curtail economic growth. By way of answer, we observed initially that EE is not the kind of theory that could replace mainstream economics in the deliberations of industry and government. The reason in brief is that it lacks a unified vision that might supplant the paradigm of the competitive market. We observed further that EE addresses the economic process in a prescriptive rather than a descriptive mode. Its descriptive efforts are aimed at the interaction between economy and environment, which puts it in a position to recommend opportune changes in economic policy and practice. But it has neither the technical expertise nor the political standing to bring such changes about.

Nonetheless, the fact that EE is primarily prescriptive does not prevent it from being of appreciable help in resolving our environmental predicament. Any change from the status quo that is not merely happenstance relies upon insights of a prescriptive sort. Prescriptive advice is advice about how things might be done in ways more in keeping with humanly significant norms, values, and aspirations. Preeminent among these are values pertaining to an environment capable of supporting human endeavors, now and into the indefinite future. There is no reasonable doubt that EE has made valuable contributions toward articulating such values, regardless of how ulti8mately they might be put into effect.

12.7 Curtailment of growth a matter of values

Part II of this study has been concerned with the role of economics in the gathering of our ecological crisis. Chapter 7 examined the relation between energy consumption and economic productivity, culminating with the general principle that the production of a given amount of economic goods introduces a corresponding measure of ecological degradation. The upshot, in brief, was that economic goods come with ecological price-tags, and that our current crisis amounts to an ecological deficit resulting from an over-production of economic goods.

Three strategies were identified for defusing the crisis. In order considered, the first was to isolate particular sources of ecological damage (e.g., sulfur dioxide emissions) and then to devise technologies (e.g., smokestack scrubbers) to eliminate them on a piecemeal basis. Chapter 8 evaluated this approach and found it wanting. One major shortcoming, among several, is that ecological degradation often takes the form of massive system malfunctions (like disruption of the earth's water cycle), which cannot be remedied by technological means.

The second strategy addresses the fact that the problem stems largely from humankind's excessive use of fossil fuels during the past two centuries. An obvious countermeasure is to replace fossil fuel with energy available from renewable sources (e.g., solar, wind, geothermal). This strategy is criticized in Chapter 9. The result, in summary, is that while it seems obvious that human industry should eliminate the use of fossil fuel to whatever extent possible, we must remember that the use of renewable energy also results in entropy that is ecologically disruptive. Increased use of energy leads to increased environmental destruction, regardless of the type of energy involved.

This result sets up the final three chapters of Part II dealing with economic growth. The third and most direct strategy for combating ecological degradation is to avoid using energy in amounts producing more entropy than the biosphere can cope with. Inasmuch as this strategy calls for levels of energy consumption far lower than those occurring presently, it runs directly counter to the mainstream doctrine that economic health requires continuing growth. In order to understand the mesmerizing force of this doctrine, we first looked into the history of the concept of economic growth in Chapter 10. We then examined various rationales offered in support of the doctrine in Chapter 11, and found them generally ineffective.

Not only does the mainline commitment to growth stand at cross-purposes to the general strategy of decreasing energy use; we should note further that this commitment is a primary cause of the environmental predicament we are concerned to alleviate in the first place. In effect, the third strategy is to break free form the influence of this commitment. Given the very low likelihood that mainline economics will relinquish this doctrine under its own initiative, we turned in the present chapter to explore the possibility that mainline economics might be effectively replaced by its ecological counterpart (EE). Our conclusion in section 12.6 is that a transition of this sort is highly improbable.

This leaves us in a quandary about how economic production and consumption can be reduced to levels compatible with environmental integrity. Persuasive as arguments offered against economic growth (by ecological economists and others) may be, the current tendency toward ever increasing levels of economic activity will not be reversed by argument alone. As long as corporate executives value profit, and as long as individual consumers value acquisitions, society will continue to heed the advice of mainstream economists.

Instead of talking about shifts in scientific paradigms, perhaps we should be talking about shifts in societal values. As matters stand, society is wedded to a set of values that encourage the proliferation of production and consumption. But there are other values that would have the opposite effect. Perhaps there is a workable solution to our environmental crisis that relies on a shift away from the values that have fostered its onset. The remainder of the study is devoted to exploring this possibility.

Notes

1. One account of the growing dominance of neoclassical economics cites Chicago, Columbia, Harvard, MIT, Princeton, Stanford and Yale as among universities responsible for the spread of mainstream doctrine (http://www.paecon.net/StrangeHistory.htm). According to this account, the U.S. Air Force, through the RAND corporation, set up a scholarship program in the 1960s for economics graduate students at these institutions, thinking that certain analytic techniques taught in these programs (e.g., game theory and linear programming) had potential use in national defense. This was seen as a continuation of the Defense Department's funding of mathematical economics beginning shortly after the end of WWII, which eventually led to the dominance of neoclassical economics worldwide (presumably with the exclusion of communist countries).

