The Development of Environmental Thinking in Economics

CLIVE L. SPASH

Cambridge Research for the Environment
Department of Land Economy
University of Cambridge
19 Silver Street, Cambridge CB3 9EP, UK

ABSTRACT: There has always been a sub-group of established economists trying to convey an environmental critique of the mainstream. This paper traces their thinking into the late 20th century via the development of associations and journals in the USA and Europe. There is clearly a divergence between the conformity to neo-classical economics favoured by resource and environmental economists and the acceptance of more radical critiques apparent in ecological economics. Thus, the progressive elements of ecological economics are increasingly incompatible with those practising neo-classical environmental economics who try to reduce all concepts to fit within the confines of their models. A group of people can be identified who teach that ecological economics is nothing more than a name for the link between mainstream economics and ecology. A new movement and paradigm are unnecessary for such ends. This viewpoint is argued to be inconsistent with the roots and ideas of the ecological economics movement. Ecological economics is seen here to be synthesising various types of economics (e.g., socialist, institutional, environmental) and moving back to explicit inclusion of ethical issues in the mode of classical political economy. This inevitably means rediscovering neglected past works and exploring new ways of thinking about socio-economics and the environment.

KEYWORDS: Ecological economics, environment, ethics, history of thought, political economy

INTRODUCTION

Neo-classical theorists, from the late Victorians to the present, have given economics the technocentric optimism which environmentalists fear has distracted from the need for fundamental changes in human behaviour. However, throughout this last century, there has been a sub-group of established economists concerned about resource conservation and systems limits. In the early

Environmental Values **8** (1999): 413–435

1900s such economists were largely practising agricultural economics, which became a distinct sub-discipline at this time. Following the Second World War, resource and then environmental economics also became established areas of study. However, the ability of these sub-disciplines to explore environmental critiques was restricted because they remained within the neo-classical framework and therefore tended to defend that paradigm. The emphasis on a mono-disciplinary approach also discouraged pluralism. Ecological economics has therefore become the latest attempt to take seriously the concern that aspects of the world such as the diversity of life in the wild, ecosystems structure and functioning, and the resources humans build into their cultures are all something more than a useful component of a welfare generating economic system.

A major concern behind this paper is the general lack of knowledge about these developments, and differences between and within schools of thought, amongst both those outside of economics concerned by economy-environment interactions, and those (natural and social scientists) applying economic analysis to the environment. In explaining how different economists view environmental analysis, associated professional societies and journals are identified. Individual economists can often be difficult to classify purely on the basis of their external association with a school of thought, and therefore some idea of underlying values needs to be probed. Thus, the aim here is to act as a guide by both identifying key individuals with their roles in forming and following different schools, and also by attempting to distil the essence of what is implied by various professional affiliations. A broad historical perspective is taken in tackling these tasks, although the general concern is to throw light on developments within economics in the latter part of this century. Those seeking detail about the ecological critique of economics between the 1860s and the 1940s should refer to the book by Juan Martinez-Alier (1990).

For many people ecological economics is indistinguishable from agricultural economics, resource economics, or environmental economics. Yet, there are significant differences amongst which the most obvious is recognition of the need to fundamentally change the current approach to economic analysis. Mainstream economists regard sub-disciplines which question the orthodoxy as inferior pursuits and have therefore resisted the message that environmental and natural systems are distinctive elements of human production and welfare. Ecological economics has grown, particularly in the last decade, for several reasons, including frustration with the sub-disciplinary status of environmental economics, the apparent failure to impact legislation, and the disregard shown for natural science information on the environment by other economists. Thus, particularly in the United States, ecological economics has been adopted by many as a revitalised environmental economics, while those avoiding it see the subject as at best a poor substitute for environmental economics and at worst bad economics by self-promoting natural scientists. However, the aspirations of ecological economics are far greater than merely providing a new lease of life for

established disciplines and lie in the development of new ideas and an interdisciplinary research agenda to explore alternative paradigms.

Ecological economics in Europe has been able to develop more freely than in North America and has naturally evolved a socio-economic perspective, which in many ways reverts to a political economy of the past. Until recently, few economists in Europe chose to specialise by studying environmental issues and those that did lacked any specific training. Prior to the 1990s, in order to gain a higher degree in environmental and natural resource economics generally meant training in North America. Thus, no strong European schools developed in environmental economics and ecological economics was not seen as tied to a particular economic tradition. While the situation may now be changing, and there have always been exceptions on both sides of the Atlantic, the dominant lead in America has been preoccupied with linking standard economic and ecological models, rather than looking for a paradigm shift. This has encouraged researchers to subscribe to ecological economics while producing research results which would fit comfortably within neo-classical environmental economics. As a result, confusion has continued over defining what the subject involves, although, as this paper hopes to clarify, the progressive element in ecological economics is based upon fundamentally different values to those of the established schools and is trying to synthesise several different non-established perspectives.

FROM THE CLASSICAL TO THE NEO-CLASSICAL

Classical economists such as Adam Smith, the Reverend Malthus and David Ricardo were concerned with limits to growth but from a different perspective to the modern theories underlying the call for sustainable development. A key common aspect for these classical economists, in this regard, was human population growth. Once combined with the dependence of production upon labour and a scarcity of land, economic growth could only stagnate because profits for capital would decline relative to wages for labour. The driving force was population growth operating economic consequences via a redistribution of returns. Absolute resource constraints were unnecessary for this theory.

John Stuart Mill, Stanley Jevons and Alfred Marshall departed from this model and moved economic theory into the modern era. Mill (1857) recognised the potential of non-renewable resources to act as constraints on economic growth independent of population pressures. He is also noted for mentioning the threat of unrestrained economic growth for natural wilderness, self-determination in natural ecosystems, and the importance of natural beauty and grandeur. Mill argued that technology could postpone constraints imposed by resource scarcity, which he regarded as increasing relative prices rather than creating sudden catastrophe. In this regard, Jevons (1865) may be viewed as more

pessimistic producing a treatise on the limits to growth in Britain due to coal depletion. The failure of his predicted disaster, due to the arrival of oil as a substitute and advances in technology, helped establish much of what remains in the mainstream economics argument against seeing resource depletion as problematic. Alfred Marshall, despite being one of several (e.g., Jevons, Menger and Walras), is often described as the father of modern neo-classical economics. His *Principles of Economics* encapsulated the central arguments, such as the use of marginal analysis (most commonly associated with supply and demand functions) and mathematical modelling, although this was relegated to footnotes throughout his own text (Marshall, 1890). Interestingly Marshal, like Adam Smith, has been selectively read by modern economists who have ignored the fact that his economics was intended to be integrated with ethics (Collison Black, 1990).

