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ECONOMIC ASPECTS OF LAND DEGRADATION IN AUSTRALIA

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In this article an overview of several economic aspects of land degradation in Australia is presented. The economic rationale for government intervention in land management decisions relating to degradation is explored. Some potential sources of inefficient private land use decisions are identified. However, there are significant difficulties in designing policies which will result in resource allocation decisions superior to market outcomes.

Land degradation and its implications for agricultural production have long been a concern for the rural sector and the Australian community generally (for example, Balderstone, Duthie, Jarrett, Eckersley and McColl 1982, p. 135). In addition, there has been increasing competition for the use of land in recent years. The land based expansion of Australian agriculture has slowed in the past decade, with growth in agricultural production coming increasingly from more intensive use of already developed land resources. Furthermore, it is generally recognised that demand for agricultural land for non-agricultural uses and for the protection of various attributes which land embodies, such as its scenic, spatial and environmental aspects, has increased. These trends in land use have aroused much public discussion on the quality of land resources in agriculture and the impacts of land degradation on agricultural production and environmental quality.

A feature of this public debate has been its domination by technical considerations which concentrate on the desirability and means of minimising land degradation. It is often merely asserted that land degradation is a significant social problem requiring substantial corrective government intervention. Associated policy recommendations frequently include government subsidy or detailed regulation of land use activities. However, in much of this public discussion about land degradation, very little attention is given to economic aspects of land degradation. Major issues, which are often not addressed, include whether or not it is economically desirable to repair areas identified as degraded and, if so, to what extent government involvement is warranted.

An economic perspective of land degradation is developed in this paper. Whereas many commentators assume the existence of a serious social problem relating to land degradation and consequently concentrate on seeking cures to this perceived problem, the approach here is to return to economic first principles in order to investigate the economic problems relating to land degradation and their causes. The objective of this paper is to review the circumstances under which a *prima facie* case for government action on land degradation may exist and the relative effectiveness of various policy approaches.

A brief description and discussion of the physical nature and extent of land degradation in Australia is contained in the following section.

Next, the basic economic approach to the issue of land degradation is outlined. Emphasis is placed on the need to manage the community's resources optimally over time, and several misconceptions frequently arising in public debate about land degradation are addressed. The basis for government intervention in land degradation is then examined in a section which includes an investigation of the sources of distortion to private land management decisions and the external effects of those decisions. Various public policy issues, including the likely effectiveness of alternative policy instruments, are next considered. Finally, the main conclusions are summarised.

Nature and Extent of Land Degradation in Australia

Land degradation is the process whereby land deteriorates through a reduction in soil depth or quality as a result of the actions of water, wind, gravity and temperature (see Woods 1983). Land degradation may be reflected in reduced productivity in current or future periods through its impact on the quality and quantity of vegetation which the land supports.

In the absence of human activity, the natural rate of land degradation in Australia is, by world standards, generally low (Olive 1983). In contrast, however, the potential for accelerated degradation is high, reflecting the highly erodible nature of most Australian soils. As a result of the modification of the natural environment for agricultural, pastoral and other purposes, rates of land degradation frequently differ from those occurring naturally in the absence of human activity. Activities such as clearing, grazing and cropping, together with their associated land management practices, can transform the natural landscape so as to increase the exposure of the soil to degradation. However, this is not always the case; some management practices, in fact, decrease rates of land degradation.

The extent of degradation in Australia is most often discussed using either one or both of two measures, namely the area of degraded land and the costs of treating that area. The most widely referenced data are those reported in the Commonwealth and State Government Collaborative Soil Conservation Study (1978). This study indicated that in 1975 over 50 per cent of the total land area in use in Australia required treatment in order to prevent further reduction in productivity due to land degradation, either with changed management practices alone or with structural works, and that the required capital cost of the latter was \$675m (approximately \$1800m in 1986 dollars).

However, it is doubtful if these widely quoted data are particularly useful. The data may be questioned on grounds of accuracy as they are essentially the sum of subjective evaluations of the status of land resources compiled in each state by district soil conservation officers using various criteria; it was not possible to ensure overall consistency. Thus, while it cannot be denied that land degradation exists in Australia, there is uncertainty as to the true extent of its physical dimensions, including rates of change, the proportions of land requiring treatment with works and with management practices only, and the distribution of degraded land between the agricultural production zones. However, even more important than the obvious lack of precision is, as discussed in the following section, the lack of relevance of this type of data for economic policy analysis.

An Economic Approach to Land Degradation

The fundamental economic problem is how to maximise the welfare of society subject to the constraints imposed by technological conditions and limited resource endowments. Land is one such resource. To the economist, land is an input in the production process and, as with other inputs such as labour and capital, it is desirable that it be allocated to its highest value uses.

The fundamental economic problem relating to natural resources is one of optimal management of each resource over time. Economic analysis provides insights into the likely requirements for optimal resource management (see, for example, Peterson and Fisher's 1977 survey on the economic exploitation of extractive resources, and Castle, Kelso, Stevens and Stoevener 1981 for discussion of many issues relevant to natural resource economics). The underlying economic notion is that resources should be used in such a way as to maximise the net present value of an activity. An important principle is that decisions on the current use of a resource should take into account its effect on the value of its future use — the so-called shadow price of the current use. In the context of land degradation this principle implies, for example, that a person whose present use of land lowers its future productivity, and hence the value of its future use, should take that decline in value into account as a cost when deciding on present land use. This is another way of saying that the user should aim to maximise the net present value of an activity rather than current profits alone.

An economic approach to the use of resources thus suggests that there should be an optimal time pattern of land use and a corresponding optimal rate of land degradation. This rate will depend on the parameters of the fundamental economic problem, which will include present and future input and output prices, consumer tastes, rates of time preference and technological conditions. The optimal rate of land degradation may be either positive or negative, greater or less than the natural rate of land degradation, and will vary over space and time, particularly in response to changing economic and technological circumstances.

Several implications follow from an appreciation of the economic approach to the land use problem and from the concept of an optimal rate of land degradation.

First, many popular policy proposals are based solely on physical aspects of the resource under consideration and possess little economic merit. For example, conservation can be defined as a redistribution of existing resource use patterns from the present to the future. Thus defined, it is not, in itself, a desirable objective of government policy. Under an economic approach to any issue, maximisation of social welfare is seen as the overriding policy objective. Thus, conservation can be regarded as a means for achieving the optimal rate of land degradation only when current rates of land degradation exceed the optimum. Similarly, preservation (that is, the maintenance of existing resource stocks or quality) is not necessarily consistent with the maximisation of community welfare and hence with economic resource usage. It can be noted also that the often-recommended criterion of maximum sustainable yield (defined by Peterson and Fisher 1977, p. 682 as the maximum rate of exploitation of a renewable resource that can be sustained indefinitely) is also a purely physical one and has little direct relationship with an economic approach to resource use. In particular, it takes no account of the costs and benefits of land use activities. Hence, land and other resource usage designed to maintain maximum sustainable yield have no guarantee of being consistent with society's optimal use of its resources.

