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ECOLOGICAL ECONOMICS: RATIONALE AND PROBLEM AREAS

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ABSTRACT

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This paper is concerned with the nature of ecological economics as an area of interdisciplinary study and with problem areas which need to be confronted. After reviewing some of the perceived aims of work in this area, some of the sources of stimulus for studying ecological economics are considered. The roles of theories of history and "utopias" for ecological economics are assessed. The notion of "paradigmatic images of the world" is then introduced and related to utopias and the way that these influence work in ecological economics. Finally, a series of practical, ethical and conceptual problem areas are outlined, which require further interdisciplinary study.

INTRODUCTORY REMARKS

Herman Daly (1987) has suggested that to be taken seriously, an area of research needs a society, a history and a journal. For ecological economics, Juan Martinez-Alier (1987) has written the history, the society is in being, and now the journal is being published. In this new journal, on a new interdisciplinary area of study, it may be helpful if early on, practitioners in ecological economics engage themselves in analysis and debate around a generally accepted range of problem areas, both practical and conceptual. As part of that engagement it might also be useful if the stimuli for and aims of ecological economics were assessed. This paper attempts to offer a range of problem areas derived from an assessment of the stimuli and aims of ecological economics as follows:

(1) The enumeration of some of the perceived aims of ecological economics, as expressed by its practitioners;

(2) a discussion of the social and psychological sources of stimulus of ecological economics;

(3) an assessment of the relationship between theories of history, models

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of possible futures ("utopias"), and scientific endeavour, and the implications of these relationships for ecological economics; and

(4) an exploration of some of the "paradigmatic images of the world" that seem to underlie and impel modes of reasoning in ecological economics.

In the light of these discussions, a final section presents a series of problem areas to which those interested in ecological economics might wish to give their attention.

THE PERCEIVED AIMS OF ECOLOGICAL ECONOMICS

A useful preliminary would be to define clearly what is meant by "ecological economics". Different authors in the field with different intellectual backgrounds (ecology, physics, chemistry, engineering, mathematics, economics, political science, sociology), quite naturally have different emphases. However, for the purposes of this paper the following brief definition is offered:

Ecological economics studies how ecosystems and economic activity interrelate *.

From this definition it is clear that the subject matter of ecological economics embraces some of the most serious problems faced today. The use of fossil fuels and carbon dioxide concentrations; the disposal of nuclear waste; the consequences of genetic engineering; deforestation and species loss; all of these problems call for an ecological economics approach, and all are pressing problems of global dimensions.

The aims of ecological economics have been divided into two groups. The first relates to scientific aims and problems, the second to political and ethical issues.

Scientific aims and problems **

Establishing an historical perspective on social–natural interactions

The carbon dioxide problem has been relatively recently recognised, but its roots run deep in history. As industrialisation has spread from Britain,

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* Here the term "interrelate" is intended to be very wide. Although this means that the definition of the term "Ecological Economics" runs the risk of being so general that it includes almost all scientific and social scientific disciplines, I feel that it would be inappropriate to arbitrarily limit the meaning of the term before the limits of the discipline become apparent to its practitioners. In particular, the recognised discipline of environmental economics, with its usually neo-classical paradigm, is in my view, a rather limited subset of ecological economics.

** The discussions at the *Conference on Ecological Economics* in Barcelona, September 1987, were particularly helpful in indicating the breadth of concerns of practitioners in this field.

first to continental Europe then to North America, and now to nearly all parts of the globe, there has been a corresponding growth in the use of fossil fuels, and hence the level of atmospheric carbon dioxide. Human social activities have profoundly influenced the global ecosystem, and the long-run interaction by no means began with industrialisation. The very extensive moorlands, heathlands and downlands of Western Europe, unlike the North American prairies, are not "natural" features. They were established from neolithic times onwards by agricultural activity and are largely maintained through the effects of human activities, such as animal grazing; the "natural" state of these areas is woodland (Hoskins, 1973). In much of the industrialised world humans live in a fabricated landscape, inhabited by species that often have been introduced by humans. Ecological economics offers one forum for analysis and debate of the long-term dynamics of human–natural interactions.