After the passing of these well known Victorian economists, the tendency has been to regard the first part of this century as a period in which little or no concern for resource depletion or environmental issues was shown by economists (e.g., see comments by Heal, 1986). The standard exception is normally given as Hotelling (1931) and his theory of the mine describing optimal non-renewable resource depletion. The earlier contribution of Gray (1914) has also been recognised, if less widely, and some have argued that he deserves more credit (see Crabbe, 1983). Gray may have been neglected because of his explicit recognition that the intergenerational allocation of resources was an ethical rather than efficiency issue. Other literature on the economics and management of mineral resources can also be found (e.g., Logan, 1930; Osgood, 1930; Wallace and Edminster, 1930; Tyron, 1932; Ciriacy-Wantrup, 1944). In addition, Martinez Alier (1990) has documented some of the historical roots of thinking in the area of energy-economy interactions with respect to forgotten academic contributions between the time of Jevons and the 1940s. The economic theory of value is discussed with regard to resource depletion by Ise (1925) who also wrote on forestry.

In fact, several authors also addressed natural resource problems as conservation issues (e.g., van Hise, 1910; Gray, 1913; Hess, 1917; Hammar, 1942; Renner, 1942). Meanwhile the development of agricultural economics, which is now generally on the decline, produced work on soil conservation (Ciriacy-Wantrup, 1938; Bunce, 1942; Weitzell, 1943; Shepard, 1945). Also of note is the foundation of the journal *Land Economics* in 1925, originally as the *Journal of Land and Public Utility Economics*, now published quarterly by the University of Wisconsin Press with Daniel Bromley (an institutional economist) as editor. In recent times this journal's applied and policy concern has been related to land use and monetary valuation of the environment (e.g., the travel cost method and contingent valuation).

In general, the literature in the first part of this century can be regarded as developing concerns in economics about conservation issues (as wise use, not

preservation) related to agriculture and forestry and establishing a theoretical approach to non-renewable resource depletion which is still fundamental to resource economics. However, such topics were no longer the concern of central figures in economic philosophy but were already relegated to specialists in sub-disciplines. Meanwhile, mainstream economics developed theories which by assumption implied economies could operate independently of either natural resource constraints or assimilative capacity and so further marginalised environmental issues.

RESOURCE AND ENVIRONMENTAL ECONOMICS

The resource economists of the 1950s tended to build upon the conservation work just outlined. They regarded the environment as a source of materials which required some specialised management due to characteristics which differentiated them from manufactured goods. These economists can be viewed as within the neo-classical school and as having strong associations with agricultural economics. Resource economics is now generally based upon the study of abstract mathematical models describing the 'efficient' and 'optimal' use of fisheries, forests and minerals.

Ciriacy-Wantrup (1952) can be seen as stimulating the development of environmental economics. His work in the 1950s inspired many who would establish environmental economics as a distinct sub-discipline in the 1960s and 1970s (e.g., Krutilla, 1967). Among his contributions is the concept of a safe minimum standard which was later adopted and revitalised by Bishop (1978). This concept is now often cited as a rejection of the conventional treatment of risk under cost-benefit analysis and a recognition of the importance of uncertainty as a distinct type of unpredictability. Some argue the safe minimum standard provides a bridge between economists and ecologist (e.g., Tisdell, 1993: 148).

The work of Kapp (1950) should also be noted here as another significant contribution at this time, although largely outside the mainstream. His approach was based within institutional economics and was critical of some key aspects of what came to be environmental economics. For example, he attacked the portrayal of environmental problems as 'externalities' rather than pervasive social costs resulting from the structure and incentives under free markets. Kapp (1970) also opposed monetary valuation because power structures in actual markets distort prices which would then fail to reflect resource scarcity (e.g., markets are mostly oligopolistic rather than perfectly competitive). In addition, he noted that the consequences of environmental disruption and benefits from environmental improvement are highly heterogeneous and cannot be compared quantitatively with one another or with control costs. Hence, Kapp rejected even the principle that social costs and benefits were quantitatively comparable. Environmental protection would provide social benefits throughout society and

for Kapp environmental policy formation was therefore a question of political economy rather than a technical issue to be decided by a tool such as cost-benefit analysis.

However, thought on environment-economy interactions within economics was moving in the opposite direction to Kapp. During the 1950s the US persisted with the worries of the Second World War about exhaustible resource depletion as evidenced by the Paley Report (Paley, 1952). This report helped lead to the foundation of Resources for the Future (RFF) which, among other activities, was responsible for promoting advances in environmental cost-benefit analysis, e.g., publishing early guides to the travel cost method (Clawson and Knetsch, 1966) and contingent valuation (Mitchell and Carson, 1989). RFF publishes a newsletter *Resources*, which covers US environmental policy from an economic perspective, but has on occasion included more critical authors such as Mark Sagoff. The institution remains a strong lobbying and research group favouring mainstream neo-classical resource and environmental economics and has supported key developments in this area.

During the 1960s, environmental economics appeared in the US as a distinct sub-discipline concerned with the growing pollution problems which were becoming evident to the general public. *Land Economics* re-focused on environmental economics, and the *Natural Resource Journal*, with an environmental law perspective, developed concerns about the political economy of environmental issues. However, the subject began to expand more as the decade ended and novel influences were brought into the economic realm.

In the late 1960s and early 1970s, the laws of thermodynamics were rediscovered as concepts with considerable implications for economics. This led to the development of materials balance theory (Kneese, Ayres and d'Arge, 1972). Simultaneously, Georgescu-Roegen (1971) was developing an extensive critique of economics also based upon the laws of thermodynamics and in particular entropy; although, unlike materials balance theory, his work remained relatively unattractive to environmental economists. The implications of the materials balance work in conjunction with general equilibrium modelling is that all the prices in the economy are incorrect in terms of efficiency because everything has an associated environmental externality (Hunt and d'Arge, 1973). However, the widespread implications of this simple and intuitive point for economics and policy have never been fully realised.

Following trends in mainstream economics, mathematical modelling took on a powerful role in the development of theory and in particular optimal control theory was adopted to model fisheries, resource depletion and pollution control. This mathematical approach gave credibility to the new sub-discipline within mainstream economics but removed it further from the actual management of environmental issues of the day and may therefore have restricted its growth and wider appeal. Outside of North America, only a handful of academics can be

regarded as even addressing the subject area at this time; e.g., in the UK, E.J. Mishan and in Sweden, Karl-Göran Mäler and Peter Bohm.

Institutionally, the 1970s were a period of consolidation by those in the USA. A major step in that regard was establishing the Association of Environmental and Resource Economists (AERE) which resulted from discussions amongst Larry Ruff, Terry Ferrar, John Cumberland, Alan Carlin, Ralph d'Arge and Kerry Smith. The *Journal of Environmental Economics and Management* (JEEM) had been established by Ralph d'Arge and Allen Kneese in May, 1974 and AERE later became the organisation controlling the journal. William Baumol was the first President of AERE in 1978, followed the next year by Kneese. Also, in 1979, the association was formally incorporated as a non-profit organisation in Washington, DC under the leadership of John V. Krutilla. Initial funding was provided in 1980 by the Ford Foundation, the Alfred P. Sloan Foundation, RFF and the Resource and Environmental Economics Laboratory of the University of Wyoming.