Second, as indicated above, optimal economic use of land resources over time might require positive rates of land degradation. The physical existence of continuing land degradation does not, in itself, prove the existence of an economic problem. A problem exists from the social viewpoint only if the *actual* rate of degradation differs from the *optimal* rate. In fact, optimal resource use might involve substantial degradation of particular land areas at particular times: this may be the case if a presently profitable land use activity is expected to become of little value in the future (for example, through adverse product and input price movements and/or technological change) and if the land area is expected to have little value in alternative uses.

Third, the existence of degraded land resulting from land use practices in the past does not demonstrate either a past or current economic problem. Past land use practices and their resulting land degradation may well have been consistent with optimal community use of the resource given the economic and technical circumstances and expectations of that time. However, even if existing degraded land were the result of suboptimal resource use in the past, it does not immediately follow that the community would be better off if actions were taken now to repair this degradation. Previous degradation should be considered a sunk cost from the community's viewpoint because only present and future costs and benefits are important in determining the actions to be taken. Repair works or policies need to be appraised on a case by case basis separately from past practices, and should be undertaken only after assessment of their future discounted costs and benefits. There would probably be little economic merit in attempting to repair all previously degraded land. The basic point to be made here is that the physical presence of land degradation does not necessarily represent an economic problem. Hence the often-quoted measures of the extent of land degradation, in particular the total cost of treating all degraded land, are not directly relevant for policy decisions aimed at maximising community welfare.

Finally, a lack of private incentives to undertake further conservation activities does not prove the existence of an economic problem with respect to land degradation, nor is it necessarily an indication of optimal allocation of resources (Bromley 1982). For example, in the absence of externalities and other distortions, if land resources are presently being utilised in an economically optimal fashion, private decision makers do not have any incentive to conserve resources further, nor would it be desirable from the community's viewpoint for them to so do.

In Australian agriculture, most land management decisions are the responsibility of private individuals. A decision by an individual land user to undertake a particular activity is influenced by, among other things, the nature of the physical environment, the current and projected economic situation, technological conditions and the nature of government policies affecting land use. Rural producers thus respond to economic signals (prices of commodities and costs of inputs) within the existing legal, institutional and policy framework. However, the possibility arises that, in some circumstances, individual decisions regarding resource use may result in an inefficient allocation of community resources. In circumstances of market failure (Bator 1958), there may be scope for government intervention to correct distortions and to promote a more efficient allocation of land resources.

There are two necessary conditions for an economic justification of government intervention in land management decisions in the context of land degradation (Kirby and Blyth 1987). First, it must be demonstrated that market failure exists, resulting in economically excessive rates of land degradation and providing the potential to increase the efficiency of the use of the community's land resources. Second, the benefits from any proposed market correction measure must be demonstrated to exceed its costs and the net benefits of this intervention must exceed the net benefits of alternative uses of the same resources. Thus, the existence of market failure is a necessary, but not sufficient, condition and provides only a *prima facie* case for intervention. A thorough analysis of land degradation policy involves consideration of both market failure and the costs and benefits of government intervention (Randall 1972; Bromley 1982).

Possible Sources of Excessive Rates of Land Degradation

Irrationality

It is sometimes argued that private decisions are often irrational, that is, that individuals are not able or willing to pursue their own self-interest. An implication of this view is that decentralised decision making will not then be in the best interests of the individual, let alone the community at large.

While it is readily accepted that individuals will sometimes make incorrect decisions (just as will governments or bureaucrats when they allocate resources), the notion of pervasive irrationality of individuals is generally rejected in economic analysis. What may at first sight appear irrational behaviour can often prove rational on closer examination. For example, a shortened planning horizon, which results in soil conservation projects which could be profitable investment opportunities in the longer run not being undertaken, might be a farmer's response to underlying influences such as lack of specific information, land tenure conditions or inheritance laws.

Informational deficiencies

Lack of knowledge. New knowledge, though it may have value to individuals and the community, is not costless to produce nor to disseminate. Private markets may generate insufficient information because of underinvestment in research projects, largely reflecting the public good attributes of knowledge (Tisdell 1972, p. 368; Newbery and Stiglitz 1981, pp. 144–8).

It is generally accepted that these issues are relevant to the rural sector (for example, Johnston and Girdlestone 1983; Samuel, Kingma and Crellin 1983), and to the question of land degradation in particular. Soil resources are a complex input into the agricultural production process and it is often difficult to understand fully the linkages between land use activities, especially if some effects become evident only after a long time lag or if there are threshold levels at which their impact changes abruptly. The benefits from research into land degradation are often embodied in production techniques and practices, and methods of land management rather than in particular products. This makes it difficult for private researchers to capture the full return on their investment by way of patents or product differentiation. Also, the rural sector is characterised by the existence of many small farms, and it often will not pay individual farmers to conduct their own research into land degradation problems, whereas such research may be beneficial from society's viewpoint. A case may therefore exist for government intervention aimed at encouraging research into the causes, effects and treatment of land degradation in Australia.

Similarly, it can be argued (for example, Samuel, Kingma and Crellin 1983, p. 9) that a public role in extension and education is necessary in order to ensure the efficient dissemination of research discoveries relating to land degradation, that is, to ensure that such knowledge is made available to those valuing it at a price reflecting the marginal cost of its dissemination.

Lack of knowledge has almost certainly played an important role in the development of land degradation in Australia. The general lack of understanding of the climate and soils, and the persistence with European methods resulted in considerable land degradation in many parts of the country during the period of early settlement (see Olive 1983; Woods 1983). However, the processes of trial and error which characterised this early period of Australian agriculture, together with the substantial government involvement in research and extension in this area since then, have led to greatly increased knowledge of management practices and of the effect of land degradation on the farm enterprise. The limitations and fragility of land and the causes and treatments of land degradation are better appreciated now than in the past (for example, Williams 1976; Condon 1982; Newman and Cameron 1982; Woods 1983). Thus it may be claimed that some of the major information gaps of the past have now been closed (for example, Dumsday 1982).

Uncertainty and irreversibility. Another aspect of the information issue is the question of uncertainty as to future technological advances, resource discoveries and availability, consumer tastes and preferences, and product and input prices. Thus private decision makers are likely to be uncertain about the future costs and benefits of their actions, with the result that they, and society at large, may later come to regret their decisions.

Uncertainty is of most concern in the context of irreversible decisions, where a chosen course of action forever eliminates some future alternative. Significant policy implications may arise when such actions restrict the range of choice available to society in the future. In particular, in the presence of uncertainty about the future, there may be value to society in the retention of options which might otherwise be foreclosed — the so-called option value.

