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INTERACTIONS BETWEEN AGRICULTURAL POLICIES AND THE ENVIRONMENT

Bengt Hyberg*

Economic Research Service
United States Department of Agriculture
Washington, DC

The paper provides an economic perspective on selected forms of land degradation in Australia and the links between land degradation and agricultural policies. The paper begins with a discussion of the main types and causes of land degradation in Australia. The discussion covers aspects of soil erosion, salinity, waterlogging and soil acidity. Relationships are hypothesised between land degradation and institutional policies influencing water use, land settlement, and input prices.

A program of research designed to improve knowledge of the economic impact of government policies is then suggested. It is argued that posited relationships need to be quantified in order to aid policy formulation.

* Dr Bengt Hyberg is currently on a USDA (ERS)-ABARE exchange program and is currently stationed with the Australian Bureau of Agricultural and Resource Economics, Canberra. The exchange study is concerned with land degradation in Australia and the United States.

Introduction

Land degradation in Australia is presently the subject of much debate. The discussion revolves around the selection of appropriate state and federal government intervention in the agricultural and environmental sectors.

Previous examinations of land degradation have generally concentrated on economic and physical considerations. While the studies concentrating on the economic considerations have in large part included physical factors, the studies have paid little attention to the institutional factors affecting resource allocation. These factors include differences between information sets available to government organisations and farmers, the regulatory agencies, and the policy environment. Institutional factors can contribute to land degradation and influence the effectiveness of government policies. Incorporation of institutional factors into the analysis is required because they modify the economic environment by changing the constraints faced by agricultural producers, thereby altering the production practices chosen.

The aims in this paper are to identify the information needed to design efficient policies, provide a brief synopsis of the information currently at hand, demonstrate the need to include institutional factors in land degradation analysis, and summarise a research program that will provide economic and institutional information that is needed to design these programs but is currently unavailable.

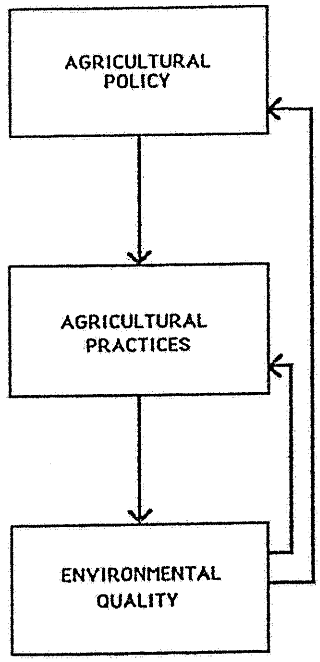
Information Required for the Design of Efficient Policy

The relationship between agricultural policy, the agricultural practices employed, and land degradation can be viewed as a three-tier process (Figure 1). Agricultural policies affect agricultural practices. These agricultural practices then, in turn, influence the level of land degradation.

Formulation of effective and efficient agricultural and environmental policies requires knowledge of three main areas of interest:
1) the physical inter-relationships between agricultural practices, land degradation, and agricultural productivity;
2) the source, magnitude, and distribution of the costs (both on and off-site) associated with land degradation; and
3) the institutional environment, interactions between different government policies, and the effect of the institutional environment and interactions on agricultural practices.

Knowledge of the physical relationships is required to provide the links between agricultural production activities and the condition of the land resource, and to furnish decision makers with the feasible technological options. Economic data are needed to analyse the producers' options in response to land degradation and different institutional settings, and to determine the effectiveness, efficiency, and distributional characteristics of different policy options. The institutional setting needs to be understood because it provides the environment in which economic decisions are made, thereby - as will be shown - placing constraints upon the producers. It is argued in this paper that institutional factors interact, have important effects on economic agents, and have frequently been overlooked or underestimated in analyses of land degradation. Thus, the full body of data is needed to determine which policies will achieve their objectives, minimise costs, and distribute the costs and benefits with the desired effect with the desired effect.