This new association effectively united the discipline in the USA and has grown to a current membership of approximately 800. The core concerns can be assessed from the AERE newsletter, JEEM, the topics of annual workshops (established in 1986) and the sources funding the organisation. The business office of AERE has always been located at RFF headquarters in Washington, DC, and been provided free of charge. The Secretary and Treasurer have always been professional staff members of RFF. Workshop funding is provided by the US Environmental Protection Agency, the National Oceanic and Atmospheric Administration (NOAA) and the Economic Research Service of the US Department of Agriculture. The controversy over the use of contingent valuation in the Exxon Valdez resource damage legal case led NOAA to establish a panel of experts which provided guidelines as to best practice. As this shows, certain branches of the US government have seemed interested in economic input on environmental issues, and this, increasingly, has meant the development of environmental cost-benefit analysis, although, as noted later, the failure of politicians to adopt economic prescriptions for the environment has been a continuing concern to environmental economists.

AERE and JEEM gave credibility to environmental economics and encouraged further specialisation. Resource economists concentrated upon fisheries, forestry and mineral extraction, while environmental economists dealt with pollution control and cost-benefit analysis. Together, resource and environmental economics explained how neo-classical models were flawed in their neglect of the resource base and waste sinks. They generally claimed corrections to markets could be made to avoid these problems and achieve efficiency gains. While popular environmentalism of the time was arguing in favour of legal restrictions and zero pollution, these economists favoured market-based instruments and optimal pollution levels determined by taking costs and benefits into account.

As the first dedicated publication in the area, JEEM held high hopes for constructive progress. However, the practical policy content originally proposed for JEEM was lost amongst mathematical models and theoretical expositions which, while winning the journal respect amongst mainstream economists, did little to address issues in practical environmental management. In general, JEEM developed into the theoretical journal of environmental economics, although in recent years some more critical articles, addressing wider concerns, have appeared, e.g., Vatn and Bromley (1994). The influence of JEEM on the sub-discipline was very strong for many years because few academic peer reviewed journals provided an outlet for those specialising in the economics of the environment. In terms of the mainstream economics journals, environmental economics was excluded with only rare exceptions. Not until the early 1990s was there a rapid growth of journals addressing economy-environment interactions and room for the expression of alternative approaches. As environmental problems became increasingly of political significance at this time, even the mainstream journals occasionally felt the need to address the subject, although usually restricting attention to specific topics dealt with by invited authors in special issues with no replies or comments allowed. Thus, despite the efforts made in establishing a distinct sub-discipline, environmental economics has remained a marginal pursuit within mainstream economics.

After the popular revival of environmentalism in the late 1980s, Europe started to follow in the footsteps of the North Americans. As environmental concern among the general public seemed to subside in the late 1970s and early 1980s so had the chance of adopting a more progressive attitude to these issues in economics departments around Europe. Not until 1991 was a European Association of Environmental and Resource Economists (EAERE) finally established. Straight away an associated journal published by Kluwer Academic, *Environmental and Resource Economics* (ERE), was started. The EAERE is a separate organisation from the US AERE, with independent activities, although closer links are now being forged. The organisation and journal have been strongly connected with academics in the Netherlands and Italy. The presidents have been Henk Folmer, Rudiger Pethig, Domenico Sinescalco and Aart de Zeeuw. The society has emphasised within its statutes the view of environmental and resource economics as a science, and this has been reflected in mathematical modelling and following the trends set by mainstream economics.

For many, this more formal spread of an apparent environmental concern within economic circles in Europe was welcomed as another opportunity to get the message across to politicians and fellow economists that the environment and economy interact in fundamental ways. However, neither have seemed particularly moved by what environmental economists have been saying. The main response to this neglect, apparent within environmental economics for some-time, has been to regard politicians and the political process as barriers to rational policy development. A general bewilderment has been expressed at the disregard

shown by politicians for the message of even basic textbooks in environmental economics. Articles on this theme have appeared regularly in the academic literature (e.g., why have so few pollution taxes been adopted while legal restrictions seem to proliferate?, why are pollution standards set without regard to costs and benefits?); for a recent example see Shogren (1998).

At the same time, in areas where environmental economics has been regarded as susceptible to criticism, for failing to address certain issues, the models have been extended. For example, environmental valuation methods have moved far from their original concentration on the direct use values of mainstream micro-economics into areas where questions relating to future generations and the existence of species are discussed. Those versed in the theoretical limits of neo-classical models have tended to regard these extensions into foreign territory as ill-advised and beyond the proper remit of economists. Thus, contingent valuation studies are attacked from within environmental economics as failing to conform to the assumption of the free market (e.g., no arbitrage) and being based upon stated, as opposed to revealed, preferences. Yet, by persisting within the relatively secure confines of mainstream neo-classical theory, environmental economics must then confine the terms of debate and so remain largely unable to adequately address or even consider central issues of concern for environmental policy. For example, concerns over the long term impact of environmental pollution are inadequately addressed as technical issues about the appropriate discount rate, while the assumption that intergenerational equity can be captured within a specific model of preference utilitarianism precludes central aspects of the ethical debate (see Spash, 1993). Thus, the requirements of neo-classical theory come into conflict with the concerns raised by environmental issues.

In order for environmental economics to maintain a position of good standing within economics requires recruiting those with strong mathematical skills and a theoretical mind-set. Those concerned with practical conservation and ecosystems management who lack that theoretical interest will therefore be discouraged from pursuing environmental economics as a method to advance their understanding of economy-environment interactions, and are likely to seek more direct routes to pursue their environmental concerns. For example, one of the latest trends in economics has been for game theoretic approaches which emphasise mathematical skills. Game theory applications to environmental issues seem to have been boosted by the availability of arms negotiations models developed during the cold war and have spread to other environmental subjects such as international relations (see Patterson, 1996). While perhaps academically satisfying, this preoccupation seems no more likely to help reduce environmental problems than it did bring about the demolition of the Berlin wall. For those concerned with achieving environmental policy changes, environmental economics therefore often appears to follow the wrong pursuits. This is unproblematic in as far as different disciplines allow specialisation and alternative disciplines exist for individuals to pursue their interests. However, for

economists wishing to study the environment the choice has been absent and the approach in environmental economics often intolerant of open debate. Thus, several factors have led to discontent within environmental economics including the rather poor record of achieving policy change, the sub-disciplinary status and, perhaps most importantly, tensions between conforming to and wishing to change the mainstream economic approach.