There has been extensive debate in the economic literature as to the existence, exact nature and significance of this option value effect. In a seminal article, Weisbrod (1964) argues that when a consumer is uncertain about future demand for a good, the consumer would be willing to pay an amount in addition to the usual measure of consumer surplus for the option to purchase the particular good at a pre-specified price. He argues that the option to consume in the future is essentially a public good, being a costless by-product of continued production. It is often difficult to exclude consumers, especially those who eventually choose not to demand the good, from enjoying the benefit of the option. This should be taken into account in order to make efficient decisions regarding continuation of future production of the good.

This option value was originally thought to be positive (Krutilla 1967; Cicchetti and Freeman 1971; Fisher and Krutilla 1974). However, Schmalensee (1972) and Henry (1974*a*) both argue that, in general, the option value can take on any value — positive, negative or zero. Within the essentially timeless world of Cicchetti and Freeman (1971), all decisions must be considered equally irreversible, and hence subject to risk and an associated option value. There is no *a priori* way of predicting whether the option value relating to a particular decision is positive or negative (it depends on the details of individual preferences and circumstances), nor does it appear likely that sufficient information is available to estimate its magnitude easily and accurately. Thus Weisbrod's original concept of option value does not appear, on balance, to provide much fruitful guidance for efficient decision making.

Henry (1974*a*,*b*) and Arrow and Fisher (1974) consider time explicitly in the form of sequential decision making in the context of irreversibility by investigating the implications of gaining extra information with the passage of time in a world of uncertainty. They find that a failure to take this information process into account results in a bias toward irreversible decisions. Thus there is a gain or quasi-option value from postponing irreversible decisions to allow information to increase.

Though the analysis of quasi-option value can provide important guidance to public decision makers who are interested in efficient resource allocation, it would not by itself appear to provide sufficient justification for government intervention in resource management decisions by individuals. The benefits of the quasi-option value can be appropriated by resource owners, and therefore could be expected to be taken into account by private decision makers interested in maximising the value of use of resources over the planning period. In making any decision, individuals must also decide how much information they will seek relating to the primary problem.

The issue of irreversibility arises frequently in the context of land management and degradation, although claims of irreversible consequences of particular land uses are sometimes exaggerated. Even seemingly devastated areas can be and have been reclaimed. For example, Australia's 'dust bowl' areas of the 1930s have had much of their potential productivity restored (Condon 1982).

The choice of land use between various alternatives (for example, agriculture or wilderness, grazing or cropping) is not directly related to land degradation *per se*, unless one imposes some hierarchy of desirable and undesirable land uses. (Such a ranking would appear to have little objective economic basis, although it would seem to underlie some policy proposals relating to land management, such as prime agricultural land retention schemes.) However, such land use decisions sometimes do involve irreversible changes and may entail risks and hence option values. If the passage of time is likely to provide more information relevant to the decision, the quasi-option value should also be considered. In the case of land clearing, a farmer may not take this value fully into account. However, any market failure problem in individual land use decisions is likely to arise not so much from quasi-option value aspects but, more fundamentally, from an inability to capture the benefits of non-agricultural alternative land uses.

The choice of land management practices and their impact on land productivity, for example, the effect of cultivation methods on soil depth, nutrient levels and the extent of gullying, are more directly related to land degradation issues than is that of land use itself. Here the costs and benefits of individual decisions are borne by the decision maker. In particular, any benefits from additional information gained from postponing irreversible actions (such as cultivation methods resulting in extensive gullying) are captured by the farmer and could be expected to be taken into account in the decision making process.

Institutional and policy environment

The policy and institutional environment within which private agricultural decisions are formulated can have implications for land degradation which are either ignored or unanticipated. The main areas of potential influence are the existing system of property rights (see Castle et al. 1981; Bromley 1982), including land tenure arrangements, and the pricing of farm inputs and outputs (see Blyth and Kirby 1985 for a detailed assessment of these effects).

Land tenure. Two broad types of tenure dominate agricultural land in Australia. Some land is alienated or held in 'fee simple' as freehold. Other land is operated by leasehold, ultimate ownership resting with the state. An outstanding feature of Australian agriculture and land administration is the dominance of leasehold tenure. In contrast to many overseas countries, only about 13 per cent of land in Australia is alienated (Campbell 1982); the percentage is far less in arid areas. The use of leased land is frequently restricted by many covenants or conditions relating to, for example, term of lease, farm size, lease disposal and property development.

It is apparent that land use administration has been directed to welfare, wealth distribution and political objectives, rather than to the efficient use of the community's land resources (see Campbell 1967, 1982; Heathcote 1969). There are grounds to support the view that the leasehold tenure system which dominates Australian agriculture can be inimical to the efficient use of the community's land resources. Features of the present system, such as uncertainty of tenure renewal and prior notice of lease termination, in conjunction with a lack of full compensation, and restrictions on the disposal and holding of land, can create incentives for land users to follow practices which accelerate land degradation (see Young 1981, 1983; Blyth and Kirby 1985).

Distorted market prices. If resources are to be allocated optimally within society, the market must relay accurately to land users the true economic value of those resources. However, market prices are sometimes distorted so as to encourage land management decisions which, while rational and profitable to the individual land user, may be inefficient from society's viewpoint. In many cases distorted price signals can have adverse impacts on decisions about the use of land resources and rates of land degradation.

An important source of price distortion, and hence resource misallocation, is government intervention in the marketplace. The government may intervene to affect prices of inputs and outputs with measures such as input subsidies and commodity price supports. While such policies may or may not achieve their stated primary objectives, many have an impact on resource allocation by way of secondary consequences that may have been ignored or unanticipated by policy makers. The effects of such policy measures on land degradation need to be considered.

One effect of a subsidy on any particular farm input is to increase the use of that input to a level beyond that in the absence of the subsidy. By changing the relative prices of inputs, the most profitable input mix is changed, the subsidised input being substituted for more expensive inputs so as to produce either greater quantities of output at the same level of costs or the same level of output at a lower cost. The resultant changes can have implications for land degradation, as illustrated in the following examples.

The impact of fertiliser subsidies on land degradation has been the subject of much debate. It can be argued that a fertiliser subsidy encourages the use of fertiliser at the expense of alternative management and production methods which may be more consistent with lower rates of land degradation (Costin and Coombs 1982, p. 430). Furthermore, run-off from fertilised land, which is likely to contain a greater concentration of chemicals, may lead to deterioration in water supply quality. On the other hand, the fertility of vast areas of poor soil has been improved and vegetative cover increased by the use of fertilised leguminous pastures (Donald 1964). Overall, the magnitude of these effects depends on the price elasticity of demand for fertiliser and the size of the subsidy in relation to the price. As the latter has declined significantly in recent years, and estimates of the elasticity are relatively low (Rose, Moir, Farquharson and Vanzetti 1984), the effects of fertiliser subsidies on land degradation and water quality are currently likely to be small.