Finding a common language and set of concepts for the analysis of economies and ecosystems

There is a surprising degree of overlap between some of the concepts and tools of economic and ecosystem analysis. Economists are familiar with the analogy drawn by Mandeville (1714) between the behaviour of social insects and human social behaviour. Conversely, the notion of economic activity has been extended to the social insects (Heinrich, 1979). Game theory models have found application in models of natural evolution as well as in social science (Maynard-Smith, 1984). The mapping of energy "flows" for use both in economic and ecosystem analysis has been suggested by Odum (1971) and continues to be a source of debate and analysis (Odum and Odum, 1981; Odum, 1984). The flow of goods or "value" in economic systems is often modelled using input-output analysis (Leontief, 1966) and such analysis of flows has been adapted to modelling the flow of energy and matter in ecosystems (Hannon, 1973; Costanza, 1984). Recently there has also been discussion regarding the use of "prices" and "interest rates" in ecosystem work (Hannon, 1985). On the other hand, ideas about evolution and coevolution are being generalised from biological science to economics (Norgaard, 1984).

The area of intersection between natural science and social science

In recent years there has been growing disquiet about the divorce of economic analysis from its "biophysical foundations". The economic activities of production and consumption are not independent of, or neutral with respect to, the global ecosystem. Human artifacts need matter for their expression; a unit of fuel once burned cannot be burned again. In other words, the laws of thermodynamics are binding upon economic activity in

its broadest sense. [For discussions of the role of thermodynamics in economic analysis see Proops (1985, 1987).] This issue has received great prominence since the publication of Georgescu-Roegen's (1971) *The Entropy Law and the Economic Process*. But humans are not simply users of materials; they are also inventors and constructors. In particular, human societies are "open systems" in the sense of Prigogine (1980). Such open systems are characterised by acting as conduits for the flow of energy, which they "tap" to allow the normal tendency to disorder that would characterise a closed system, to be countered. Further, open systems may exhibit steadily increasing degrees of structure and organisation over time. The physical theory of open systems is relatively new and still being formulated and generalised, but already it offers insights into the behaviour of systems which are far from thermodynamic equilibrium. In particular the open systems approach offers an alternative and complementary viewpoint on the biophysical nature of human activity (Jantsch, 1980; Proops, 1983; Prigogine and Stengers, 1984).

Political and ethical issues

As a forum and structuring for policy analysis

It is generally recognised that the world is a complicated place, and single causes can have many outcomes and single outcomes many causes. The interaction between the ecosystem and human social activities is particularly rich in such relationships. For example, the impact on climate, ecosystem development and economic activity of increasing levels of carbon dioxide is a widely recognised area for study and concern (Edmonds and Reilly, 1985). It is not yet, however, an area where a simple and generally accepted prognostication is available, unlike the fluorocarbon debate. Ecological economics offers a forum for the consistent and coherent analysis of such areas of interaction.

A framework for the ethical analysis of intertemporal and interspecies choice

Much of the literature on resource use hinges upon the way present generations view their human successors. It is apparent that future generations cannot share in current market activities. Future generations can offer nothing to the present generation to "exchange" for the right to use resources in the future. How can the putative rights of future generations be established and accounted for? Similarly, human life is only one of the forms of life in the ecosystem, yet in conventional analysis only the desires and needs of humans are considered. Can and should the "rights" of non-human species be considered? Both of these issues can be sensibly discussed only in a wide social–natural framework, such as is offered by ecological economics (Daly, 1980).

The influencing of decision makers

Often expressed is the concern that ecological economics gives high priority to influencing those who take decisions which have substantial consequences for the ecosystem. For example, the banning of the production and sale of fluorocarbons is a current issue. The use of civil nuclear power is another. In both cases practitioners have sought to put the argument, usually against, in a way likely to achieve the policy changes they desire.

THE SOURCES OF STIMULUS OF ECOLOGICAL ECONOMICS

That ecological economics as a subject matter has, I hope, been established by the preceding section. The antecedent question is: What are the social and psychological roots of such enquiry? This is an important issue which should be confronted if ecological economics is to make good and well-founded progress. In this section the four areas of motivation which are important in giving impetus to the formulation and study of ecological economics will be briefly discussed.