ECOLOGICAL ECONOMICS

A tradition of thought which can be classified as ecological economics can be traced back at least to the middle of the last century (Martinez-Alier, 1990). However, the current movement is founded upon the concerns of the 1960s and early 1970s for limits to growth (e.g., Boulding, 1966; Meadows et al., 1972) and the study of the flow of energy and materials in the economy based upon the work of Georgescu-Roegen (1971). In addition, the management of environmental externalities as pervasive social costs and the resulting restrictions on the applicability of cost-benefit analysis reflect the studies of Kapp (1950). However, past writers expressing such an ecological critique of economics failed to find a collective institutionalised academic niche which would establish a discipline or new paradigm. The more formal establishment of associations and journals only occurred in the late 1980s.

In Barcelona in 1987, at a meeting hosted by Juan Martinez-Alier, the International Society for Ecological Economics (ISEE) was born. European researchers played a key role in the formal creation of the movement, voting in Barcelona for the name Ecological Economics while placing an American ecologist, Bob Costanza, at the head. Among the 30 people present at this meeting were Malte Faber, Silvio Functowiz, Mario Giampietro, Ann-Marie Jansson, Martin O'Connor, John Proops, Jerry Ravetz and Mathias Ruth. The society was formally established in the USA in 1988 and has expanded from there to include branches in Australia/New Zealand, Brazil, Canada and Europe, chapters in India and Russia, an affiliated society in China and proposed chapters in Africa and across South America. The ISEE now has almost 2000 members in 81 countries. The society journal, *Ecological Economics*, is published twelve times per year by Elsevier Science Publishers and a quarterly bulletin is sent to members. The current structure (under reform) has a Board of Directors which consists of Bob Costanza, Herman Daly, Ann-Marie Jansson, John Peet and Juan Martinez-Alier, while the society President is Richard Norgaard.

The ISEE headquarters are currently based at the University of Maryland's Institute for Ecological Economics (IEE) which was itself founded in 1991 by grants from The Ford Foundation and the John D. and Catherine T. MacArthur Foundation. Full-time IEE faculty include the Director Bob Costanza, Associate Director Herman Daly and Senior Fellow John Cumberland (who was involved

in the early development of the AERE). Costanza has exerted a strong influence over the society, as both chairman of the Board and president for the first decade and editor of the society journal. As the society has expanded, the need for a regionally representative, democratic structure has grown and a move away from the dominant US base seems inevitable.

Ecological economics as an international society was founded around the idea of uniting two groups of academics coming from narrow methodological backgrounds, ecologists trained in natural science falsificationist methodology and neo-classical economists trained in logical positivism. Indeed, in the introduction to the first issue of the journal *Ecological Economics*, Bob Costanza stated that the subject would extend the overlap between neo-classical environmental economics and ecological impact studies and encourage new ways of thinking about linkages between ecological and economic systems. Neo-classical economics was to be included as a subset of the new discipline; something of a surprise for many environmental economists no doubt. However, a more open model of pluralism was probably intended where different approaches to the same issue are compared and contrasted rather than subsumed under a new overarching structure. More importantly, excessive concentration on the 'improved linkage' approach detracted from the search for and adoption of a new paradigm.

In this latter regard, the methodology of ecological economics is still refreshingly open. For example, at the risk of generalising, the European branch tends more to socio-economics and political economy while the Americans lean towards a scientific approach. The European Society for Ecological Economics (ESEE) was formally established as a charity in France in 1996 with the election of the officers of the Society held during a European Conference at the University of Versailles; Sylvie Faucheux was re-elected in 1998 to a second term as President. The movement in Europe has aims quite distinct from environmental economics societies such as the EAERE or AERE. As in the ISEE, the central objectives are to combine knowledge across the specialist areas of ecology and economics and see that policy advice on environmental problems be formulated on this basis. In addition, the ESEE encourages analysis of the social aspects of environmental policy and wider consideration of the place of humans within the environment. This implies a different methodology from mainstream economics while allowing for a discourse on the development of a socio-economic and ecological discipline. A series of books on ecological economics is to be published by the ESEE through Edward Elgar Publishers in order to help synthesise new ideas. A distinguishing feature of the European movement is the search for co-operation with philosophers, sociologists and psychologists to explore ethical, social and behavioural fundamentals of human well-being.

While the pluralism expounded by this approach is refreshing, the apparent expansion of economics may worry some that colonisation of ideas is all that is intended. Previous extensions of neo-classical economics (e.g., crime, health,

environment) seem to have reassured the economics profession of the universality of their approach while allowing outside critiques to be regarded as largely irrelevant. For example, the concept of total economic value has been used by some to claim all environmental values can be adequately addressed in cost-benefit analysis. Unfortunately, some research along these lines has indeed appeared under the guise of ecological economics and, despite being technically deficient even within the neo-classical paradigm, has been widely publicised, e.g.,, attempting to value the world's ecosystems in monetary terms. However, such work clearly deviates from what is progressive in ecological economics and also corrupts the meaning and content of concepts in both ecology (e.g., ecosystems functions) and economics (e.g., marginal valuation under *ceteris paribus*).

The potential of ecological economics to develop new paradigms has attracted a variety of those more critical of established approaches. The disparate positions held by this group of individuals is unified by the common belief that effective environmental policy formation requires linking natural and social sciences. That is, studying environmental problems without regard to economics is viewed as misguided in the same way as the economic approach has been misguided by excluding the natural science perspective. The work of environmental economists is then commended for identifying problems in the efficient allocation of resources and exposing the fallacy of economic analysis independent of the biosphere. However, this same work leads these critics to the conclusion that much of neo-classical economics is an impediment to further advancement. Yet, the pluralism preached by ecological economics encourages the continued participation of and reluctance to move beyond mainstream economic approaches.

Thus, a tension has remained within ecological economics. A crude characterisation of this situation might be that there are two possible directions for ecological economics: either accept neo-classical theory as basically sound and aim to develop mathematical models linking it with ecology or, learning from past experience, accept that how economic systems interact with nature means moving away from old approaches and developing new paradigms. The first path has in principle been trodden by resource and then environmental economics for several decades, although without specific emphasis on ecology and with wavering enthusiasm by the late 1980s. While neo-classical economics offers a type of theoretical rigour attractive to scientifically trained academics, this same rigour reduces environmental problems to narrow technical issues and deliberately excludes a range of potential options and an interdisciplinary approach. Given the critique of economics that underlies the historical writings in the area, and that drove the formation of ecological economics, the second approach seems the only sensible alternative.

