Forum

Resource Economics and the Environment

S.R. Harrison and C.A. Tisdell*

Recently, a number of specialty areas have developed dealing with the economics of natural systems, resources and the environment. These include natural resource economics, environmental economics, ecological economics and bioeconomics. As well, new government departments, research institutes and tertiary courses have evolved in these areas. This paper examines the evolution and characteristics of the new areas of specialisation, and their relationship with the more traditional discipline of agricultural economics. Environmental economics is viewed as a wider interdisciplinary field than natural resource economics, and ecological economics or bioeconomics is depicted as a branch of natural resource economics dealing with living resources.

1. Introduction

In recent years, increased priority has been placed by the community and governments on preserving natural resources and protecting the environment. New government departments and agencies which focus on resource industries and environment have been formed. University economics departments have moved into teaching in areas which in some cases were the preserve of agriculture or agricultural economics, new degree courses have been introduced, and new learned journals launched.

The neoclassical framework traditionally adopted by agricultural economists has not fitted well with the emerging concepts of sustainable development and resource management, with respect to issues such as intergenerational equity, discounting, ethics and scientific uncertainties. The role of traditional specialty areas in agricultural and farm management economics has as a result been to some extent supplanted by natural resource, environmental and ecological economics.

Any examination of professional roles and definitions of discipline areas is fraught with danger. Economics is a diverse field, and the safest definition is "what economists do". While recognizing these difficulties, we feel that there is a need to clarify the nature of the various sub-discipline areas, and the relationships between them. Clearly, some confusion exists about the scope of each specialty area. Demarcation problems have arisen between what is to be taught in different university departments (e.g. Agriculture and Economics departments) and even what is taught in different subjects within departments.

This paper reviews the particular characteristics and differences between the branches of economics dealing with natural systems. The assessment is of necessity subjective and preliminary. Evidence is gleaned from the definition of terms, issues, approaches and methodologies adopted and the roles of public institutions involved. The nature and evolution of the main specialty areas in economics of natural systems and the environment are reviewed, and comments made on the relationships between major areas.

2. Early Writings and Background

The classical economists recognized land (basically all natural resources), labour and capital as scarce resources, and Malthus and Ricardo in particular were pessimistic about human welfare in the face of population growth and resource depletion (Pearce and Turner 1990, p. 10). Unlike Malthus, Ricardo had no explicit concept of an absolute limit on growth, but rather saw scarcity as a relative

* Department of Economics, University of Queensland, Qld. 4072. This paper has benefitted from the comments of three anonymous referees and the editor of *RMAE*. We are grateful for their comments. The usual *caveat* applies.

Review coordinated by the Editor.

measure. Malthus acknowledged (more than Ricardo) that technological change could postpone reaching the limit indefinitely. A more optimistic view was taken by Mill; while raising the problem of exhaustible-resource scarcity independent of population growth, he acknowledged that technological improvements could postpone the "stationary state". This optimism was shared by early neoclassical economists such as Jevons and Marshall. Jevons however raised concern over the possible exhaustion of British coal stocks as a constraint on economic growth. Marshall argued that the "growth of organization and knowledge" would prevent land scarcity and diminishing returns from curtailing economic growth (Barbier 1989, p. 17). From about the 1870s, the neoclassical economists concentrated on markets. The idea that government intervention should be limited to demonstrable cases of market failure had its foundations in Pigou's work on externalities in the 1920s, although not emerging in its current form until after World War II.

While the conservation movement can be traced back to at least the 19th century, such as the publication of *Man and Nature* by Marsh (1865) and the early American conservationists (Barbier 1989), the next 100 years was in general a period of technological optimism. An exception was Hotelling who in 1931 deplored the wasteful consumption and disappearing supplies of the world's natural resources, associated with excessively low resource prices (Cummings and Pearse 1985, p. 23). However, it is only in the last 30 years that substantial attention has again turned to resource limits to economic progress. Community attitudes have been influenced by changing issues of national concern and by an number of influential publications. Carson (1963) drew attention to the environmental and health dangers of synthetic pesticides. Toffler (1971) raised concerns over the rapid rate of change in society, the adverse externalities of new technology and the rate of resource depletion of the "throw-away society". Commoner (1971) argued that the ecosphere was being driven towards collapse, and discussed the origins of the "environmental crisis".

A neo-Malthusian group emerged in the early 1970s; the gloomy predictions of Ehrlich's *The Population Bomb* (Ehrlich 1971) and the Club of Rome's "limits to growth" (Meadows et al. 1972) attracting wide attention. About the same time, formation of the OPEC oil cartel and sudden escalation of oil prices created acute energy resource problems for many countries.

There has been a fundamental change in environmental concern over the last three decades. In the 1960s and 1970s the focus was on depletion of resources and Malthusian limits on primary raw materials. However, the oil shocks and subsequent price changes and energy conservation measures effectively reduced the fear that markets would not anticipate scarcity of materials. In the 1980s, interest shifted to global environmental issues affecting quality of life and long-term survival of species, usually rendered intractable by open access/common property characteristics (e.g. atmosphere, oceans, biodiversity). Institutional approaches to resource economics (e.g. property rights) have been fundamental in this awareness shift.

The changes in approaches by economists have reflected changing community values and political influences. The writings of Carson, Toffler, Commoner, Ehrlich and others have preceded the development of a "green" movement which emerged when environmental activism coalesced for political purposes with various other activist movements. Porritt and Winner (1988) distinguish between "light greens" who want to improve the current economic system, and "dark greens" who advocate radical changes.

3. Sustainable Development

The Brundtland Report[1] argued for development which "meets the needs of the present without com-

[1] This followed a series of influential international conferences and reports, including the Paris Biosphere Conference and the Washington DC Conference on Ecological Aspects of International Development (both in 1968), the UN Conference on Environment and Development in Stockholm (1972), and the *World Conservation Strategy* (IUCN, 1980).

promising the ability of future generations to meet their own needs" (WCED 1987). Formulating a more precise definition of sustainable development has presented difficulties; a plethora of definitions have been proposed (Pezzey 1989; ABS 1992), and some argue that the concept is only in the initial stages of being operationalised (e.g. James 1991). Intergenerational equity implies providing a wealth or capital inheritance for future generations equal to that which the present generation received. Sustainability which does not detract from future generations' welfare, or requires current generations to compensate later generations for irreversible losses, can be construed as Pareto optimality applied across generations (Pearce and Turner 1990).