2. Ecological economist Herman E. Daly, in the introduction of his *Beyond Growth* (Beacon Press, Boston, 1996), tells about an encounter with once Chief Economist of the World Bank, Lawrence Summers (later U.S. Secretary of the Treasury and then President of Harvard University). Summers had just come back from a conference on *The Limits of Growth* (Meadows, et al.), which he found worthless, and was asked by Daly what he thought about a certain diagram in the book showing the economy as a subset of the more inclusive natural environment, similar to one Daly had previously put forward himself. As Daly relates it, Summer's response was a curt "That's not the right way to look at it."

3. Thus the title, for instance, of J.R. Kahn's *The Economic Approach to Environmental and Natural Resources* (The Dryden Press, Fort Worth, 1995).

4. Pertaining to the knighting of Sir Partha Dasgupta of St. John's College for his work in environmental economics (http://www.admin.cam.ac.uk/news/dp/2002080901).

5. The relevance of the Second Law to economics had been pointed out earlier by Frederick Soddy, Nobel laureate in chemistry (1921), in his *Wealth, Virtual Wealth, and Debt: The Solution to the Economic Paradox* (E.P. Dutton & Co., Inc., New York, 1933).

6. "Global Comprehensive Models in Politics and Policymaking," by Paul N. Edwards, in *Climate Change*, vol. 32, January 1996, pp. 149-161.

7. In his *History of Economic Analysis* (Oxford University Press, New York, 1954, p. 41), Joseph Schumpeter refers to the "preanalytic cognitive act" in which researchers "visualize a distinct set of coherent phenomena as a worthwhile object of…analytic effort," which then "supplies the raw material for the analytic effort."

8. In *Beyond Growth*, Herman Daly attributes to G-R the image of an irreversible hourglass representing the unidirectional flow of high-grade solar energy from the upper chamber into the lower where it becomes unusable entropy. On the upper arch of the lower chamber is a repository of materials, including fossil fuels, which are not yet fully degraded and hence still usable in the production of economic goods. For G-R, the economic process is equivalent to converting resources from this finite repository into products of economic value.

9. *The Entropy Law and the Economic Process*, p. 284.

10. G-R wraps up a substantial discussion of the nature of time with the remark that one of the main objectives of his book is to prove "that the economic process as a whole is not a mechanical phenomenon" (p. 139).

11. This is a simplified statement of what is known by economists as the "Cobb-Douglas production function." See Cutler J. Cleveland, "Biophysical Economics: from Physiocracy to Ecological Economics and Industrial Ecology," in *Bioeconomics and*

Sustainability: Essays in Honor of Nicholas Georgescu-Roegen, J. Gowdy and K. Mayumi, eds. (Edward Elgar Publishing, Cheltenham, England, 1999), pp. 125-254.

12. *Beyond Growth* (Beacon Press, Boston, 1996), p. 197, et al.

13. For example, *An Introduction to Ecological Economics*, by Robert Costanza, John Cumberland, Herman Daly, Robert Goodland, and Richard Norgaard (St. Lucie Press, Boca Raton, Florida, 1997); and *Ecological Economics: An Introduction*, by Michael Common and Sigrid Stagl (Cambridge University Press, Cambridge, 2005).

14. Also called biophysical economics, which has been defined as the use of ecological and thermodynamic principles to analyze the economic process (see C.J. Cleveland, op. cit.).

15. See fns. 2 and 8 of this chapter.

16. See, for example, *Beyond Growth*, pp. 14-15, 69, 166-67, passim.

17. This is a paraphrase of Daly's definition in *Beyond Growth*, p. 9. It derives from the Report of the Brundtland Commission, *Our Common Future* (Oxford University Press,, 1997), which calls development sustainable if it "meets the needs of the present without compromising the ability of future generations to meet their own needs."

18. Daly has little to say about how long qualitative improvements of this sort could continue without additional quantitative throughput. In case the earth's carrying capacity has already been exceeded, moreover, drastic cuts in throughput might be necessary, in which case even limited qualitative improvement would be problematic.

19. In its focus on actual preferences instead of what *ought* to be preferred, conventional economics is able for the most part to eschew value-laden statements of principle and policy. But values presumably are involved in its choice to present the economy as a

context in which people seek personal benefits with monetary prices, as distinct from well-being of a non-quantitative sort (e.g., happiness, companionship, fulfillment).

20. For one example, see Herman Daly's Preface to *Economics, Ecology, Ethics* (W.R. Freeman and Company, San Francisco, 1973) entitled "Introduction to the Steady-State Economy." The terminology of scientific paradigms and paradigm shifts comes from Thomas Kuhn's much quoted *The Structure of Scientific Revolutions* (1970). Kuhn's scientific paradigm seems closely related to Schumpeter's notion of a preanalytic vision (fn. 7 this chapter).