Whether all those currently subscribing to the movement will follow the developing path is unclear but unlikely. Currently, there are several contending

themes which might define the core of ecological economics and pulling these together without alienating certain factions will be difficult. In a past edition of *Environmental Values*, Giuseppe Munda (1997) outlined his opinion of what form some of the key concepts. These were that ecological economics is concerned about the policy consequences of its arguments, openly claims ethical positions rather than neutrality, accepts that values can be disputed and incommensurable, recognises distributional issues as a primary concern and sees the ecological concept of scale as limiting material growth. In addition, he proposed the coevolutionary paradigm as described by Norgaard (1988; 1994) as a potential unifying theme. Evolutionary dynamics are an important aspect of ecological economics which emphasise that economic and environmental systems are interacting and changing, often unpredictably, rather than static, and this implies analysing non-deterministic processes rather than optimal paths to static equilibria. However, the particular interpretation via the coevolutionary paradigm remains a topic for open debate within ecological economics. Thus, while the subject remains open, and is for this reason attractive to many struggling to develop a comprehensive understanding of environmental values, Munda describes what is progressive in ecological economics and shows how it is moving distinctively away from mainstream economics.

As new concepts are developed within ecological economics, the 'improved linkage' route of combining existing economic approaches with natural science information seems too limiting. The themes of the developing subject area no longer sit comfortably in the mechanistic framework of environmental and resource economics and as a result the divide between the two seems set to grow. In this regard, the reader should note that the neo-classical approach is but one type of economics which has been operating within ecological economics. Institutional economics has been exerting its influence and may offer a forum for open debate more amenable to many (for a review see Spash and Villena, 1998). Marxism and socialism have also been entering the debate with authors considering how the environment should be included in their more traditional analyses; one result has been the development of political ecology, (see, for example, O'Connor, 1994; Keil et al., 1998). In addition, rethinking the role of science in society along the lines proposed by Funtowicz and Ravetz (1992; 1993) will change the perception of ecologists and economists as to their role in environmental policy formation.

DEFINING VALUES OF ECOLOGICAL ECONOMICS

Ecological economics is currently more of a movement than a discipline because the interdisciplinary requirements make a core methodology hard to define. One approach to trying to probe the values which underlie the subject is to look at what ecological economists do. This requires identifying those who ascribe to

the discipline and studying their work. However, as noted, an initial policy in the ISEE was to gain wide support from established academics prepared to sign-up to the general concept of studying economy-environment interactions. Environmental economists interested in how ecology might contribute to economics joined, while continuing their work as before, and only some of these had a view to developing new approaches. This has resulted in the names of individuals long associated with a narrow neo-classical environmental economics approach appearing under the banner of ecological economics.

Others, trying to draw together ecology and neo-classical environmental and resource economics, see no contradiction in being on the governing council of neo-classical associations, such as EAERE or AERE, while assuming the mantle of ecological economics. The potential contradiction is avoided for them because they study 'ecology and economics' and in doing so regard each as distinct subject areas with specific types of narrowly defined interactions. For example, Turner, Perrings and Folke (1997) 'do not see ecological economics as an alternative paradigm'(p. 27), refer to it as being closer to renewable resource economics than environmental economics, and reduce all concerns to side constraints on economic activities (convenient for the optimal control modelling favoured by resource economists).

This perception of the movement as 'ecology and economics' can be associated with the expression of a particular set of values and concentration upon the science approach to both subjects. An individual trained in mathematics or physics who has switched into economics (not uncommon) and who is concerned about the environment might prefer the greater degree of linkage between natural science and economics emphasised by ecological economics. Similarly, an ecologist might feel their interest in economic interactions with the environment is best served by adopting neo-classical models from environmental economics and assume this is the only aim of ecological economics. These people might also satisfy their core concern, to extend the scientific approach by linking models, through association with environmental economics where a logical positivist methodology is still common and the emphasis is upon technical competence and mathematical model building skills. Technical competence is of course important to avoid misleading use of current economic tools, but extending technical competence across disciplines is a relatively limited (although often challenging) educational goal. However, what such individuals do not require is a new discipline called ecological economics because for them there is only a combined science of 'ecology and economics' based upon the two established disciplines.

Ecological economics consists of more than linking economic market models with ecological production function analysis and providing 'robust' numbers. Otherwise it would indeed merely be environmental economics renamed and could employ the same methods and methodology. As the history

of environmental economics has shown, the emphasis on being a part of the mainstream school of economics has meant pushing to one side problems which fail to conform to theoretical expectations. Examples of such problems are Georgescu-Roegen's work on entropy, Ciriacy-Wantrup's concerns about the epistemology of uncertainty, Kapp's critiques of valuation, and the general inadequacies of the underlying behavioural model as noted, for example, by Knetsch (1994). Furthermore, while environmental and resource economics has been restricted to micro-economics, ecological economics has been progressive at both micro-economic (e.g., household consumption level) and macro-economic (economic growth and sustainability) levels.

Consideration of ecology also presents fundamental insights into economics rather than a few extra constraints. Holling et al. (1995) suspect many economists ignore ecological information despite the accumulated body of evidence from natural, disturbed and managed ecosystems. In particular, they identify four key features common to the function and structure of many ecosystems which economists should bring into their subject. A précis of their points is as follows:

(i) Ecosystem change is episodic rather than continuous and gradual. For example, uncommon events, such as hurricanes, can unpredictably reshape structure at critical times or in vulnerable locations.

(ii) Scaling up from small to large is a non-linear process. Thus, spatial attributes vary with scale rather than being uniform.

(iii) Ecosystems exhibit multiple equilibria, an absence of equilibria and are destabilised by forces far from equilibria. The movement between such states maintains structure and diversity. This contrasts with the conception of ecosystems as single equilibrium systems with functions operating to maintain the stable state.

(iv) Recognising that ecosystems have multiple features, which are uncertain and unpredictable, requires management and policies to be flexible, adaptive and experimental at scales compatible with those of critical ecosystem functions.

Besides learning from ecology the movement has begun to look across other divides such as ethics, psychology and politics, and to recognise the importance of methodological and value issues. For example, debates over the motives behind natural capital maintenance are poorly reflected by reduction purely to the degree to which people believe inputs are substitutable, a very mechanistic reductionism; driving issues concern ignorance being epistemologically different from risk (Faber, Manstetten and Proops, 1996) and the recognition of non-human values (Spash and Clayton, 1997). Other ethical considerations relate to the moral standing of unborn future generations and the inadequacy of debates upon appropriate interest rate derivation to even address the issue (Spash, 1993).

A defining aspect of commitment to ecological economics is then the extent to which concepts, such as discounting, are seen as problematic in themselves, the issues they raise are debated and the search initiated for alternative approaches. For some economists even questioning the orthodoxy is heretical, and values and information which it excludes must therefore be irrelevant to economics. The socio-economic approach to ecological economics accepts the need for future generations of humans to have a voice and that both intra- and inter-generational distribution are issues the current economic and political system fails to adequately address.