The main differences between definitions concerns the extent to which man-made capital and technical know-how can substitute for natural capital. The Pearce school take the view that the stock of natural capital should not decline (Pearce et al. 1989, 1990). Similarly, Grey and Marlow (1991) are critical of the concept of "optimal depletion rate", and argue that natural capital has no substitutes.

On the other hand, most economists would consider that consuming some natural resources at present can make both current and future generations better off. According to this view, *ecological* sustainability could include such things as limiting extraction rates of biological resources to their renewal rates; landcare and control over degradation of other resources; maintenance of biological diversity, ecosystems and wildlife habitat; prevention of species extinctions; recycling; and avoiding exceeding the capacity of the environment to absorb waste products. There is a need also to ensure sustainability with respect to economic and social systems (Barbier 1987).

Further insights can be obtained by examining developments which have had undesirable impacts on natural resources or local communities. In Australia, the food and energy sectors probably create the greatest impacts, though mining, transport, tourism and urban growth may also be listed. Problems have occurred with regard to degradation of agricultural land (erosion, salinity, acidification, weed infestation) and water (toxic blue green algae, salinity, aquifer depletion); loss of tropical and temperate forests; loss of fish breeding stocks and habitat; landscape impacts of mining; shortage of landfill sites for solid waste disposal; and urban encroachment on prime agricultural land. Table 1 shows how wide these impacts or effects are in agriculture.

Table 1: A Sample of Environmental Issues of Direct Relevance to Agriculture

	Issues	Effects
1.	Biodiversity	Loss threatens sustainability of agricultural production; intensification of agriculture reduces biodiversity.
2.	Climatic change	Considerable impact on the viability of agricultural production and type of agriculture.
3.	Acid rain	Acidification of soil - reduced crop yields.
4.	Industrial air pollution, e.g. dust chemicals such as fluoride and lead	Usually reduced yields, possibility of food unsuitability for human consumption.
5.	Water pollution from industry and from agriculture	Chemical pollutants can threaten crop and livestock. Runoff of nitrates from agriculture can threaten to choke waterways with weeds, promote algal bloom, contaminate underground water supplies.

Table 1 (contd)

	Issues	Effects
6.	Removal of trees and vegetation	In some areas, results in rising salinisation of soil, loss of biodiversity, greater soil erosion, more variable streamflows.
7.	Pesticides	Residuals in food may reduce its acceptability. Use may have direct spillover impact, e.g. spray drift. May reduce biodiversity.
8.	Water use	Reduces streamflows with impact on other users. May result in a non-optimal pattern of water use, adverse impact on fishing, navigation.
9.	Infrastructure for agriculture such as dam, roads	Can have major environmental impact.
10.	The environment in which animal husbandry occurs	Intensive husbandry (e.g. of poultry) may reduce acceptability of product.
11.	Soil quality	Danger that it may not be sustainable as a result of 'abuse', e.g. excessive cultivation and use of chemical fertilizer.
12.	Availability of depletable resources used as agriculture inputs	Modern agriculture depends heavily on non-renewable resources, e.g. energy, artificial fertilizer.
13.	Ecotourism	Farm-based or regional tourism can be affected by changes to the local agricultural environment and its surroundings.
14.	Biosphere reserves (and catchment area management)	Environmental integration of agricultural activities with non-agricultural forms of land use involves agricultural economics.
15.	Use of antibiotics	Resistance of germs as a result of use - sustainability.
16.	Animal food additives - hormones, antibiotics, somatotropins	Risks to human health.