The perception of things getting worse

The majority of people in Western economies are well-fed, well-clothed, and employed in comparatively interesting and untaxing labour, at least by the standards of the preceding periods of arduous peasant agriculture and sweated industrialisation. For the great majority in the industrialised West the quest for material comfort can be regarded as over, although improvements in technology and levels of consumption continue at rates which are historically unprecedented. But industrialisation has its penalties in the form of historically high population densities, industrialised agriculture, and the rapid depletion of natural resources. Have the costs outweighed the benefits? Are we now facing a future where standards of comfort can be expected to drop as natural resources become scarcer, food and water supplies become ever more polluted, and humans, especially poor humans in the developing countries, become ever more numerous and clamourous for consumption goods? This view was particularly strongly voiced during the early seventies, at the time of the *Limits to Growth* debate (Meadows et al., 1972), by, inter alia, Commoner (1971) and Ehrlich and Ehrlich (1972).

The ecological categorical imperative

Kant saw morality as being an objective requirement, independent of what any one may want. He termed the guidance to action given by morality a "categorical imperative". For many environmentally minded persons this

moral imperative extends to the natural world also. They see humans as having squandered nature's riches and abused the implicit contract with past and future generations to act as steward over the natural world. Humans no longer live in harmony with nature. Are Western bloc industrial capitalism and Eastern bloc state capitalism short-lived aberrations, resulting from humans breaking faith with their nature? [See Pearce (1987) for a discussion of the problem of the intrinsic value of the natural world for economics.]

Ecological economics as a "revolutionary" activity

During the nineteenth and early twentieth centuries the key social ills were seen to be the poverty and economic and political oppression that were the common lot of the great bulk of the industrial population. The source of this suffering was held to be the inequitable distribution of wealth and income then prevalent, which meant that low average income per capita for all was reflected by abject poverty for many and considerable affluence for a very few. The political force which arose to confront and to right these wrongs was socialism, particularly Marxism; this drew together the energies of predominantly the young and the intellectuals (Lichtheim, 1970). The sacrifice of earlier generations of working people has resulted in generally much improved material conditions for the majority of the industrial population. It may be argued that in the Western world the problem has now moved from the issue of social justice to that of the sustainability of social institutions, as resources are depleted and the environment poisoned. Again, the young and the intellectuals have drawn together, this time under the banner of environmentalism.

The opening up of world views

Social analysis and the perception of the natural world are inseparable (Cotgrove, 1982). However, economic analysis as currently practiced is divorced from, and even does not recognise, its biophysical foundations. On the other hand, ecosystem analysis makes no sense if human activity is excluded; human activity is pervasive, fast-acting and often irreversible, but it too is "natural". The growth of interest in the entropic foundations of economic and natural activities (Georgescu-Roegen, 1971; Faber et al., 1987) has encouraged the opening up of world views, and there is a growing recognition of the value of multi-disciplinary work in establishing the interrelations between social behaviour and the natural world (Faber and Proops, 1985).

Having suggested some of the motivations behind ecological economics, I now turn to an examination of how the above concerns can be placed within

the framework of our understanding of the historical process, and our visualisation of possible futures.

THEORIES OF HISTORY AND "UTOPIAS"

To make sense of the world, and to inform our actions, we must both look backward to our history and look forward to our potential futures. Both historical analysis and assessing the future are difficult and demanding activities. Both to a greater rather than a lesser extent are socially conditioned activities. In particular, our notions of the past, and how to undertake historical analysis, will influence our notions of the future.

The "open" and "closed" models of history and the future

How does the world evolve? Are there general historical laws that lay out the direction, even details, of historical events (Carr, 1961)? That is, is history a *necessary* process? Or is history a *contingent* process? Contingent, that is, upon the minutiae of the world; the failed coup, the drunken general, the inspired inventor. If the former is held to be the case we have a "closed" model of history: the past flows into the future like well-channelled river, and the place of humankind on the stream of history can be charted and predicted. In such a world view, knowledge of the past allows us to know a substantial amount about the future. An analogy would be that, in a well-channelled stream a boat can be navigated by looking only to the stern, as the local shape of the stream just past gives sufficient information for the local shape of the stream ahead to be judged.