This concern for disenfranchised humans and the importance given to distributional issues is common amongst ecological economists. Social and community values are recognised as key to improving human well-being and therefore part of the consideration in addressing environmental problems. Appealing to a theory of human motivation based solely upon individual preferences, even when altruistic, is then somewhat contradictory. Much of environmentalism is concerned with a sense of community across space and time. An opinion shared with socialist critiques is that free market systems educate individuals to act as selfish hedonists and create self perpetuating power structures which reinforce inequity. Thus, ecological economics is also interested in exploring alternative institutions and processes. Such an institutional approach needs to consider how a variety of values can be expressed and how to prevent the loss of values which occurs when they are squeezed to fit within the free market paradigm. The aim for ecological economics must be to develop new ways of thinking about the world around us and approaches for resolving (not necessarily solving) environmental conflicts.

More controversial is the extent to which ecological economists accept that moral standing be given to non-human entities. Proops (1989: 62, 72) has identified questions over rights for animal species, plants and depletable resources as part of the research agenda on ethical values required in ecological economics. While Costanza and Daly (1987: 4) have noted the ability of humans to misperceive the value of natural resources which leads them to state that: 'Some notion of intrinsic value must therefore be introduced as a check on human perceptions and to allow us to study the economies of nature which do not include humans'. Unfortunately, they fail to expand upon their conception of intrinsic value. One possible expression of this concern might be in the development by ecologists and social scientists of the concept of ecosystem health which seems to equate ecosystems to people in that ecosystems are more than an aggregation of component species and the implication is that as entities they can be harmed, i.e., be given poor health (Costanza, 1992: 240-241). There also seems to be a key underlying concern in the concept of natural capital maintenance that goes beyond preservation of useful engineering features, and this might also be described as value within ecosystems themselves. Although, naming nature as capital is a mechanistic approach which reduces the meaning of the underlying

concept, similar in effect to 'commodification' of wildlife. Thus, for ecologists studying ecosystems health and economists discussing natural capital, ecosystems are in fact often regarded as purely functional production systems serving human ends. In fact there appears to be a concentration upon aspects of value which contribute either directly or indirectly to human well-being. Indeed, while discussions on the basis for sustainability have brought the land ethic of Aldo Leopold (1987) into play, the values expressed are mostly couched in terms of poverty alleviation and intergenerational equity (see Spash and Villena, 1998). Thus, recognition that non-human entities have value beyond reduction to individual human preferences, expressed either in the market place or political arena, remains an issue for open debate in ecological economics. Any debate which does ensue will undoubtedly reflect different cultural values which themselves require greater acceptance within economics.

Neo-classical economist traditionally withdraw from such debates, claiming these matters are non-economic. They may therefore reject the results which indicate that people hold values diverging from theoretically accepted expectations, e.g., claiming studies have been poorly or unscientifically conducted. Ethical debates in cost-benefit analysis have resulted in open attacks on even the idea of studying environmental ethics (Pearce, 1996). Methods, such as contingent valuation, may be rejected completely rather than asking what they actually indicate when unexpected results arise. Others try to extend the model to include any occurrence of wider concepts of value in a comprehensive cost-benefit analysis. When confronted by the possibility that non-human existence may have some value in and of itself, some environmental economists have claimed this is approximated by human willingness to pay for a poorly defined concept of another entity's existence. However, methods such as contingent valuation can be used to show the presence of rights based positions which can be consistent with rejecting this interpretation (Spash, 1998). The point here is that, in making values fit the *a priori* model, the concepts missing from economic theory or which fall outside the market are perverted, e.g., equating intrinsic value to existence value (Pearce, Markandya and Barbier, 1990), reducing ignorance to probabilities (Chichilnisky and Heal, 1993).

This process of narrowing down the room for debate is standard practice within mainstream economics. In a presidential address for the ISEE, Richard Norgaard (1998: 7) briefly discussed a challenge he repeatedly faces, often from fellow economists (from both the political right and left), that 'hurting peasants to save forests is immoral'. He states that:

> …the dilemma is symptomatic of a larger problem, how economics and public discourse have coevolved in a particularly dishonest and morally vacuous way. Now I ask why the choice is between the peasant and the forest that our descendants might need? Where are the people driving the BMWs today, or even those driving Fords, in this myth? Why is it that we have these debates between rich environmentalists and rich developmentalists over moral dilemmas where the rich themselves are absent?

He goes on to locate the cause of such myths within the historical development of welfare economics as a method for removing any apparent need for moral discourse or politics from the agenda of the economic policy advisor.

As Norgaard notes, such mythical dilemmas are used to defend the status quo. This can be seen in other areas such as the perpetuation of the myth of the 'tragedy of the commons' (Hardin, 1968), which has been used to deride communitarian values and promote private ownership. The historical tragedy has been the destruction by private profiteers of customs and cultures which managed resources in common and prevented over-exploitation. However, the myth of common ownership being a tragedy is far more useful for those who favour the spread of private property rights and the rule of the market. A whole set of issues about institutional arrangements, political structures and cultural relationships with non-human entities is then neatly reduced to the efficiency of private markets.

This is part of a more general methodological problem in economics where, of the two roots of economics, the engineering aspect has become dominant while the ethical approach is ridiculed as unscientific. Sen (1987) has argued that the ethical approach to economics is traceable to Aristotle and the engineering one to Kautilya, a 4th-century advisor to the Indian emperor. In reintroducing the ethical element as an integral part of economics, and recognising the narrowness of reducing such issues to an engineering equation, ecological economics is taking a distinct and neglected path to economic policy.

CONCLUSIONS

Environmental concerns have been relatively unimportant for established economists during the past century but have in recent decades become politically (and therefore economically) relevant. Mono-disciplinary approaches to environment-economy interactions have been recognised by many to be inadequate. Figure 1 summaries the process of development which thinking about the role of the environment has undergone this century within economics. In this process, ecological economics is an important departure because it attempts to integrate and synthesise many different disciplinary perspectives. In order to achieve social and environmental sustainability, there is a belief in the need to understand current approaches to economics and ecology but most importantly to develop a new paradigm.

The review here shows that ecological economics has been viewed by some as merely linking environmental economics with ecology. However, this is inconsistent with the ecological and environmental critique of economics which resource and environmental economists have been unable to address. The argument has been put forward that in Europe a socio-economic approach has been developing while in North America the dominant trend has been to favour an objective science viewpoint. This latter view was termed the 'improved