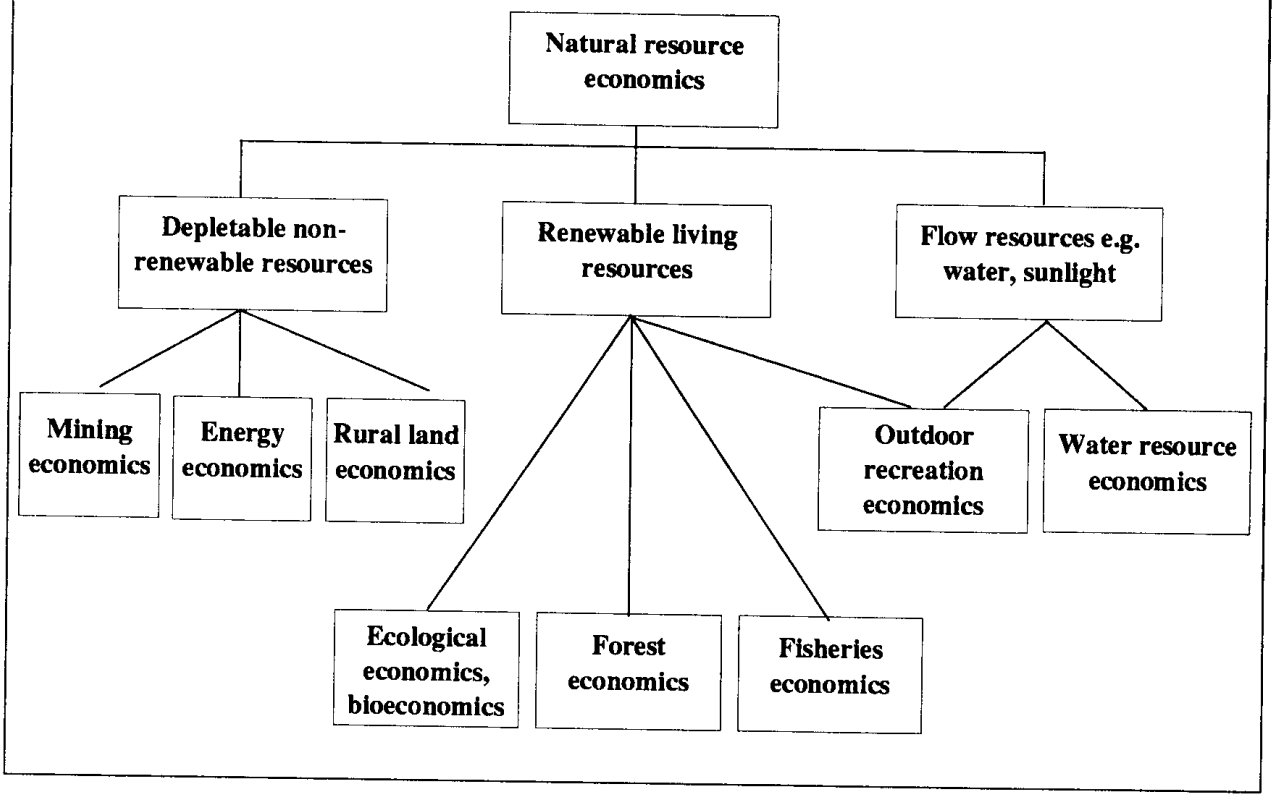
4. What is the Relevant Discipline

4.1 Natural resource economics

Natural resource economics is concerned with management and use of resources that are renewable (some only conditionally on restrained use) - such as land, water, forests and fisheries - and non-renewable, such as minerals and fossil fuels. This concept is improved by distinguishing between stock and flow resources. Figure 1 presents this framework. The elements of this discipline date back many years, e.g. the Hotelling rule for extraction of non-renewable resources dates back to 1931, key aspects of welfare economics stem from work by Pigou and Marshall, and rules for forestry rotation were formulated by Faustmann in 1849. Courses in mining and forest economics have existed for many years in Departments of Geology and Forestry. However, the specialization as it is now known took recognizable form in the 1960s and 1970s[2].

[2] Significant natural resource economics books of this era include Barnett and Morse (1963), Reynolds et al. (1974), Pearce (1975), Lecomber (1979) and Howe (1979). As well, prominent journals include *Natural Resources and Development, Natural Resources Journal, Journal of Energy and Natural Resources Law, Water Resources Research, Journal of the Institution of Water and Environmental Management, Ocean and Shoreline Management, The Mining Review, NSW National Parks Journal, Journal of Applied Recreation Research, Recreation Research Review, Australian Journal of Leisure and Recreation*, and *Australian Parks and Recreation*.

Figure 1: Specialisation Areas of Natural Resource Economics



In the 1980s, there were a number of attempts to clarify the nature of natural resource economics, and its relationship with the neoclassical economics paradigm. Anderson (1982) noted the movement of the "new resource economics" away from the neoclassical paradigm. Bromley (1982, 1985 p.44) has taken an institutional perspective:

> Markets and market processes operate within an institutional structure that defines rights and duties, obligations and opportunities. ... for every structure of resource endowments - and institutions define and specify resource endowments - there is a Pareto-efficient outcome. ... since institutions define markets, and since markets indicate to economists what is considered to be efficient, institutions define what we consider to be efficient outcomes. But economists usually ... search for efficient outcomes within a fixed institutional environment.

While natural resource economics as a specialty area of study has a long history in North America, it is a relatively new development in Australia, in spite of the importance of resource-based industries to the economy. Greater prominence has been accorded by the spate of recent public inquiries. Effort has been directed to cost-benefit analysis of alternative resource management scenarios (ABARE 1990, Bennett 1990), including application of the contingent valuation method to estimating the consumer surplus from resource conservation (Hundloe et al. 1990; Imber et al. 1991). Estimated conservation values of specific natural areas in the order of $500m per year have led to a good deal of controversy. Inter-industry analysis has been employed to determine regional impacts of resource conservation and development policies (Mangan 1991). Other techniques offering potential include multiple goal programming (Romero and Rehman 1987; RAC 1992), game theory, simulation and geographical information systems (Harrison and Tisdell 1992).

An important concept for natural resource economists is that of "property rights". Commercial extraction of resources such as forests and fisheries and urban and tourism developments can alienate property rights for community recreation. On the other hand, conservation decisions can restrict property rights of loggers and mining interests, and lead to compensation claims. Natural resource issues thus have significant legal implications, and it is notable that some of the major natural resource inquiries in Australia have been chaired by prominent lawyers, e.g. the Resource Assessment Commission (Justice D.G. Stewart) and the Fraser Island Commission of Inquiry (Mr. G.E. Fitzgerald).

While natural resource economics is basically an area of applied microeconomics, attention to macroeconomic issues is also warranted. In this regard, attempts are being made to include natural resource depletion and environmental pollution by way of "satellite" national accounts (ABS 1989; Cairncross 1991). For example, the average annual rate of growth in GDP of Indonesia over the period 1971-1984 was estimated at 7 per cent; when allowance was made for depletion of oil, timber and soil stocks this was reduced to 4 per cent (Repetto et al. 1989).

4.2 Environmental Economics

In the sense that "environs" are surroundings, the "environment" may be described as "the conditions or influences under which any person or thing lives or is developed" (Onions 1973). The environment is significant from the view of inputs and outputs of economic systems. On the input side, neoclassical economic models have recognized environmental variables as exogenous to the system under study, i.e. outside the control of management, and often subject to a high degree of uncertainty. Depending on the particular system being modelled, exogenous variables may include weather, the economic environment (input and product prices), technological change and legal and institutional arrangements. On the output side, the environment (air, water, landfill) is a sink to absorb wastes of both production and consumption activities.

Production of goods and services often creates spillover effects or externalities, private costs and benefits differing from social costs and benefits. Because of externalities of production, the economics of agriculture, forestry, mining and energy, transport and tourism all have overlaps with environmental economics. Neoclassical economists have traditionally regarded the environment as extraneous to economic analysis, assuming away these externalities to simplify the analysis. Environmental economics has led to attention to externalities as *central* rather than incidental to economic analysis.