But what if the minutiae of history *do* matter? The passage of time ceases to be an unrolling of a largely preordained future, as in the Newtonian model of planetary motion. Instead the future becomes rich with radical uncertainty. We have an "open" model of history. The stream is no longer well contained, but ever branching like a river delta (Faber and Proops, 1986, 1987; Passet, 1987). Looking backwards is no longer sufficient to allow us to steer the boat along a steady and uninterrupted course.

Ecological economics as a dialectical science

Ecological economics deals with the interactions between humans and the natural world, interactions which themselves are ever evolving as the very interactions impact upon the ecosystem and alter it, and as perceptions of the environment also change (Common, 1988). One could say that ecological economics seeks to understand the human position in the world, where that world is being simultaneously created and destroyed by humans. That is, it

is not sufficient to consider the world as in "being", as the nature of the world is continually transforming the world; the world is always "becoming". [For an excellent discussion of the roles of being and becoming in the natural world see Prigogine (1980); for a dialectical analysis of biological evolution see Levins and Lewontin (1985).] Ecological economics is therefore, from its subject matter, a very dialectical subject. Its object of study is the process of social creation and ecological transformation and destruction.

The future and "utopias"

Any assessment of the future requires that we have a standard of reference against which we can judge likely or possible outcomes. Many of us carry within us a largely ill-formed but still important image of the world as it might be. *The Republic* of Plato (ca. 400 BC) is often cited as the earliest such vision fully enunciated and internally consistent. The *Utopia* of More (1516) is perhaps the most famous and most copied. Indeed, with no disrespect to More, nor in any derogatory sense, I shall refer to such world views as "utopias" henceforward. Published modern versions of utopias include *A Modern Utopia* by Wells (1905), *The Dispossessed* by Le Guin (1974), and much modern science fiction writing. Also within the term "utopia" I shall encompass anti-utopias, or dystopias, such as those in *Gulliver's Travels* (Swift, 1726), *The Time Machine* (Wells, 1895), *Brave New World* (Huxley, 1932), and *Nineteen Eighty Four* (Orwell, 1949). [For excellent discussions on various aspects of Utopias see Manuel (1965) and Kumar (1987).]

A utopia is not a description of a real world, either past or future; instead it is an enunciation of what the world *could* be like. It seems to me that the predominant neoclassical paradigm of economics has much in common with such a utopia: if only humans were rational, self-interested beings, and all production processes were "well-behaved", then the neoclassical paradigm describes what the world would be like.

It is not implied that utopias are in any sense a bad thing. Indeed, from their ubiquity they may even be *necessary* for humankind to confront and make sense of historical experience. However, there are dangers to utopias. Utopias are not real and, in principle, can never exist. In most cases, perhaps even all, they are not images towards which we should strive; rather they are imaginings against which we can judge likely outcomes. If policies seem to be leading us towards a state of the world we can characterise as "1984", most of us would urge a reassessment of those policies. Dangers lie in taking a utopia and making it a concrete objective. For example, the notion of the "steady-state economy", enunciated by Daly (1973, 1977) is such a utopia. It gives a description of a world as it might be, under certain

strong assumptions. This is clearly recognised by Chapman (1975) in his parable of the "Island of Erg". If only men were sensible, if only social institutions were just and forward looking, if only politicians were less shortsighted and avaricious; if only! The expectation is that we are unlikely to achieve a steady-state economy by rational and beneficial policies. However, as a utopia it *does* offer a very useful yardstick for the policies that can be recommended, and for those that should be resisted.

History, utopia and scientific activity

It is suggested above that two approaches to history as a process may be taken: history as "closed" and history as "open". It is also indicated that the model of history used would be likely to be influential in the establishment of utopias; anticipation of the future springs from understanding of the past. Is it possible to indicate how different utopias might derive from these two models of history? Consider first history as "closed", with the world unfolding, in an ordered way. This unfolding may be necessary but this does not imply that it is good. If the world is a Newtonian mechanism, and if man is outside this mechanism and can influence it, then man may be able to determine the future in terms of a preferred utopia. Alternatively, it may be that the world is running down by necessity without any possibility for man to influence its development. On the basis of either concept of closedness, regularities occur both between past and present and between social and natural relations at any one time. Relations can be identified, and a "good" and "natural" state of the world suggests itself. It is clear that utopias will offer themselves where regularity and order prevail.