Water pricing has been used extensively as a means of providing assistance to Australian agriculture and to encourage land settlement and regional development. It is widely recognised that water for irrigation is underpriced in the rural sector (see, for example, Watson, Reynolds, Collins and Hunter 1983). As a consequence, the use of water for irrigation is greater than it would be if it were priced according to its economic cost. One effect of this more intensive use of land and water is increased salinity problems resulting from disturbance of the natural hydrological system (Balderstone et al. 1982, p. 140; Woods 1983, p. 92). While water remains relatively inexpensive, irrigators have little economic incentive to reduce its use. Appropriate water pricing and water allocation policies are seen as the most important instruments for encouraging more efficient use of water (Department of Resources and Energy 1983) and, indirectly, for reducing rates of land degradation.

Until August 1983, farmers were allowed, under section 75A of the Income Tax Assessment Act 1936 (Cth), special deductions of 10 equal instalments over 10 years for land clearing and preparation. Prior to 1973, they were allowed to deduct from gross income the full cost of land clearing in the year in which it was incurred. This concession is likely to have had implications for rates of land degradation, as the removal of vegetation is recognised as a prime factor in land degradation on all types of land (Woods 1983, Ch. 5). First, it may become profitable to undertake greater clearing in existing agricultural areas and to expand cropping onto marginal land, at times increasing the risk of erosion. Second, land clearing may be associated with problems of secondary, or dryland, salinity, which occurs when a vegetative cover of large trees and deep rooted shrubs is replaced by introduced pastures and crops, and when management practices such as fallowing, which reduce water uptake, are introduced (Cary, Ferguson and Berlin 1982). Hodge (1982) argues that reliance on private market decisions alone is likely to lead to the extent of clearing exceeding the socially optimal level. Concessions which create incentives to clear land, such as the section 75A tax concessions prior to August 1983, only exacerbate this problem.

Off-site effects of land management decisions

A classic case of potential market failure, whereby individual decision making results in an inefficient use of society's resources, occurs when there are off-site or external consequences of some action or decision. An economic problem may exist when the externality is Pareto relevant; that is, when it is possible to modify the action so that some members of the community can be made better off without others being made worse off.

There are many examples of land use decisions and land degradation which may result in external effects. First, some of the lost, eroded soil may be washed into watercourses, reducing water quality for downstream users and causing sedimentation in water storages. Second, eroded soil may be deposited on roads, causing damage or requiring clearing for safe use. Third, some land use practices may create 'dust bowls' which, if subjected to wind erosion, may result in nuisance, inconvenience and concern to communities. Fourth, the clearing of native trees and irrigation practices may result in a rising water table and increased salinity in nearby land. Finally, excessive rates of land degradation may also result from externalities from the decisions of people other than the land owner. For example, road construction authorities and other public authorities working on or adjacent to a farmer's property can sometimes cause land degradation by their choice of location and construction techniques.

In these and other cases, a problem can arise because decision makers fail to consider all the costs and benefits of their actions. They are likely to be primarily concerned with the costs borne and benefits reaped by themselves. Because the effects of their decisions are not fully internalised, there may be a divergence between private and social costs and benefits. The existence of such externalities is likely to be an important source of market failure, and a cause of excessive rates of land degradation.

It is useful to distinguish two broad cases. The first may be termed the 'small number' case, where the external effects have an impact on only a few individuals. In an extreme case an immediate neighbour might be the only externally affected party. For example, soil erosion on one property might result in siltation of a neighbour's dam or damage to a road following a boundary fence line. Such cases usually provide little cause for government concern. An economically efficient solution to such problems can often be achieved by way of private negotiation; the small number involved makes it easy to identify the affected parties, and the transaction costs of bringing them together to reach voluntary, mutually agreed arrangements are relatively low. In practice the negotiated (either explicit or implicit) solution may often be on a *quid pro quo* basis. Another characteristic of the small number case is that the property rights are generally clearly defined, providing a legal basis for settlement. A possible exception is when one of the parties is a public authority, such as a road construction or electricity authority. The very nature of such bureaucracies appears ill adapted to simple negotiated arrangements.

Externalities which originate from or affect a large number of parties present a much more difficult economic problem. For example, land clearing by particular farms in a catchment area may lead to increased soil loss, thereby silting a town water supply system and imposing costs of lower water quality and decreased storage capacity on a large number of users. In such cases, voluntary solutions are unlikely to occur because of the high transaction costs involved in identifying, contacting and negotiating with all the affected parties. In addition, when the benefits of actions which reduce the external effects of land degradation are non-excludable, the 'large number' case offers greater scope for free-riding behaviour. Difficulties are further exacerbated by the geographically diffuse nature of much land degradation. For instance, it is very difficult to measure accurately the soil loss from an individual property and hence to identify the exact source of any observed siltation. Similarly, it is often impossible to apportion the damage of a salt-affected area to individual properties.

The large number case is essentially defined by the feasibility of a negotiated settlement. When numbers are so large that private negotiation is unlikely there may be a need, in the interests of an efficient allocation of resources, for government intervention by way of fiscal and/or regulatory powers. Whether or not a policy initiative is economically justified depends, of course, on an assessment of the costs and benefits of intervention.

The use of private discount rates

When making investment or land management decisions which have effects in the future, the costs and benefits over time of the alternatives under consideration must be expressed on a common basis. The commonly recommended procedure is to convert the future stream of expected net benefits to its discounted present value (Abelson 1979). In this procedure the discount rate plays two roles. It reflects, first, the opportunity cost of financing the action decided. Second, it reflects the rate of time preference and thus enables intertemporal aggregation of expected net benefits. The net present value, and hence the economic assessment, of an investment or management decision is sensitive to the particular discount rate used. Higher discount rates give relatively greater weight to costs and benefits occurring in the near future and would, other things being equal, increase the likelihood of judging as unprofitable an investment or land management practice tending to redistribute net returns to the more distant future, such as many structural works or agricultural practices designed to lessen the rate of land degradation. The choice of discount rate thus plays a crucial role in investment project appraisal and private decision making, both generally and with respect to land degradation.

The question then arises as to whether or not the rates of discount used in making decisions accurately reflect society's valuation of future costs and benefits. Some would argue that they do not and, in particular, that private rates are too high. If this were true, there would be a persistent tendency for private land management decisions to result in rates of land degradation in excess of those preferred by society.