Environmental economics as a separate (university-based) specialty dates to about 1970, when a large number of books on this topic began to appear[3]. Many environmental problems have been attributed to market failure and to lack of well defined (exclusive) property rights. Environmental economics is a broad and multi-disciplinary field, and practitioners range from the orthodox to the radical. The main subject matters include:

---

[3] Some of the earlier books include

Economics and the Environment: A Materials Balance Approach (Kneese et al., 1970)
Ecology, Economics and Environment (Behan and Weddle, 1971)
Environmental Economics (Crocker and Rogers, 1971)
The Economics of Pollution Control and Environmental Policy (Freeman, 1971)
The Economics of Environment (Boehm and Kneese, 1971)
Economics and the Environment: Selected Readings (Dorfman and Dorfman, 1972)
The Economics of Environmental Policy (Freeman et al., 1973)
Economics and the Environment (Edel, 1973)
The Economics of Environmental Protection (Thompson, 1973)
Environmental Economics (Seneca and Taussig, 1974)
Environmental Economics: A Theoretical Inquiry (Maler, 1974)
Environmental Economics (Pearce, 1976).

A number of journals were also launched, including

Journal of Environmental Management
Journal of Environmental Economics and Management
Environmental Conservation
Environment and Planning D: Environment and Space
Environment WA

- integrity of ecosystems
- maintenance of biodiversity
- preservation of wildlife habitat
- incorporation of externality costs and benefits in economic analysis
- the polluter-pays and beneficiary-compensates principles
- extension of property rights (e.g. setting limits on discharges and introducing tradeable permits)
- safe minimum standards.

In response to this wider awareness, governments around the world have established environment departments and environmental protection agencies. These have the role of watching over the state of the environment, managing national parks and wildlife services and enforcing legislation over air and water pollution and disposal of solid waste. They provide a balance in relation to departments administering resource-using activities. For example, the Environmental Protection Agency in the USA appears to wield considerable power, and large amounts of compensation have been awarded by courts for environmental damage such as oil spills.

As a result, environmental economics courses are now taught in a variety of departments at tertiary institutions, including economics and engineering. Although having its foundations in microeconomics, environmental economics tends to be a broad and multidisciplinary field, requiring comprehension of science and engineering principles as well as legal and socio-economic issues. Much research work involves sophisticated techniques, and some of the literature such as in the *Journal of Environmental Economics and Management* is highly complex and mathematical.

The emphasis on environmental economics training varies considerably between countries. According to Pearce et al. (1990, p. ix),

> Environmental economists play a significant part in undergraduate and graduate courses in the USA and Canada; it is growing in importance in Europe. At the time of writing, however, there is not a single graduate course in environmental economics in the UK. Environmental economics as a discipline applied to problems of developing countries remains a specialisation of fewer economists still ....

4.3 Resource and Environmental Economics

The distinction between environmental and natural resource economics is not clearcut. Sometimes they are grouped as a single discipline. Thus Randall (1987) writes of "resource and environmental economists" or REEs, which he describes as basically applied micro-economists. Similarly, Barbier (1989, p. 55) writes of "environmental and resource economics - the sub-discipline in economics concerned with economic-environmental interactions"[4].

It is possible, however, to identify differences between natural resource and environmental economics. The former has a tradition of interest in efficient use of resources. The latter developed as a specialty area at a time when increasing attention was being paid to conservation of natural resources and control of pollution, and has been in part a reaction to the economic orthodoxy of natural resource economics.

[4] A number of textbooks include both areas in their titles, e.g. Tietenberg's 1992 *Environmental and Natural Resource Economics*. Some journals address both areas, e.g. *Journal of Resource Management and Environmental Planning, Progress in Resource Management and Environmental Planning*. Some journals also link agricultural economics with resource economics, e.g. *Northeastern Journal of Agricultural and Resource Economics*.

A Commissioner for the Resource Assessment Commission took the view that "Any economist will tell you that the environment really ought to be classified as a resource; hence it should fall squarely into the policy arena concerning the allocation of resources" (James 1991). Further, he described the "pollution absorbing capacities" of the environment as a renewable resource. In this context, environmental economics may be regarded as subset of natural resource economics. An opposing view is that the environment is much more than a resource. In a sense it is all resources, but particularly air, water, recreation areas and cities (the "built environment"). But it is also a sink, which assimilates waste products of society. Use of any natural resource will have an impact on the environment. The environment is, in a fundamental sense, the life-support system for human activity. Thus Tisdell (1993a, p. 4) argues that natural resource economics is a subset of environmental economics, albeit an important one: "... natural resource economics has become the single largest area of concentration in studies of environmental economics". Under this view, environmental economics differs from natural resource economics primarily in its wider range of items and values to be considered.

An important distinction between natural resources and the environment lies in the boundaries of impacts. Extraction of resources usually is carried out under national sovereignty and property rights. Environmental problems, on the other hand, are not necessarily confined to national or state boundaries. Deforestation in an upper catchment may lead to pollution or flooding of downstream countries or states. A country can inflict air pollution and acid rain on its neighbours. Ozone depletion and atmospheric warming are global problems. Thus a major area of concern of environmental economists is with international and global issues, and with international arrangements for property rights to resources. This supports our argument for environmental economics to transcend resource economics.

4.4 Ecological Economics and Bioeconomics

Ecology is "that branch of biology which deals with the relations of living organisms and their surroundings, their habitats and modes of life, etc" or "the science of the economy of animals and plants" (Onions 1973). Ecologists are scientists who deal with these life forms and their environments.

The term "bioeconomics" has been widely used - usually as an adjective describing models in neoclassical studies rather than an economics specialization - since economists became interested in integrating biological and economic models (Dent and Anderson 1972). On the other hand, ecological economics is a relatively new specialization area. According to *The Macquarie Dictionary* the words 'bionomics' and 'ecology' have identical meanings: "ecology" is "the branch of biology which treats the relations between organisms and their environment; bionomics" (Delbridge 1981). This being so, one might expect there to be a corresponding synonym for 'ecological economics', and 'bioeconomics' is in fact this synonym. Thus the term "bioeconomics" is currently used to discuss what has become known as "ecological economics" (Clark 1989; Garcia 1991)[5].