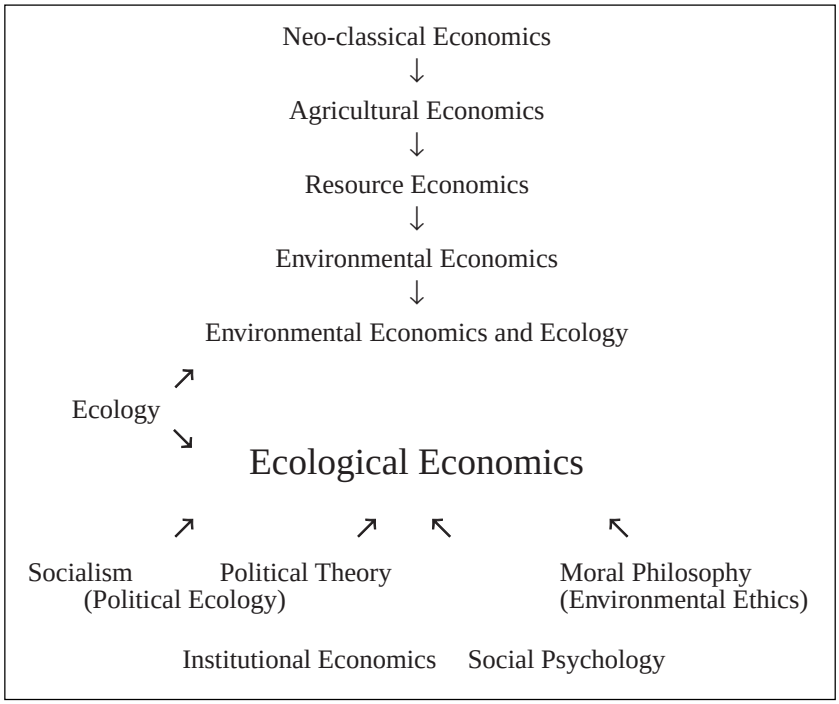

FIGURE 1. Economic perspectives on the environment

linkage' approach and defines a group of scholars working under 'ecology and economics'. Rather confusingly for the external observer, this approach has encouraged neo-classical economists to present their work under the title of ecological economics. However, ecological economics is moving beyond these disciplines; for example, by placing importance upon the open discussion of ethical issues, rather than assuming resource and environmental problems can be meaningfully analysed from the ethically neutral perspective of an objective science. Ecological economics is synthesising different perspectives and is raising issues which environmental economics has been unable to address. For example, the psychological model of individual behaviour underlying micro-economics is unable to account for such fundamental concepts as social context, environmental attitudes and ethical beliefs. When it tries to do so the theoretical anomalies either cause a rapid retreat or dramatic perversion of the original concept.

A central part of defining ecological economics as a distinct new subject rotates around the importance of incorporating moral values and being prepared to openly debate difficult issues, such as the set of morally considerable entities, the rights of future generations and treatment of the poor. The socio-economic

approach to ecological economics recognises a failure to account for issues of equity and culture and rejects the dominance of efficiency in economics. Some consensus exists around the key aspects of any new paradigm, which will need to include the recognition of ecosystems constraints, a concern for equity, fairness, effectiveness and efficiency in economic systems, and a regard for the moral standing of others both within current and across future generations of humans. The independent value of non-human entities remains more controversial. In order to address these issues, the subject is moving towards a new political economy. However, whereas one individual might in the past have aspired to master the sum of human knowledge, in such a subject, this no longer seems possible. More feasible and necessary is an open mind working with others from different disciplinary backgrounds but with similarly open minds.

An interdisciplinary approach to the environment can only be achieved by individuals being prepared to cross disciplinary boundaries and learn the language of other academic disciplines. This is where ecological economics holds out the greatest hope. In the past, much emphasis in environmental work has been placed upon rhetorical reference to interdisciplinary research but in fact this has meant producing reports which are merely a combination of chapters written by mono-disciplinary groups and bound together without regard to the inconsistencies. Open debate and synthesis is essential to allow academics the potential to understand why their work is seen as incorrect, or even on occasion offensive, to those with other perspectives. At the same time, this must be achieved without making individuals paranoid or feeling they must be defensive and withdraw behind their disciplinary boundaries. A central aim of this type of pluralism is to create the academic freedom to address environmental problems. Ecological economics offers the potential for individuals to be specialists in one area while being mindful of other perspectives.

As ecological economics moves away from the engineering approach to the ethical side of economics there will be a transition in which some of the methods, if not the methodology, of environmental and resource economics remain of practical use. However, as shown in Figure 1, ecological economics as the study of well-being in society is open to influences from several disciplines as well as attracting economists of various persuasions (e.g., socialist, institutional, environmental). The point of ecological economics is to recognise the environment as a complex collection of ethical and evaluative considerations. While many environmental economists would accept the relevance of considerations outside their analysis, they claim to leave these to the mythical ‘decision-maker’. The potential of ecological economics is to include these as essential aspects of analysis. Thus, for example, the goals of traditional ‘development’ and ‘growth’ can be recognised as being excessively materialistic on social, ethical and environmental grounds. In this way, ecological economics is now facing the challenge of exploring how to go beyond the limits of the disciplines it combines and develop a political economy of Nature.

REFERENCES

Bishop, R. C. 1978. Endangered species and uncertainty: the economics of a safe minimum standard. *American Journal of Agricultural Economics* **60**: 10-18.

Boulding, K. E. 1966. The economics of the coming Spaceship Earth. In H. Jarrett (ed.) *Environmental Quality in a Growing Economy: Essays from the Sixth RFF Forum*. Baltimore: Johns Hopkins University Press, pp. 3-14.

Bunce, A. C. 1942. *The Economics of Soil Conservation*. Ames: Iowa State College Press.

Chichilnisky, G. and G. Heal 1993. Global environmental risks. *Journal of Economic Perspectives* **7**(4): 65-86.

Ciriacy-Wantrup, S. 1938. Soil conservation in European farm management. *Journal of Farm Economics* **20** (February).

Ciriacy-Wantrup, S. 1944. Taxation and the conservation of resources. *Quarterly Journal of Economics* **58**(February).

Ciriacy-Wantrup, S. 1952. *Resource Conservation: Economics and Policies*. Berkeley: University of California Press.

Clawson, M. and J. L. Knetsch 1966. *Economics of Outdoor Recreation*. Baltimore and London: Johns Hopkins University Press.

Collison Black, R. D. 1990. Jevons, Marshall and the utilitarian tradition. *Scottish Journal of Political Economy* **37**(February): 5-17.

Costanza, R. 1992. Toward an operational definition of ecosystem health. In R. Costanza, B. G. Norton and B. D. Haskell (eds) *Ecosystem Health: New Goals for Environmental Managment*. Washington, DC: Island Press: 239-256.

Costanza, R. and H. E. Daly 1987. Toward an ecological economics. *Ecological Modelling* **38**: 1-7.

Crabbe, P. J. 1983. The contribution of L. C. Gray to the economic theory of exhaustible resources. *Journal of Environmental Economics and Management* **10**: 195-220.

Faber, M., R. Manstetten and J. Proops 1996. *Ecological Economics: Concepts and Methods*. Cheltenham, England: Edward Elgar.

Funtowicz, S. O. and J. R. Ravetz 1992. The good, the true and the postmodern. *Futures* **24**(10): 963-976.

Funtowicz, S. O. and J. R. Ravetz 1993. Science for the post-normal age. *Futures* **25**(7): 739-755.

Georgescu-Roegen, N. 1971. *The Entropy Law and the Economic Process*. Cambridge, Massachusetts: Harvard University Press.