The view that the social rate of discount is lower than private rates is based on two main arguments. The first is essentially an equity or welfare argument concerning the distribution of resources and incomes among different generations; the second concerns an intergenerational form of market failure due to free riding.

In the equity argument, it is asserted that the present generation has insufficient concern for its own future and for that of future generations (see Pigou 1932). Similarly, attempts are sometimes made to stigmatise individuals' preferences for their own consumption over that of future generations as 'socially irrational' (see Marglin 1963, p. 96). Another variant of this equity argument is the assertion that it is 'unjust' that unborn generations are unable to participate in the decision making processes, both economic and political, of the present generation (Neher 1976).

One implication of this equity argument is that, in order to overcome the chronic problem of individual short-sightedness, society is in need of far-sighted bureaucrats and politicians able to redistribute resources in favour of future generations by using lower discount rates or by taking into account the expected preferences of future generations. According to the proponents of this view, existing members of society are 'guardians of future generations' (Scott 1978) and 'trustees of unborn generations' (Pigou 1932). It is also suggested that new constitutional rules or endorsements should be sought, such as Neher's 'quasi-golden rule' which states that the present generation should pass on to the next generation as much capital as is presently available. In the context of land degradation, Woods (1983, p. 4) notes the spread of the equivalent notion of 'stewardship', under which the 'land owner and society of today are beginning to be regarded as stewards of land with an obligation to consider the needs of future generations and to hand it on without loss of productivity or use potential'.

This intergenerational equity argument can be criticised in many ways. First, the alleged myopic lack of concern for the future of oneself and of future generations is only asserted to exist. In fact, it is clear that individuals are influenced by considerations of their likely future circumstances (an observation consistent with the earlier rejection of the notion of pervasive irrationality). In addition, mechanisms such as bequests exist and are used to express concern for future generations. Furthermore, private market processes enable and encourage the taking of decisions having effects after one's life span, for example, exchange of title to assets before death.

Second, no guidance is provided as to the extent of the alleged divergence between social and private discount rates. Hence any policy action based on this equity argument may be little more than arbitrary tinkering with the discount rate (Fisher and Krutilla 1975). Furthermore, who is to decide the preferences of future generations?

Third, the concern which the present generation feels for its own and others' future is reflected in its attitudes, decisions and actions. Though education and the dissemination of ideas may help to fill information gaps and thus influence these attitudes, it can be argued that government intervention or coercion, which rejects the existing attitudes of members of its society in order to provide increased resources for future generations, is undemocratic, unnecessarily authoritarian and essentially arbitrary, regardless of how benevolent and sincere the intention (Marglin 1963; Walsh and Brennan 1978).

Related to this point is another: the intergenerational equity argument offers no clear explanation of the mechanism by which bureaucrats and politicians overcome the myopia which plagues the remaining members of the present generation. In contrast to this public spirited ideal, Niskanen (1971) argues that bureaucrats may, in fact, enjoy a direct private benefit in using lower discount rates to create a larger sphere of influence for themselves.

Finally, it can be noted that the concern shown in this equity argument for the plight of future generations seems to be based on a Malthusian notion of resource depletion and a consequent inability of future generations to provide adequately for themselves. However, much of the available evidence suggests that, though some resource stocks may be diminishing in a physical sense, technological advances, economies of scale, and product and input substitution have offset this decline so that society is in little danger of a sudden loss in welfare from this source (Krutilla 1967; Peterson and Fisher 1977). In fact, living standards have been rising over time. Thus, as Tullock (1964) and Scott (1978) note, policies designed to decrease present consumption and increase investment activity by lowering discount rates may involve a transfer of income essentially from relatively poor present generations to relatively rich future generations.

The second main argument used to support the use of 'social discount rates' is one of intergenerational market failure developed by Marglin

(1963) and Sen (1967). In contrast to the authoritarian approach of the previous argument, they accept as given the degree of concern that members of present generations feel for those of future ones and do not pass subjective judgments on the appropriateness of that concern. They argue, however, that, although individuals would prefer that everyone invests more for the benefit of future generations, free-riding behaviour results in underinvestment and in market rates of interest which are too high. Thus, in their analysis, the contribution to the future made by the current generation has public good characteristics. It may therefore be possible to use government coercion to meet the unsatisfied individual preferences, and so make members of the present generation better off, by undertaking more long-term investments than each individual finds desirable to make privately. One means of achieving this objective would be the use of lower discount rates when assessing public investments so as to increase the total level of savings in the community.

There are, however, several problems with this argument. First, the conditions on which the above analysis is based may not hold. For example, Sen (1967) assumes that a deceased's estate is shared equally among the succeeding generation. However, if there are no death duties, then the benefits of an individual's terminal savings may be captured by that individual. To the extent that bequests are capable of fully capturing the private benefits of saving for future generations the tendency of the individual to underinvest is reduced.

However, a problem might still arise with respect to the composition, as distinct from the level, of bequests. Krutilla and Fisher (1975, p. 62) note that bequests are applicable only to private property resources and goods. When there are public good aspects under consideration, for example the environmental amenity value of land resources, there may continue to be an inadequate legacy. However, if the issue of the optimal use of land resources is being considered, the basic problem is the public good aspect of land use, and this problem exists not only in relation to future generations but also in relation to present ones. In addition, Krutilla (1967) notes that lower discount rates are not an appropriate solution to this problem because they stimulate investment generally, often resulting in more rapid exploitation of the natural environment and elimination of its amenity value. Thus the initial static problem of neglecting amenity value or public good aspects may become dynamically compounded by discounting investment returns at a lower rate (Fisher and Krutilla 1975).

A second criticism of the Marglin–Sen intergenerational market failure argument is that, in the absence of empirical studies, it provides little guidance for policy makers and so is likely to involve arbitrary discount rate adjustments.

Third, even if the alleged market failure does exist and is somehow measured, a question remains as to whether governments can successfully correct the problem. Consider the case in which the government attempts to increase the level of investment in the community by lowering the discount rate applicable to public investment projects. Warr and Wright (1981) argue that private savings are displaced by increased public savings, because individuals make their private decisions after taking into account those of the public sector. This crowding-out effect may leave the level of total savings in the community unchanged and the government without control of the savings rate.

The overall conclusion from this discussion is that there do not appear to be strong economic grounds for deviating from the use of private rates of discount. Hence the use of market interest rates by farmers is unlikely to be a source of excessive rates of land degradation in the community (see also Castle et al. 1981; Quiggin 1986).

Some Broad Public Policy Considerations

In the previous section there are identified several potential sources of problems relating to private decisions about land use management, which may possibly leave scope for government intervention to increase efficiency gains for the community. From an economic perspective, the major potential problem areas in land management include informational deficiencies, the system of land tenure and property rights, distorted market signals reaching farmers, and the external effects of land use decisions. Policies which are commonly directed at lessening land degradation include land use regulations and public subsidies of soil conservation expenditures. However, there are significant difficulties with both approaches.