The focus of the earliest contributions to bioeconomics tended to be the use of depletable resources. This is however, a rather one-sided concentration. Nevertheless, one can see why many of these contributions, such as those of Georgescu-Roegen (1977) and Daly (1980), can be considered to belong to bioeconomics or ecological economics. Living things depend ultimately (and often directly) upon the non-living environment for

[5] Development of ecological economics was stimulated by global policy documents such as the IUCN World Conservation Strategy of 1980 and Brundtland Report of 1987 (Tisdell, 1990a). The journal *Ecological Economics* was launched in 1989, and books on this subject have only appeared in the last few years (e.g. Martinez-Alier and Schlupmann, 1987; Costanza, 1991; Peet, 1992; and Pearce 1993).

their existence, even though in addition most higher order species, including human beings, cannot live without utilizing other living things. Thus, in considering the living world, we cannot ignore the non-living portion of the environment on which life depends. It is this aspect which makes it difficult to delineate the living world from the non-living, and in reality they cannot be completely divorced. However, traditionally much economic theory has tended to ignore the link (Perrings 1987). Economists in considering the circular flow of the economy overlook important loops in the interdependence of the economy with ecological processes (Ehrlich 1989; Tietenberg 1992). However, despite this interdependence factor, and the links of living things with the non-living environment, it seems essential if a subject is to be considered a part of bioeconomics or ecological economics that it refers to living things in relation to their surroundings or environment as life-support systems. Furthermore, it should relate to the basic economic problem of satisfying (human) wants subject to the limited availability of resources or scarcity of means to do so, although the wants or objectives to be pursued need not be entirely man-centred (Tisdell 1991).

The emphasis of ecological economics or bioeconomics is upon living things and their relations with their surroundings. However, the works described by their authors or others as belonging to bioeconomics (ecological economics, 'green economics') cover a wide range of topics using diverse paradigms. Thus for example Clark (1976) makes the economic management of living or biological resources his central focus whereas for Georgescu-Roegen (1971) and Gowdy (1991) the entropy of non-renewable and non-living resources is of central concern. Whereas Clark adopts the paradigms of neoclassical economics and its peripheral extensions, Georgescu-Roegen adopts a neo-Malthusian paradigm based on the physical laws of thermodynamics. How is it possible that both these contributions can be considered to belong to bioeconomics? The former focuses mostly in the living environment but is relatively conventional in approach; the latter concentrates on the non-living environment and is unconventional in approach.

It is not the conventionality or otherwise of the paradigm which determines that both these contributions belong to bioeconomics but rather the subject matter. The fact is that every living thing depends for its continuing existence on its surroundings: no living thing can be "an island unto itself". Although Georgescu-Roegen gives little attention to the biological world as such, he concentrates on the dependence of human beings on non-renewable (depletable) resources for maintenance of their standard of living and continued existence. Thus one aspect of the dependence of one organism (mankind) on the natural environment, especially depletable resources, is explored. His conclusion is that in order to expand the period of likely existence of the human race, rates of exhaustion of non-renewable resources should be reduced and much greater attention should be given to the conservation of biological resources. Consequently, his results have important bioeconomic implications. In fact, he has argued that human population levels and economic demands should be reduced to those supportable by the sustainable use of renewable resources alone.

The primary focus of ecological economics on living things would largely exclude interest in mining, or in general in non-renewable resources. Relative to resource and environmental economics, the formation of a specialty area allows a sharper focus on biodiversity, preservation of species, and management of specific biological resources. In discussion on the role of the journal *Ecological Economics*, Costanza (1989, p. 1) states

> Ecological Economics addresses the relationships between ecosystems and economic systems in the broadest sense. These relationships are the locus of many of our most pressing current problems (i.e. sustainability, acid rain, global warming, species extinction, wealth distribution) but are not well covered by any existing discipline.

Ecological economists are clearly dissatisfied with the outlook adopted by more traditional branches of economics and also natural sciences:

> Environmental and resource economics, as it is currently practised, covers only the application of neoclassical economics to environmental and resource problems. Ecology, as it is currently practised, sometimes deals with human impacts on ecosystems, but the most common tendency is to stick to natural systems.

Ecological economists strive to achieve a close integration or "conceptual pluralisation" of economics and ecology. They see natural resource economists as too traditional and too interested in the exploitation of resources[6]. While not necessarily adopting ecocentrism, most question the anthropocentric orientation and neoclassical approach of traditional economists, and seek a new paradigm of economics. Many are attracted to the "land ethic" of Aldo Leopold, as are land economists and natural resource economists. However, many ecological economists take this ethic further, conceding that species other than *homo sapiens* may have an independent right to existence, and that mankind has stewardship responsibilities for nature (Tisdell 1990b; cf. Rolston 1988). Nevertheless, there are also some natural resource economists who take this view (Clark 1991).

Costanza (1989) points out that ecological economics and bioeconomics are likely to involve a greater range of paradigms than are used in conventional neoclassical economics. This is partly a consequence of the wider subject matter of ecological economics, the need for a holistic cross-disciplinary approach and the inescapable dynamic and historical aspect of the issues. In this regard, the subject has much in common with development economics. Costanza further views ecological economics as concerning the management of sustainable development. While attempting to delineate ecological economics, he concedes that this specialty will be, in the final reckoning, "what ecological economists do"!

5. Relationship between Agricultural Economics, Resource Economics and Environmental Economics

5.1 Subject Areas

Natural resource and environmental economics are distinguishable from other branches of economics by two primary characteristics: their emphasis on natural endowments the replenishment rate of which is largely exogenous to economic systems (zero in the case of exhaustible resources) and, because of this exogenous replenishment, a central concern with resource allocation between different periods. This raises issues of discounting and time treatment, as discussed in the next section.

5.2 Method of Handling Issues

Another useful basis for comparison is the way in which particular resource management issues are addressed. An example would the management of grazing lands. Rangeland management may be viewed as achieving sustained yields of livestock products under agricultural economics; for natural resource economics it might introduce depletion of the productive capacity of the soil; for environmental economics externalities created for neighbouring properties; for ecological economics, effects on living systems.