On the other hand, an "open" notion of history suggests new possibilities, altering relationships between nature and humankind. Such an approach to history makes the formulation of a utopia much more difficult. By its nature, a utopia is an image of the World as it might be, but an "open" model of history demands the recognition that there are an infinity of ways the World might be. In these circumstances a utopia becomes evanescent, no longer serving as a Platonic ideal but rather as a sketch of an imagining, a transient speculation.

How, then, can the concept of history and its attendant utopias impact upon scientific discourse and social policies by humans towards nature? To use a term of Koestler (1967), I believe this to be a Janus-like * operation. One face of Janus is towards the past, with its established knowledge and received wisdom; the other face is towards the future, towards utopias and

* Janus was a Roman god, who acted as the doorkeeper to heaven. To aid him in this task he had two faces, one on the front of his head and one on the back.

potentials for action. Within Janus itself there is the need for scientific investigation and policy formulation, the bridge between inherited knowledge and concepts, and imaginings of the future and how they might be achieved.

PARADIGMATIC IMAGES OF THE WORLD

Where do utopias come from? Why do individuals have different utopias? Why do social groups often share utopias? Some sense can be made of this by going one step further back in this chain of relationships. Underlying any utopia there must be a notion of what constitutes "The World". With regard to utopias relevant to ecological economics, particularly important is the notion of "nature and the natural" Such a notion could be called a "paradigmatic image of the world" (PIW). It is suggested there are four predominant PIWs at present; these are: (1) undisturbed nature—the Hunter-Gatherer World; (2) humankind in nature — the Agricultural World; (3) the human as creator—the Industrial World; and (4) Gaia: the Creative and Self-Sustaining World.

As the PIWs that constitute belief structures are usually implicit deep below the surface activities of science, the enunciation of a PIW is often most clearly achieved by reference to the cultural behaviour that takes the expression of belief structures as its central aim; that is, creative literature. Unusually, therefore, in a scientific paper, literary sources have been freely drawn from in the remainder of this section.

Undisturbed nature—the Hunter-Gatherer World

An evocative statement of the undisturbed nature PIW is to be found in the *Canadian Railroad Trilogy* of the Canadian singer-songwriter Gordon Lightfoot (1981: side 2, track 2):

There was a time in this fair land
When the railroads did not run,
When the wild majestic mountains
Stood alone against the sun,
Long before the white man
And long before the wheel,
When the green, dark forest
Was too silent to be real.

This is a powerful expression of the image of North America, in this case Canada, in its "natural" state; it suggests the natural world to be a strong, elemental force; it is virgin, uncorrupted, untainted by humans who seek to control nature. Here humans are present only as actors within nature, hunting and gathering much as non-human animals do. The ecological equilibrium that exists is not perceived to be significantly different from that

which would prevail if humans had not evolved. This PIW seems, to this European, to be particularly strong among North American ecological economists. It views humans, at least agricultural/industrial European humans, as intrusive upon a world of nature. The human is the intruder, the despoiler. This PIW has been excellently documented in the literature of North America by Marx (1964). For a recent comment on this PIW, from a European perspective, see Reed (1988).

Humankind in nature—the Agricultural World

With a history of several thousand years of established agriculture in Europe, it is not surprising that this seems to be the predominant PIW among Western European ecological economists. Humankind is part of nature through harmonious agriculture and husbandry. An ecological equilibrium has been achieved, but this is very different from that which would result without human activities. The landscape is accepted as embodying humans and their works, but these are seen as humankind and nature in synergy rather than conflict. As Wordsworth (1798) put it in *Tintern Abbey*:

> ..... Once again I see
> These hedge-rows, hardly hedge-rows, little lines
> Of sportive wood run wild; these pastoral farms,
> Green to the very door; and wreaths of smoke
> Sent up, in silence, from among the trees!

A harsher judgement upon this PIW has been given by a Marxist social critic, in this case in the context of political analysis (Nairn, 1981, p. 262):

> ... this ... English world where the Saxon ploughs his field and the sun sets to strains by Vaughan Williams.