Land use regulations are sometimes imposed to control specific aspects of land use in an attempt to restrict soil loss to some minimum standard. Regulations for soil conservation may take many forms. For example, leasehold covenants may restrain stocking rates, cropping or the clearing of vegetation. Land clearing regulations have emerged as another common measure to stem the growth of land degradation as well as to protect some plant and animal species. Mandatory practices such as specific cultivation methods may also be enforced on land users.

If the aim is the efficient use of land resources and, in particular, optimal rates of land degradation, the informational demands of a regulatory approach are substantial. For example, in the case of fixing soil loss limits, both the marginal external damage costs and the marginal abatement costs of reducing rates of land degradation must be known. Thus, the regulatory authority needs a detailed knowledge of the entire range of measures and practices affecting rates of land degradation and their cost implications.

Where there are difficulties in obtaining this information, a frequent response is to set standards or mandatory practices in a largely arbitrary fashion. Since fixed standards do not reflect variations in conditions from farm to farm, or from time to time, the direct regulatory approach can often prove to be inflexible in the face of changing technologies and market circumstances, because it allows insufficient discretion in the choice of management practices. For example, it is questionable whether a system of mandatory practices would have been sufficiently flexible to permit, after the 1982–83 drought, the increased use of less conservation-oriented land preparation techniques in order to cope with the heavy crop stubble and weed growth associated with the unusually favourable seasonal conditions that then occurred. In addition, if property owners are currently meeting required standards, they have little incentive to make technical advances relating to the external effects of land degradation. Finally, the direct regulatory approach can often involve significant enforcement costs.

Direct regulations are likely to be most successful where the production system is simple and there are few production alternatives. Satisfaction of these conditions is rare throughout the Australian agricultural environment, and there may therefore be few areas where regulations can be effectively applied. In view of these factors, the smaller and more homogeneous the area over which the regulation is imposed, the greater is the likely effectiveness. In fact, Chisholm (1978) argues that direct regulations are usually preferable only when a single party is involved, and are not suited to the externality problems most often generated by land degradation. In cases where threshold effects are likely, he recommends transferable quotas, such as land clearing rights.

Input subsidies (such as direct subsidies on structural works, concessional credit programs offered by state soil conservation services, and tax concessions for certain capital expenditures relating to land degradation) are another popular form of intervention. However, there are several problems limiting the effectiveness of subsidies to reduce existing rates of land degradation.

First, land degradation is the result of many interacting management practices, and rarely is there a close correlation between one input and the degree of degradation. Thus, much information is needed by government authorities when there are several possible conservation measures and when it is difficult to calculate the least-cost subsidy arrangement. If only a subset of management inputs or practices is subsidised (as is often the case, for reasons of administrative ease), the production decisions of land users will be distorted and reflect a bias toward the particular subsidised inputs or practices. For example, the availability of concessions exclusively for structural works may lead to excessive investment in works relative to other management practices.

As Chisholm (1978) notes, subsidies provided for soil conservation efforts are most effective when dealing with simple farming systems in which there are few alternative outputs and production methods. In the more complicated systems typical in the Australian rural environment, the subsidy approach does not provide a clear incentive for land users to develop least-cost methods of reducing rates of land degradation unless it covers all factors and practices affecting land degradation.

A second problem with the use of subsidies is that they lower the private opportunity cost of land degradation by reducing the costs of repair. Hence, they provide incentives to adopt practices which are relatively more conducive to land degradation, thereby offsetting to some extent the direct effect of the subsidised activities in reducing degradation. For example, if, in response to a subsidy for contour bank construction, farmers find it profitable to increase stocking rates, the reduction in soil loss may be less than expected. Similarly, the existence of subsidies for soil conservation may cause the development of erosion-prone marginal land for agriculture, or its transformation from grazing to crop production, where in the absence of the subsidy the land would remain relatively undisturbed, with little threat of accelerated degradation from the extended grazing or cropping made profitable by the subsidy. In each of these examples, the subsidy encourages land management practices which carry the risk of increased rates of land degradation. Thus, while subsidies may increase expenditure on conservation measures, they may also increase the need for such expenditures (see Baumol and Oates 1975; Chisholm 1978).

A third problem with the subsidisation of particular inputs or techniques is the resultant reduction of incentives to develop and apply new conservation technologies. In addition, subsidies provide an incentive only when there exists some private benefit from the subsidised action. In cases where the proportion of private benefits to social benefits of an activity is relatively small (for example, tree planting to alleviate dryland salinity), large rates of subsidy, perhaps approaching 100 per cent of the cost, may be required.

In addition to the disadvantages listed above, there may be significant secondary costs associated with the provision of subsidies. For example, there may be efficiency costs from raising the additional taxation revenue used to pay subsidies designed to alleviate problems of land degradation. Such efficiency costs can be quite significant (Rose et al. 1984, p. 24; BAE 1985, p. 30).

Given the difficulties at times associated with regulations and subsidies to control rates of land degradation, increased consideration might be given to the use of penalty taxes on the activity generating externalities. These may offer several advantages. If the tax rate is set equal to the marginal external cost of land degradation, an efficient allocation of land resources is possible, as land users must then take into account the external costs of their actions. The tax instrument approach also minimises the informational demands on the regulatory authorities in the sense that, in order to implement it, information on marginal external damage alone is required. This is especially the case if the external damage function is linear, such as in silting from a catchment, when a per unit tax on net soil loss is appropriate. A third advantage is that, as farmers are free to choose their techniques in order to minimise costs of production, a given reduction in land degradation can be expected to be achieved at the least cost. In particular, the tax approach is consistent with 'intersource' efficiency, that is, it equalises the marginal cost of reduced land degradation across different land users. This is especially important when there is a wide variety of methods available to lessen land degradation, or when relative prices change so that the choice of the most economical abatement method also changes. A further related advantage is that the use of a penalty tax creates an ongoing incentive for technical progress to lessen the costs of production and of erosion abatement.

However, there are some practical difficulties in attempting to apply penalty taxes to land degradation. As land degradation is often diffuse in nature, it can be very difficult to measure directly and accurately the level of, say, soil loss. It can also be difficult to assign the damage to particular individuals. Thus the costs of monitoring and other administrative costs are often very high. However, where these costs are relatively low, the penalty tax approach may prove fruitful. Furthermore, over time, technical advances in monitoring and measurement may make direct taxes on the external effects of land degradation more feasible. In the meantime, however, these difficulties often lead to recommendations for the use of taxes on those production inputs closely related to land degradation and conservation activities.