Resource and environmental economics pays particular attention to intertemporal issues. The appropriateness of discounting techniques is questioned, since any non-trivial positive discount rate will place negligible weight on benefits and costs more than about 30 years into the future. It is sometimes argued that the discount rate should be

[6] Given the optimism of mainstream neoclassical economics with respect to technological improvements and resource substitution, it is surprising to note lingering references to economics as the "dismal science" by ecologists such as Ehrlich (1989) who present a pessimistic neo-Malthusian prognosis for the future of mankind.

reduced relative to the social time preference rate (STPR) or social opportunity cost (SOC), to place greater weight on future outcomes. However, there is no unambiguous relationship between the discount rate and the rate of environmental deterioration. While high discount rates favour short-term payoffs,

> ... the demand for natural resources is generally less with high discount rates than with low ones. High rates also discourage development projects that compete with existing environmentally benign land uses ... (Pearce and Turner 1990, p. 224).

A number of alternatives to adjustment of discount rates for allowing for intertemporal impacts have been proposed. These include ensuring that environmental impacts are properly understood and valued, and treating conservation of at least some types of natural capital as "sustainability constraints" on development.

5.3 Linkages Between Agriculture, Resource Use and the Environment

To what extent can agricultural economics be considered to be a part of natural resource, environmental or ecological economics, and vice versa? Firstly, most agricultural production is heavily dependent on the environment. The productivity of domestic crops and animals depends integrally on their surroundings and most traditional agricultural production economics has been concerned with the impact on agriculture production of manipulating the environment encountered by crops and livestock. To a large extent the environment created for modern agriculture is artificial (Oldfield 1989), e.g. applications of fertilizer and water are managed. However, in most cases the natural environment continues to play a role, e.g. the basic natural quality of soil, hours of sunlight, amount and variability of rainfall. Most agricultural production economics can be legitimately considered a branch of environmental economics or ecological economics. But traditionally agricultural economists have tended to concentrate on the environment *in situ*, especially the managed part of it, ignoring *ex situ* factors, interdependencies, and a number of sustainability questions. There is now a new awareness of the importance of such matters and an appreciation that the traditional focus can be too narrow.

Ultimately, all living things depend for their existence on the natural environment. All artificial environments can only be constructed by using natural resources and it seems only maintained by their use, notwithstanding the human input. Thus even though modern agriculture depends heavily on the maintenance of artificial environments (Oldfield 1989), ultimately its sustainability depends on natural environments, and the productivity of modified agricultural environments depends heavily on the initial natural conditions of the environment. Increasing concern is being expressed about the erosion of the natural resource base on which agriculture ultimately depends, e.g. loss of biodiversity, soil depth and soil quality (Harlan 1976; Rose 1992; CEPA 1992). It is human use of natural resources which creates the impacts or effects which are important to environmental economics.

These impacts, some of which are listed in Table 1, occur not only on the production side, but also on the sales or marketing side, indirectly through the dependence of agriculture on other industries. Examples relate to non-agricultural inputs to agriculture such as chemical fertilizer, environmental spillovers confined to agriculture, the direct external economic impacts of economic activities in agriculture on other industries and the environmental impact of non-agricultural industries on agriculture (Tisdell 1991).

Discussion

A variety of specializations now exist with respect to economics of natural resources and the environment. In part, these have arisen due to factors such as the declining role of agriculture in the economy, greater public interest in the environment, and greater public-sector efforts to conserve natural resources. As well, adherence of agricultural

economists to neoclassical economics has led to the need for a new generation of economists with greater focus on sustainability and equity issues.

Emergence of new specialty areas has implication for training of economists (Longworth 1992). Opportunities for training in these specialisations has been very limited. A clear understanding of the scope of each specialization, and the tolerance to accept some overlaps, will be necessary when designing courses. Ideally, co-operative teaching programs will develop, where expertise from various backgrounds can be pooled to best advantage.

There is also need for more co-operative efforts in research activities. There has been an increasingly integrated approach by government to management of resources. Programs in community land care, and more recently integrated catchment management, have brought into closer co-operation the activities of various government departments, business houses and community organizations. This has led to the need for economic analysis which integrates concepts from various specialty areas.

The changes which are taking place do not necessarily present insurmountable problems for agricultural economists, many of whom have substantial training in natural science and ecology and possess a high degree of adaptability. This has been demonstrated by the wide interest in agricultural systems research and bioeconomic modelling, and by extensive joint research with agricultural scientists. On the other hand, there is a tendency for the Australian Agricultural Economics Society (AAES) to view its role as part of the agricultural science profession (Sturgess, 1992).

In Australia, there is a lack of a natural resource society, and the AAES is the default body for specialists working in this area. There are limited publication outlets for papers on resource and environmental economics, and it is to be hoped that the agricultural economics profession will accommodate these areas of research interest.

Within the umbrella grouping of resource and environmental economics (REE) there is disagreement as to whether environmental economics is a subset of environmental economics or the converse, or whether these are parallel specialisations. The view espoused here is that environmental economics is the broader field, in terms of concern for both inputs and outputs of production, rural and urban environments, and global as well as national issues. Ecological economics or bioeconomics is viewed as a subset of natural and environmental economics dealing with living resources.

It could be argued that resource and environmental economics is a fashion which has found its time, but that time has now passed. During times of high unemployment, priorities are likely to shift to job creation and economic growth, and trade opportunities and reforms. There are signs of a decline in the green movement, the influence of green political parties in Germany and Tasmania having collapsed. The Industries Commission now appears to have shifted emphasis from natural resource management to value-adding activities and impediments to international trade. The Resource Assessment Commission has been put in moth-balls. The ESD working group process became politicised and the recommendations of the working group do not appear to have had effective political follow-up, as predicted by Tisdell (1993b).

No doubt, community concern for air and water quality, food health, biodiversity, land degradation, amenity values, and animal welfare will continue. Further development of economic methodology to address these issues is required. However, at the national and state level, public institutions (such as environment departments and environmental protection agencies) and procedures (e.g. mandatory environmental impact assessment) have now been put in place to ensure adequate attention is paid to issues of resource depletion and environmental degradation. As well, international agencies such as GATT, OECD and the World Bank have adopted routine environmental safeguard procedures. As a

result, it can be expected that in the future training and employment in resource and environmental economics will be less of a novelty and more of an established field.