The human as creator—the Industrial World

Nature is the background and inspiration for human achievements. Human resourcefulness and inventiveness rejoice in the challenge of nature. There is unlikely to be an ecological equilibrium achieved as human activities are continually altering the relationships between species. Nature is a tabula rasa upon which humankind can write its destiny. For example, Wells (1895, p. 79) expressed it thus:

> It is a law of nature we overlook, that intellectual versatility is the compensation for change, danger, and trouble. An animal perfectly in harmony with its environment is a perfect mechanism. Nature never appeals to intelligence until habit and instinct are useless. There is no intelligence where there is no change and no need of change. Only those animals partake of intelligence that have to meet a huge variety of needs and dangers.

This paradigmatic image of the world is close to that of some of the less mainstream branches of economic thought, such as the Austrian School (Rizzo, 1979), and the evolutionary economists (Nelson and Winter, 1982).

Gaia: the Creative and Self-Sustaining World

Gaia is the world, all it contains, all it has been, all it might become. It created itself, and all the elements within it work in harmonious ways to sustain it as it changes over the eons. The role of humanity is not privileged, nor very significant to Gaia. The destiny of individual species, or even whole groups of species, is unimportant. As Shelley (1816) expressed it in *Mont Blanc*:

> The fields, the lakes, the forests, and the streams,
> Ocean, and all the living things that dwell
> Within the daedal earth; ...
> All things that move and breathe with toil and sound
> Are born and die; revolve, subside, and swell.
> Power dwells apart in its tranquillity,
> Remote, serene and inaccessible.

This PIW has been clearly expressed in its scientific rather than literary aspects by Lovelock (1979). Gaia stands opposed to the other three PIWs, for in Gaia humans are not central nor even significant. Unlike the others, the Gaia PIW is not anthropocentric, in as far as a human world view can avoid anthropocentricity. As Lovelock (1987) recently noted:

> Friends of the Earth are really friends of the people of Earth. No-one speaks for the planet.

PROBLEM AREAS FOR ECOLOGICAL ECONOMICS

To summarise the discussion so far, ecological economics is already being practiced by individuals with a wide range of backgrounds. Interest in ecological economics has a number of practical, conceptual and ethical sources and the aims of ecological economics need to be understood in terms of their concepts of history, and their formulation of utopias. These utopias are themselves largely dependent on the underlying paradigmatic image of the world held by that individual/group/society.

This range of backgrounds, concerns, understandings of history, utopias and PIWs means that ecological economics presents many challenges, both in terms of problems and methodologies. A list of what is perceived to be the major problem areas for this new interdisciplinary approach is now offered. These areas are ordered under three headings: Measurement and Policy; Ethical Values; and Concepts and Methods. However, it will be apparent that this subdivision is not absolute, and that some of the problem

areas overlap two or even three headings. The listing of problem areas is not meant to be exhaustive but is intended to stimulate discussion.

Measurement and policy

How can we tell if things are getting worse?

A fundamental tenet of ecological economics is that there are problems to confront in the relationship between humankind and nature. Are these problems fundamentally different and more intractable than those faced by previous generations? Is human ingenuity coping with the problems as they arise? Or are the problems growing in magnitude and becoming of a qualitatively different type? Are things getting worse? If so, by what standards?

How can we judge the effectiveness of policies?

When a problem is identified and policies are established to ameliorate it, how are we to judge the effectiveness of these policies? Is a relatively narrow judgement appropriate, or should a wider assessment be taken, involving all the possible consequences of the policy itself? That is, under what circumstances is a "partial equilibrium" approach suitable, as opposed to a "general equilibrium" approach, remembering that a partial equilibrium approach will be less expensive and can be much more easily interpreted?

How can we assess and cope with global phenomena?

Some issues in ecological economics are of a local nature but many are global issues. What are the analytical tools available to deal with such issues as "public goods"? How appropriate are they to problems involving many nations, with differing political ideologies and vastly disparate levels of wealth and income? What social institutions are appropriate to decision making on such issues?

How important is resource use vis-à-vis pollution?

Two distinct strands appear in ecological economics; the use of resources, and the generation of pollution. How far are these linked, and to what extent can they be conceptually separated? Which of these is likely to have the greatest impact in the long-run? Which is most threatening to the survival of humankind?

The growth debate—what does it mean?