The use of input taxes offers some advantages in relation to measurement and administrative feasibility. However, though it may be relatively easy to measure input usage, detailed technical knowledge of the production process (in particular, the linkage between input usage and land degradation) is required. This is additional to the knowledge required about the amount of land degradation causing external effects. In some cases, however, these technical relationships may be sufficiently clear. For instance, there may be a reasonably direct relationship between the use of fertiliser and water quality. Similarly, Dumsday (1982) suggests that there is a roughly linear relationship between water usage and the degree of land salinity. Thus, a tax on water usage would approximate a tax on salt emissions. In circumstances such as those where there is a reasonably clear and direct link between a particular production input or activity and land degradation, input taxes can form an efficient policy response.

When there is less than perfect information with which to set regulations or incentives, the best approach may be one that combines standards with incentives (Chisholm 1985). In the combined approach, a degradation standard is defined, such as a level of soil loss or salinity, and degradation rights are allocated. This could be based on a catchment, for example. At the same time a charges system is established whereby a charge or tax is levied on land users who degrade their land beyond the level of their right. Similarly, a subsidy or compensation payment is given to land users who abate soil loss or salinity to levels less than their degradation right. Use of the combined approach may reduce the risk of imposing on society the cost of an uninformed or incorrect estimation of control costs. Chisholm (1985) suggests that this approach is appropriate in situations where marginal damages vary and there is uncertainty about the costs of control.

Conclusions

Several economic issues relating to land degradation in Australia are analysed in this paper. The need for such an analysis is based on the perception that public discussion on this topic has been dominated by purely technical considerations with little regard to the economic aspects and implications. This point is illustrated by the amount of attention paid to measures of the physical extent of land degradation in Australia. Both the accuracy and relevance for government policy of these data can be questioned.

The fundamental principle underlying the economic approach adopted is that society's resources, including land, should be allocated in such a way as to maximise the community's economic welfare. Within such a framework, soil conservation and purely technical aims have no intrinsic merit in themselves, but rather need to be related to a more fundamental goal — the maximisation of community welfare. The use of such an economic framework also enables the correction of several popular misconceptions regarding land degradation.

In Australia, the majority of land management decisions are made by private decision makers. Such decisions are complex because of uncertainty about the future values of the wide range of parameters which affect the profitability of agriculture and because some decisions, once made, have irreversible consequences. It is an open question whether government intervention can solve all of the problems of resource misallocation leading to a rate of land degradation different from the optimal rate. Before an economic justification for government intervention in a private land management decision exists, two conditions must be fulfilled. First, a *prima facie* case of market failure must be established and, second, the benefits of the proposed government policy must be shown to exceed its costs. It has been illustrated in this paper that in some circumstances a *prima facie* case for government intervention does exist.

From a detailed analysis of the rationale for government intervention in relation to land degradation, there appear to be valid grounds for concern regarding the efficiency of private land use decisions in relation to some informational deficiencies, the system of land tenure, the distortion of market signals by some governmental policies, and off-site or external effects. However, two of the most popular perceived problems (namely that land users must make decisions with irreversible consequences without perfect knowledge and the use of market interest rates in performing project appraisals) are unlikely to provide strong economic grounds for government intervention.

It has also been shown that there are significant difficulties in designing policies which will result in resource allocation decisions superior to market outcomes. In particular, doubts exist as to the effectiveness of two of the most popular policy instruments, namely the provision of subsidies for soil conservation and direct land use regulations. Furthermore, analysis of the benefits and costs of government intervention will be complicated because of interactions between the effects of policies which are already in place and those designed to change the rate of land degradation. In addition, from society's point of view there are indirect costs of intervention, such as the efficiency costs of raising additional tax revenue, of which account is often not taken. Scope exists for greater consideration of the use of penalty taxes and a combined incentives and standards approach to influence rates of land degradation.

References

Abelson, P. (1979), *Cost Benefit Analysis and Environmental Problems*, Saxon House, Southampton.

Arrow, K. J. and Fisher, A. C. (1974), 'Environmental preservation, uncertainty and irreversibility', *Quarterly Journal of Economics* 82(2), 312–19.

Balderstone, J. S. (Chairman), Duthie, L. P., Jarrett, F. G., Eckersley, D. P. and McColl, J. C. (1982), *Agricultural Policy Issues and Options for the 1980s*, Working Group Report to the Minister for Primary Industry, AGPS, Canberra.

Bator, F. M. (1958), 'The anatomy of market failure', *Quarterly Journal of Economics* 72(3), 351–79.

Baumol, W. J. and Oates, W. E. (1975), *The Theory of Environmental Policy*, Prentice-Hall, New Jersey.

Blyth, M. J. and Kirby, M. G. (1985), 'The impact of government policy on land degradation in the rural sector' in A. J. Jakeman, D. G. Day and A. K. Dragun (eds), *Environmental Quality Control*, Centre for Resource and Environmental Studies Monograph 15, Australian National University, Canberra, pp. 105–24.

Bromley, D. W. (1982), 'Land and water problems: an institutional perspective', *American Journal of Agricultural Economics* 64(5), 834–44.

Bureau of Agricultural Economics (1985), *The Implications of Taxation Reform for the Rural Sector*, A BAE Submission to EPAC, AGPS, Canberra.

Campbell, K. O. (1967), 'Current issues in Australian land policy', *Economic Papers* 25, 1–15.

—— (1982), 'Land policy' in D. B. Williams (ed.), *Agriculture in the Australian Economy*, Sydney University Press, Sydney, pp. 225–39.

Cary, J. W., Ferguson, T. O. and Berlin, P. (1982), 'Economic and social costs of salinity' in M. J. Taylor, R. G. Dumsday and P. A. Bruyn (eds), *Salinity in Victoria*, AIAS Occasional Publication No. 6, Australian Institute of Agricultural Science, Melbourne, pp. 16–34.

Castle, E. N., Kelso, M. M., Stevens, J. B. and Stoevener, H. H. (1981), 'Natural Resource Economics, 1946–75' in L. R. Martin (ed.), *A Survey of Agricultural Economics Literature*, Volume 3, University of Minnesota Press, Minneapolis, pp. 393–500.

Chisholm, A. H. (1978), Controlling non-point sources of pollution with special reference to soil erosion. Paper presented at the 22nd Australian Agricultural Economics Society Conference, Sydney, 7–9 February.

—— (1985), 'The choice of pollution control policies under uncertainty' in A. J. Jakeman, D. G. Day and A. K. Dragun (eds), *Environmental Quality Control*, Centre for Resource and Environmental Studies Monograph 15, Australian National University, Canberra, pp. 1–21.

Cicchetti, C. J. and Freeman, A. M. (1971), 'Option demand and consumer surplus: further comment', *Quarterly Journal of Economics* 85(3), 528–39.