Gray, L. C. 1913. The economic possibilities of conservation. *Quarterly Journal of Economics* **27**: 515-519.

Gray, L. C. 1914. Rent under the assumption of exhaustibility. *Quarterly Journal of Economics* **28**: 466-489.

Hammar, C. H. 1942. Society and conservation. *Journal of Farm Economics* **24**(February): 109-123.

Hardin, G. 1968. The tragedy of the commons. *Science* **162**(13 December 1968): 1243-1248.

Heal, G. 1986. The intertemporal problem. In D. W. Bromley (ed.) *Natural Resource Economics Policy Problems and Contemporary Analysis*. Boston: Kluwer Nijhoff Publishing, pp. 1-36.

Hess, R. H. 1917. Conservation and economic evolution. In Ely et al., *The Foundations of Natural Prosperity.* New York: Macmillan.

Holling, C. S., D. W. Schindler, B. W. Walker and J. Roughgarden 1995. Biodiversity in the functioning of ecosystems: An ecological synthesis. In C. Perrings, K.-G. Mäler, C. Folke, C. S. Holling and B.-O. Jansson (eds) *Biodiversity Loss: Economics and Ecological Issues*. Cambridge: Cambridge University Press.

Hotelling, H. 1931. The economics of exhaustible resources. *The Journal of Political Economy* **39**(2): 137-175.

Hunt, E. K. and R. C. d'Arge 1973. On lemmings and other acquisitive animals: Propositions on consumption. *Journal of Economic Issues* **7**(June): 337-353.

Ise, J. 1925. The theory of value as applied to natural resources. *American Economic Review* **15**: 284-291.

Jevons, W. S. 1865. *The Coal Question: An Inquiry Concerning the Progress of the Nation and the Probable Exhaustion of our Coal-mines*. London: Macmillan.

Kapp, K. W. 1950. *The Social Costs of Private Enterprise*. New York: Shocken.

Kapp, K. W. 1970. Environmental disruptions and social costs: A challenge to economists. *Kyklos* **23**: 833-847.

Keil, R., D. V. J. Bell, P. Penz and L. Fawcett (eds) 1998. *Political Ecology: Global and Local*. London: Routledge.

Kneese, A. V., R. U. Ayres and R. C. d'Arge 1972. *Economics and the Environment: A Materials Balance Approach*. Washington, D C: Resources for the Future.

Knetsch, J. L. 1994. Environmental valuation: Some problems of wrong questions and misleading answers. *Environmental Values* **3**(4): 351-368.

Krutilla, J. V. 1967. Conservation reconsidered. *American Economic Review* (September): 777-786.

Leopold, A. 1987. *A Sand County Almanac and Sketches Here and There*. Oxford, England: Oxford University Press.

Logan, L. M. 1930. *Stabilization of the Petroleum Industry*. Norman: University of Oklahoma Press.

Marshall, A. 1890. *Principles of Economics;* 1st edition. London: Macmillan.

Martinez-Alier, J. 1990. *Ecological Economics: Energy, Environment and Society*. Oxford, England: Basil Blackwell.

Meadows, D. H., D. L. Meadows, J. Randers and W. W. Behrens III 1972. *The Limits to Growth*. New York: Universe Books.

Mill, J. S. 1857. *Principles of Political Economy*. London: Parker.

Mitchell, R. C. and R. T. Carson 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Washington, D C: Resources for the Future.

Munda, G. 1997. Environmental economics, ecological economics, and the concept of sustainable development. *Environmental Values* **6**(2): 213-233.

Norgaard, R. B. 1988. Sustainable development: A co-evolutionary view. *Futures* (December): 606-662.

Norgaard, R. B. 1994. *Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future*. London: Routledge.

Norgaard, R. B. 1998. *Beyond Growth and Globalization*. 10th V. T. Krishnamachari Lecture, Institute of Economic Growth, Delhi, India.

O'Connor, M., Ed. 1994. *Is Capitalism Sustainable? Political Economy and the Politics of Ecology*. New York: Guilford Press.

Osgood, W. 1930. *Increasing the Recovery of Petroleum.* New York: McGraw-Hill.

Paley, W. S. 1952. Resources for Freedom: Report of the President's Materials Policy Commission. Washington, DC, United States, Government Printing Office. .

Patterson, M. 1996. *Global Warming and Global Politics*. London: Routledge Ltd.
Pearce, D. 1996. *Valuing the environment: The perspective of ecological economics*. Valuing the Environment Lecture Series, University of Cambridge.
Pearce, D., A. Markandya and E. B. Barbier 1990. *Blueprint for a Green Economy*. London: Earthscan.
Proops, J. 1989. Ecological economics: Rationale and problem areas. *Ecological Economics* **1**(1): 59-76.
Renner, G. T. 1942. *Conservation of Natural Resources*. New York: Wley.
Sen, A. K. 1987. *On Ethics and Economics*. Oxford, England: Basil Blackwell.
Shepard, W. 1945. *Food of Famine: The Challenge of Erosion*. New York: Macmillan.
Shogren, J. F. 1998. A political economy in an ecological web. *Environmental and Resource Economics* **11**(3-4): 557-570.
Spash, C. L. 1993. Economics, ethics, and long-term environmental damages. *Environmental Ethics* **15**(2): 117-132.
Spash, C. L. 1998. Investigating individual motives for environmental action: Lexicographic preferences, beliefs and attitudes. In J. Lemons, L. Westra and R. Goodland (eds) *Ecological Sustainability and Integrity: Concepts and Approaches*. Dordrecht, The Netherlands: Kluwer Academic Publishers, **13**: 46-62.
Spash, C. L. and A. M. H. Clayton 1997. The maintenance of natural capital: Motivations and methods. *Philosphy and Geography* **1**(*Space, place and environmental ethics*): 143-173.
Spash, C. L. and M. Villena 1998. *Investigating an institutional approach to the environment: socio-ecological-economics*. International Society for Ecological Economics 5th Biennial Conference, Santiago, Chile.
Tisdell, C. 1993. *Environmental Economics: Policies for Environmental Management and Sustainable Development*. Aldershot, England: Edward Elgar.
Turner, K., C. Perrings and C. Folke 1997. In J. C. J. M. van den Bergh and J. van der Straaten (eds) *Economy and Ecosystems in Change*. Cheltenham: Edward Elgar, pp. 25-49.
Tyron, F. G. 1932. *Mineral Economics*. New York: McGraw-Hill.
van Hise, C. R. 1910. *The Conservation of Natural Resources in the U.S.* New York: Macmillan.
Vatn, A. and D. W. Bromley 1994. Choices without prices without apologies. *Journal of Environmental Economics and Management* **26**: 129-148.
Wallace, B. and L. R. Edminster 1930. International Control of Raw Materials. Washington DC, Brookings Institute.
Weitzell, E. C. 1943. Economics of soil conservation. *Land Economics* **19**(August): 339-353.