References

ABARE (AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS), 1990, *Mining and the Environment: Resource Use in the Kadadu Conservation Zone*, submission to the Resource Assessment Commission, AGPS, Canberra.

ABS (AUSTRALIAN BUREAU OF STATISTICS), 1989, *National Accounts*, March quarter, AGPS, Canberra.

ABS (AUSTRALIAN BUREAU OF STATISTICS) 1992, *Striking a Balance! Australia's Development and Conservation*, ABS Cat. No. 1314.0, AGPS, Canberra.

ANDERSON, T.L. (1982), "The new resource economics: old ideas and new applications", *American Journal of Agricultural Economics* 64, 928-934.

BARBIER, E.B. (1987), "The Concept of Sustainable Development", *Environmental Conservation* 14(2), 101-110.

BARBIER, E.B. (1989), *Economics, Natural-Resource Scarcity and Development: Conventional and Alternative Views*, Earthscan Publications, London.

BARNETT, H.J. and MORSE, C. (1963), *Scarcity and Growth: The Economics of Natural Resource Availability*, Johns Hopkins University Press, Baltimore.

BEHAN, R.W. and WEDDLE, R.M., eds. (1971), *Ecology, Economics, Environment*, University of Montana, Missoula.

BENNETT, J.W. (1990), *Alternative Natural Resource Management Options for Fraser Island and the Great Sandy Region*, report prepared for the Commission of Inquiry into the Conservation, Management and Use of Fraser Island and the Great Sandy Region, Canberra.

BOEHM, P. and KNEESE, A.V. (1971), *The Economics of Environment: Papers from Four Nations*, Macmillan, London.

BROMLEY, D.W. (1982), "Land and water problems: an institutional perspective", *American Journal of Agricultural Economics* 64, 834-844.

BROMLEY, D.W. (1985), "Markets and externalities", in Bromley, D.W. ed., *Natural Resource Economics: Policy Problems and Contemporary Analysis*, Kluwer Nijhoff Publishing, Boston, pp. 37-68.

CAIRNCROSS, F. (1991), *Costing the Earth*, Business Books, London.

CARSON, R.L. (1963), *Silent Spring*, Hamilton, London.

CEPA (COMMONWEALTH ENVIRONMENT PROTECTION AGENCY) (1992), *Development of a National State of the Environment Reporting System*, Discussion Paper, Canberra.

CLARK, C.W. (1976), *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*, John Wiley, New York.

CLARK, C.W. (1989), "Bioeconomic modelling and resource management", in S.A. Levin, T.G. Hallam and L.J. Cross, eds, *Applied Mathematical Ecology*, Springer, New York, pp. 11-57.

CLARK, C.W. (1991), "Economic biases against sustainable development", in R. Costanza ed., *Ecological Economics*, Columbia University Press, New York.

COMMONER, B. (1971), *The Closing Circle: Man, Nature and Technology*, Knopf, New York.

COSTANZA, R. (1989), "What is ecological economics?", *Ecological Economics* 1(1), 1-7.

COSTANZA, R. ed. (1991), *Ecological Economics: The Science and Management of Sustainability*, Columbia Univ. Press, New York.

CROCKER, T.D. and ROGERS, A.J. (1971), *Environmental Economics*, Dryden Press, Hinsdale.

CUMMINGS, R.G. and PEARSE, S.R. (1985), "Comment 1", in Bromley, D.W. ed., *Natural Resource Economics: Policy Problems and Contemporary Analysis*, Klewer Nijhoff Publishing, Boston, pp. 21-28.

DALY, H., ed. (1980), *Economics, Ecology, Ethics: Essays towards a Steady State Economy*, Freeman, San Francisco.

DELBRIDGE, A, editor-in-chief, (1981), *The Macquarie Dictionary*, Macquarie Library, St. Leonards, N.S.W.

DENT, J.B. and ANDERSON, J.R. (1972), "Systems, management and agriculture", Chapter 1 of J.B. Dent and J.R. Anderson, eds, *Systems Analysis in Agricultural Management*, Wiley, New York.

DORFMAN, R. and DORFMAN, N. eds. (1972), *Economics of the Environment: Selected Readings*, Norton, New York.

EDEL, M. (1973), *Economics and the Environment*, Prentice-Hall, Englewood Cliffs.

EHRLICH, P.R. (1971), *The Population Bomb*, Ballantine Books, New York.

EHRLICH, P.R. (1989), "The limits to substitution: meta-resource depletion and a new economic-ecological paradigm", *Ecological Economics* 1(1), 9-16.

FREEMAN, A.M. (1971), *The Economics of Pollution Control and Environmental Quality*, General Learning Press, New York.

FREEMAN, A.M., HAVEMAN, R.H. and KNEESE, A.V. (1973), *The Economics of Environmental Policy*, Wiley, New York.

GARCIA, L.M.C. (1991), "Bioeconomics of Interdependent Fishery and Forestry Resources", Ph.D. dissertation, University of Minnesota.

GEORGESCU-ROEGEN, N. (1971), *The Entropy Law and the Economic Process*, Harvard University Press, Cambridge MA.

GOWDY, J.M. (1991), "Bioeconomics and post keynesian economics: a search for common ground", *Ecological Economics* 3, 77-87.

GREY, F. and MARLOW, J. (1991), "Yes Virginia, There is an Intertemporally Efficient Price for Natural Resource - Intergenerational Equity and Efficiency in the Real World", *Issues in the Pricing and Management of Natural Resources*, Economic Planning and Advisory Council, Background Paper No. 16, AGPS, Canberra, pp. 47-54.

HARLAN, J.K. (1976) "The plants and animals that nourish man", *Scientific American* 253 (3), 88-97.

HARRISON, S.R. and TISDELL, J.G. (1992), "Current applications of operations research in natural resource management", *OR Bulletin* 11 (4), 2-6.

HOWE, C.W. (1979), *Natural Resource Economics*, New York, Wiley.