What do we mean by "economic growth"? What are the social roots of growth, and how are these dependent on relations with the ecosystem? What are the consequences of reduced growth rates? If a long-run aim were to be

economic activity in harmony with the global ecosystem, does this necessarily imply a zero economic growth rate? What policies might lead to socially equitable harmony with the global ecosystem?

Are some utopias "better" than others?

What are our underlying notions of "what the world might be like"? How important are current utopias in determining our policy stances? How well founded are our utopias in our understanding of history and science? How dangerous might be utopias in our formulation of social policy?

Environmentalism: science or social movement?

How far is environmentalism a reasoned response to threats to the ecosystem, and how far a focus for more general social discontent? How far should ecological economists maintain scientific objectivity ("aloofness")? What is the place of normative analysis in ecological economics?

Ethical values

Population as pollution—the ethical dilemma

On a global scale, are humans a renewable resource or a particularly virulent form of pollution? If the aim of social policy is to generate the "greatest good for the greatest number", what is that "greatest number"? How can considerations of ecological economics be integrated with demographic analysis and notions of social justice?

The present status of future generations

How far is the welfare of far distant (potential) generations important today? Does the present generation have a view that past generations "could have done better by us"? What is the social trade-off between the poor today and the maybe-poor-maybe-rich of future generations?

The ethical hazards of myopic decision making

What sort of time horizon is appropriate in decision making? How far should future generations be included in present decision making? Does myopic decision making accept the openness of the future, or simply ignore the rights of future generations? Does the use of full intertemporal models of choice lead us to a form of intertemporal authoritarianism?

Can we reconcile ecological economics with anthropocentricity?

Is ecological economics the study of the relations of humans *with* nature, or of humans *in* nature? Is the status of humans privileged only because of a "faulty telescopic faculty"? Do other animal species have "rights"? Do plants have "rights"? Do depletable resources have "rights"?

Concepts and methods

Establishing concepts and analytical tools for ecological economics

What are the common tools and methods available for examining natural and social systems? Can we devise a common language and set of concepts for dealing with the wide range of interests and backgrounds of workers in the field of ecological economics? What is the role of energy analysis and energetic modelling in ecological economics? Does the notion of an "energy theory of value" offer useful insights? Does "coevolution" offer a coherent conceptual framework for ecological economics?

Entropy and open-system analysis

Does the notion of entropy and the second law of thermodynamics provide a common basis of discussion for economic and ecosystem analysis in the long-run? Does it help to establish the biophysical roots of economics? Does open-system analysis offer a contrasting perspective on economies and ecosystems? How far are these approaches contradictory, and how far are they complementary?

Risk and uncertainty in decision making

How do we assess the risk associated with the impact of economic activity on the ecosystem? How do we formulate policy in the face of risk? When we face radical uncertainty about the future effect of present policies, how do we cope? What stance can we take to options being kept open for future generations?

History as open or closed

Does history offer us useful insights into the future? Can we reduce uncertainty about present actions by studying the past? How far does human ingenuity and inventiveness force a view of history as "open" and contingent? What are the implications for how we study human–natural interactions of these two different approaches to history?

CONCLUDING COMMENTS

I shall close on a cautiously optimistic note. Human activity is, for the foreseeable future, likely to be Earth based. Economists are increasingly coming to recognise that the study of human activities on a finite planet, in the long-run, requires a different set of concepts to those useful for the economic analysis of households, firms and nation states in the short- and medium-term. In a complementary way, ecologists, and other natural scientists, are increasingly recognising that economic activity is here to stay;

human activities are coming to dominate the global ecosystem, and ecosystem analysis which does not explicitly include economic activities makes less and less sense. The stage seems to be set for a coming together of these two disciplines so that problems of resource use and pollution in the global ecosystem can be discussed and assessed in a conceptual framework worthy of these problems.

However, this coming together needs to be firmly based; a short-term coalition between economists and natural scientists will be insufficient. Economists and natural scientists will need to do more than talk together occasionally. Economists will need to familiarise themselves with the tools and concepts of natural science, and the natural scientists with those of economic analysis. Only when these tools and concepts have been digested and internalised will there come into being a shared language and set of concepts. Only then will there be the opportunity for long-term fruitful dialogue.

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