Commonwealth and State Government Collaborative Soil Conservation Study 1975–77 (1978), *Report 1: A Basis for Soil Conservation Policy in Australia*, Department of Environment, Housing and Community Development, AGPS, Canberra.

Condon, R. W. (1982), Pastoralism in Australia's arid lands. Paper presented at the Australian Conservation Foundation Conference, Broken Hill, 21–25 May.

Costin, A. B. and Coombs, H. C. (1982), 'Farm planning for resource conservation', *Search* 12(12), 429–30.

Department of Resources and Energy (1983), *Water 2000: A Perspective on Australia's Water Resources to the Year 2000*, AGPS, Canberra.

Donald, C. (1964), 'The progress of Australian agriculture and the role of pastures in environmental change', *Australian Journal of Science* 27(7), 187–98.

Dumsday, R. G. (1982), 'Policy options for salinity management' in M. J. Taylor, R. G. Dumsday and P. A. Bruyn (eds), *Salinity in Victoria*, AIAS Occasional Publication No. 6, Australian Institute of Agricultural Science, Melbourne, pp. 69–86.

Fisher, A. C. and Krutilla, J. V. (1974), 'Valuing long run ecological consequences and irreversibilities', *Journal of Environmental Economics and Management* 1(2), 96–108.

—— (1975), 'Resource conservation, environmental preservation, and the rate of discount', *Quarterly Journal of Economics* 89(3), 358–70.

Heathcote, R. L. (1969), 'Land tenure systems: past and present' in R. D. Slatyer and R. A. Perry (eds), *Arid Lands in Australia*, Australian National University Press, Canberra, pp. 185–208.

Henry, C. (1974*a*), 'Option values in the economics of irreplaceable assets', *Review of Economic Studies* (Symposium 1974), 89–104.

—— (1974*b*), 'Investment decisions under uncertainty: the "irreversibility effect"', *American Economic Review* 64(6), 1006–12.

Hodge, I. (1982), 'Rights to cleared land and the control of dryland seepage salinity', *Australian Journal of Agricultural Economics* 20(3), 185–201.

Johnston, B. and Girdlestone, J. (1983), *Implications for Future Research of Recent Developments and Trends in Agriculture*, AGPS, Canberra.

Kirby, M. G. and Blyth, M. J. (1987), 'An economic perspective on government intervention in land degradation' in A. H. Chisholm and R. G. Dumsday (eds), *Land Degradation: Problems and Policies*, Cambridge University Press, pp. 213–22.

Krutilla, J. V. (1967), 'Conservation reconsidered', *American Economic Review* 57(4), 777–86.

—— and Fisher, A. C. (1975), *The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources*, Johns Hopkins University Press, Baltimore.

Marglin, S. A. (1963), 'The social rate of discount and the optimal rate of investment', *Quarterly Journal of Economics* 77(1), 95–111.

Neher, P. A. (1976), 'Democratic exploitation of a replenishable resource', *Journal of Public Economics* 5, 361–71.

Newbery, D. M. G. and Stiglitz, J. E. (1981), *The Theory of Commodity Price Stabilisation: A Study of the Economics of Risk*, Clarendon Press, Oxford.

Newman, P. and Cameron, I. (1982), *Attitudes to Conservation and Environment in Western Australia*, a Report for the Department of Conservation and Environment, Environmental Science, Murdoch University, Perth.

Niskanen, W. A. (1971), *Bureaucracy and Representative Government*, Aldine and Atherton, Chicago.

Olive, L. J. (1983), Impact of European-style land use. Paper presented at a workshop on Soil Management under Drought and Flood, Australian Society of Soil Science (ACT) and the Australian Institute of Agricultural Science, Canberra, March.

Peterson, F. M. and Fisher, A. C. (1977), 'The exploitation of extractive resources: a survey', *Economic Journal* 87(4), 681–721.

Pigou, A. C. (1932), *The Economics of Welfare*, 4th edn, Macmillan, London.

Quiggin, J. (1986), Failures and imperfections in policy analysis: the case of land degradation. Paper presented at the 30th Conference of the Australian Agricultural Economics Society, Canberra, 3–5 February.

Randall, A. (1972), 'Market solutions to externality problems: theory and practice', *American Journal of Agricultural Economics* 54(2), 175–183.

Rose, R. N., Moir, B. G., Farquharson, R. J. and Vanzetti, D. M. (1984), *Assistance for the Consumption and Production of Fertilizers*, A BAE Submission to the IAC, AGPS, Canberra.

Samuel, S. N., Kingma, O. T. and Crellin, I. R. (1983), *Government Intervention in Rural Research: Some Economic Aspects of the Commonwealth's Role*, BAE Occasional Paper No. 76, AGPS, Canberra.

Schmalensee, R. (1972), 'Option demand and consumer's surplus: valuing price changes under uncertainty', *American Economic Review* 62(5), 813–24.

Scott, A. (1978), Is the government the guardian of future generations? Paper presented at the Environmental Economics National Conference, Department of Science and the Environment, Canberra, 29–30 May.

Sen, A. K. (1967), 'Isolation, assurance and the social rate of discount', *Quarterly Journal of Economics* 81(1), 112–24.

Tisdell, C. A. (1972), *Microeconomics: The Theory of Economic Allocation*, John Wiley and Sons, Sydney.

Tullock, G. (1964), 'Comment on the social rate of discount and the optimal rate of investment', *Quarterly Journal of Economics* 78(3), 331–6.

Warr, P. G. and Wright, B. D. (1981), 'The isolation paradox and the discount rate for benefit-cost analysis', *Quarterly Journal of Economics* 96(1), 129–45.

Walsh, C. and Brennan, G. (1978), Economic analysis and public choice perspectives of environmental policy: damage taxes, regulations and standards. Paper presented at the Environmental Economics National Conference, Department of Science and the Environment, Canberra, 29–30 May.

Watson, W. D., Reynolds, R. G., Collins, D. J. and Hunter, R. D. (1983), *Agricultural Water Demand and Issues*, Water 2000 Consultants Report No. 5, Department of Resources and Energy, AGPS, Canberra.

Weisbrod, B. A. (1964), 'Collective-consumption services of individual-consumption goods', *Quarterly Journal of Economics* 78(3), 471–7.

Williams, M. (1976), The perception of the hazard of soil erosion in South Australia: a review. Paper presented at National Hazards Symposium, Academy of Science, Canberra.

Woods, L. E. (1983), *Land Degradation in Australia*, Department of Home Affairs and Environment, AGPS, Canberra.

Young, M. D. (1981), 'Arid land administration, management and tenure in Australia — recent inquiries and current policy issues', *Rural Marketing and Policy* 11(2), 29–31.

—— (1983), An analysis of the main arid land tenure options in Australia. Paper presented at Social Science Symposium, CSIRO, Deniliquin, 17–20 May.