HUNDLOE, T.J. et al. (1990), *Non-Extractive Natural Resource Uses in the Great Sandy Region*, Report for the Department of Environment and Heritage submission to the Commission of Inquiry into the Conservation, Management and Use of Fraser Island and the Great Sandy Region, Brisbane.

IMBER, D., STEVENSON, G and WILKS, L. (1991), *A Contingent Valuation Survey of the Kakadu Conservation Zone*, Resource Assessment Commission, Research Paper No. 3, Canberra.

IUCN (INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE), 1980, *World Conservation Strategy*, Gland, Switzerland.

JAMES, D.E. (1991), *Economics, Environment and Sustainable Development*, Resource Assessment Commission, Occasional Publication No. 1, AGPS, Canberra.

KNEESE, A.V., AYRES, R.U. and D'ARGE, R.C. (1970), *Economics and the Environment*, Johns Hopkins Press, Baltimore.

LECOMBER, R. (1979), *The Economics of Natural Resources*, Macmillan, London.

LONGWORTH, J.W. (1992), "Sustainability and agricultural education", *Review of Marketing and Agricultural Economics* 60 (1), 79-88.

MALER, K-G. (1974), *Environmental Economics: A Theoretical Inquiry*, Johns Hopkins University Press, Baltimore.

MANGAN, J. (1991), Consultancy Undertaken for the Government Statistician's Office for the Commission of Inquiry into the Conservation, Management and Use of Fraser Island and the Great Sandy Region (1991), *Final Discussion Paper*, Appendices Volume 1, pp. 211-246, Goprint, Brisbane.

MARSH, George P., (1865), *Man and Nature*, Charles Scribner, New York.

MARTINEZ-ALIER, J. and SCHLUPMANN, K. (1987), *Ecological Economics: Energy, Environment and Society*, Blackwell, Cambridge.

MEADOWS, D.H., MEADOWS, D.L., RANDERS, J. and BEHRENS, W. (1972), *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*, Universal Books, New York.

OLDFIELD, M.S. (1989), *The Value of Conserving Genetic Resources*, Sinauer Associates, Sunderland, Mass.

ONIONS, C.T., ed. (1973), *The Shorter Oxford English Dictionary*, 3rd edn., Clarendon Press, Oxford.

PEARCE, D.W. ed. (1975), *The Economics of Natural Resource Depletion*, Wiley, New York.

PEARCE, D.W. (1976), *Environmental Economics*, Longman, London.

PEARCE, D. (1993), *Ecological Economics and Sustainable Development: Essays in the Theory and Practice of Environmental Economics*, Edward Elgar, Aldershot.

PEARCE, D., BARBIER, E. and MARKANDYA, A. (1989), *Blueprint for a Green Economy*, Earthscan Publications, London.

PEARCE, D.W., BARBIER, E. and MARKANDYA, A. (1990), *Sustainable Development: Economics and Environment in the Third World*, Edward Elgar, Aldershot.

PEARCE, D.W. and TURNER, R.K. (1990), *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf, London.

PEET, J. (1992), *Energy and the Ecological Economics of Sustainability*, Island Press, Washington.

PERRINGS, A.C. (1987), *Economy and Environment: A Theoretical Essay on the Interdependence of Economic and Environmental Systems*, Cambridge University Press, Cambridge.

PEZZEY, J. (1989), "Economic analysis of sustainable growth and sustainable development", IBRD Department of Environment Working Paper No. 15, Washington DC.

PORRITT, J. and WINNER, D. (1988), *The Coming of the Greens*, Collins, Glasgow.

RAC (RESOURCE ASSESSMENT COMMISSION) 1992, *Multi-Criteria Analysis as a Resource Assessment Tool*, RAC Research Paper No. 6, Canberra.

RANDALL, A. (1987), *Resource Economics: An Economic Approach to Natural Resource and Environmental Policy*, 2nd edn., Wiley, New York.

REPETTO, R., MAGRATH, W., WELLS, M., BEER, C. and ROSSINI, F. (1989), *Wasting Assets: Natural Resources in the National Income Accounts*, World Resources Institute, Washington DC.

REYNOLDS, J.E., REDFERN, J.M. and SHULSTAD, R.N. eds. (1974), *Readings in Natural Resource Economics*, MSS Information Corp., New York.

ROLSTON, H. (1988) *Environmental Ethics*, Temple University Press, Philadelphia.

ROMERO, C. and REHMAN, T. (1987), "Natural resource management and the use of multiple criteria decision-making techniques: a Review", *European Review of Agricultural Economics* 14(1), 61-89.

ROSE, R. (1992), "Economic aspects of conserving biological diversity", *Agriculture and Resources Quarterly* 4(3), 378-388.

SENECA, J.J. and TAUSSIG, M.K. (1974), *Environmental Economics*, Prentice-Hall, Englewood Cliffs.

STURGESS, N. (1992), "President's column", *AAES News* 4(4), 1.

THOMPSON, D.N. (1973), *The Economics of Environmental Protection*, Winthrop, Cambridge, Mass.

TIETENBERG, T.H. (1992), *Environmental and Natural Resource Economics*, 3rd edn, Harper Collins, New York.

TISDELL, C.A. (1990a), *Ecological Economics and the Environmental Future*, Discussion Paper in Economics No. 28, University of Queensland, St Lucia.

TISDELL, C.A. (1990b), *Ecological or Green Economics: Genuine Contribution or Fashionable Fad*, Discussion Paper in Economics No. 47, University of Queensland, St Lucia.

TISDELL, C.A. (1991), *Economics of Environmental Conservation*, Elsevier Science Publishers, Amsterdam.

TISDELL, C.A. (1993a), *Environmental Economics and Sustainability*, Edward Elgar, Aldershot, UK.

TISDELL, C.A. (1993b), "Ecologically sustainable development (esd) and industry: policies, economic attitudes and australian proposals", Discussion Paper in Economics No. 109, University of Queensland, St Lucia.

TOFFLER, A. (1971), *Future Shock*, Pan, London.

WCED (WORLD COMMISSION FOR ENVIRONMENT AND DEVELOPMENT), 1987, *Our Common Future*, Oxford University Press, Oxford.