FIGURE 1 - The Relationships Between Agricultural Policy, Agricultural Practices and Environmental Quality



Agriculture and Land Degradation in Australia

Soil erosion, dryland and irrigated salinity, waterlogging, and soil acidification are forms of land degradation which have been identified as reducing agricultural production and resulting in off farm damages. The extent of land degradation has increased over time, and in a number of cases may have accelerated in recent decades.

To understand the effects of land degradation on agricultural productivity, it is important to have a general understanding of the physical consequences of the land degradation. In order to recognise how government policies on agriculture can affect land degradation, it is again necessary to have an understanding of the physical factors contributing to the land degradation processes. This section outlines the major forms of land degradation and describes the forces that contribute to the degradation.

Soil erosion

Soil erosion, as one of the major geological forces shaping the earth, is inevitable. Soil erosion occurs when energy from wind, flowing water, gravity, or some combination of these forces displaces soil. The rate of soil erosion accelerates as the land is cleared and the soil disturbed, increasing its exposure to erosive forces. Agriculture requires land to be cleared and prepared, thereby increasing the rate of soil erosion over the level observed on undisturbed land. Deforestation can be viewed in some cases as the transformation of unproductive land covered with native species into productive agricultural land. However, the replacement of deep-rooted native vegetation with more shallow rooted crops on pasture is associated with increased soil erosion and rising ground water levels.

The rate of erosion depends on several variables. The fineness and cohesiveness of the soil aggregates, the amount of precipitation, the slope of the land and the length of the slope, wind velocity, vegetative ground cover, and cultivation practices employed all affect the rate of soil erosion. Of these, only the amount of precipitation cannot be altered, although changing the slope of the land is rarely practical in an economic sense. The size of the basic soil particles cannot be changed, but improving soil structure through practices such as the incorporation of organic matter can increase the aggregation of the soil particles allowing them to adhere and thereby increasing the effective particle size. The length of a field's slope can be altered by terracing or installing banks. Wind velocity can be reduced by planting windrows. Vegetative cover can be changed by altering the crop rotation or the stocking level. Contour farming, strip cropping, and stubble mulching are management practices that can be employed to decrease erosion.

Soil erosion removes organic matter, nutrients, and soil particles from a paddock. This reduces the agricultural productivity of the land. L. Watt (New South Wales Soil Conservation Service, personal communication, November 1989) estimates that a net loss of one tonne of soil from some areas of New South Wales would result in a 0.023 per cent loss in yield. This appears to be an insubstantial reduction, but if a loss of 10 tonnes per hectare per annum continued for 20 years, yields on the sites affected would decline almost 5 per cent. The quality of the land decreases because the nutrients, organic matter, and soil removed by erosion are no longer available for plant growth. The shallower the topsoil, the more these effects will be felt (MacLeod and Johnston 1990). Agricultural productivity decreases if increased inputs cannot compensate for these losses.

Erosion also causes production costs to increase. Increased use of agricultural inputs such as fertiliser, higher machinery costs due to operating around gullies, loss of productive land, and reductions in the useful life of farm dams or other farm structures all cause production costs to rise. The combination of reduced productivity and increased production costs would result in lower total production if all other factors were held constant. Of course, other factors are not held constant - prices change, additional land can be brought into production, and yields increase through technological innovation.

Soil erosion not only affects agricultural production, but has off-site effects. To the extent that eroded soil moves off a property, it can interfere with production of other farms and industries. Eroded soil fills drainage ways, farm ponds, weirs, dams, roads, and irrigation systems, reducing their productive lives and increasing maintenance costs. Soil entering waterways increases the turbidity of the surface waters lowering their recreational and aesthetic values, while agricultural chemicals attached to the soil can contribute to toxicity or eutrophication. Eroded soil particles and nutrients have the potential to reduce the navigational and biotic capacity of streams, rivers, lakes, and dams and increase the cost of water purification for human and industrial consumption.

Salinity

Salinity can be defined as the concentration of salts in the cultivated layer of the soil. Salinity reduces agricultural production by lowering crop yields, and rendering land unsuitable for agriculture. At lower salinity levels crop and pasture production can continue, but at lower levels. However, as the salinity is increased only more salt-tolerant vegetation can survive, until a point is reached where all vegetation is eradicated and agricultural production is eliminated. As the vegetation becomes sparser the soil becomes exposed to the forces of wind and rain, soil erosion increases, and scalding becomes a problem.

Salinity comes in two forms, dryland and irrigated salinity. The same basic mechanism leads to salinisation for both forms: a rising water table transports salt from an underground saline formation to a point where capillary movement can draw the salt-laden water into the root zone, or the upper portion of the soil. A general rule of thumb is that when a saline water table rises to within two metres of the ground surface, salinity becomes a problem (New South Wales Water Resources Commission 1985). As the water evaporates the salt is left behind, increasing the salinity of the soil.

With dryland salinity, the water table rises when the vegetative cover in a catchment is converted from deep-rooted species such as trees and shrubs to more shallow-rooted crop and pasture species. The change in vegetative cover leads to a rising water table, because unlike crops and grasses, deep-rooted vegetation can remove ground water before it rises to a level which leads to saline soils. In addition, trees and shrubs tend to have higher rates of evapo-transpiration. The combination of shallower root systems and lower rates of evapo-transpiration results in less ground water being removed from a higher water table.

With irrigated salinisation, the primary cause of rising water tables is the irrigation of crops and pasture with water from other catchments. The introduction of the additional water into a hydrologic system that previously had obtained an equilibrium between water recharge and discharge, results in a rising water table. If the water in the catchment (including that added through irrigation) cannot be discharged through the subterranean strata then irrigation will result in the water table rising to the surface, and salinisation will result. Altered evapo-transpiration regimes also contribute to the rising water tables associated with irrigated salinisation, but in this case have a lesser role.

Both irrigation and vegetative changes resulting in dryland and irrigated salinisation can have consequences for neighbouring landowners. Clearing of property in the upper reaches of a catchment can result in rising water tables in the lower portions of that watershed. In addition, irrigated salinity has further consequences for downstream landowners because salt from the irrigated area is introduced into waterways, increasing the salinity of surface water and thereby reducing the desirability of that water for irrigation, human and livestock consumption, and recreation uses. Increasing salinity also increases water costs for industrial and human consumption.

<u>Waterlogging</u>

Waterlogging is the saturation of the soil resulting from rising water tables. The soil saturation reduces the air space available to roots, thereby limiting plant growth. Upon total soil saturation most plants are unable to survive. In addition to affecting plant growth, waterlogging increases production costs by reducing machinery efficiency. Thus, waterlogging reduces productivity by removing land from agricultural production, reducing yields, and increasing production costs.

Because waterlogging is caused by rising water tables, it is associated with the same practices that lead to salinity, changing vegetative types and irrigation. In areas with a saline underground formation waterlogged sites eventually become saline.

Soil acidification

Soil acidification occurs when the acids in the soil become sufficiently concentrated to cause the necessary plant nutrients to become chemically fixed to soil particles. This reduces their availability to the grasses of improved pastures. If soil acidity is not treated, the composition of the pasture grasses becomes less desirable for fodder, leading to a decline in agricultural production. In extreme cases, soil acidification can result in pasture land becoming unsuitable for livestock production. Soil acidity affects 26-35 million hectares of land in Australia (B. Rolfe, Australian National University, personal communication, November 1989). It can be treated by applying lime, raising production costs but reducing yield losses associated with the acidity.

Soil acidification is associated with repeated applications of superphosphate, which is used to increase nitrogen production from leguminous plants. Sulfur and nitrogen applications on susceptible soils also contribute to soil acidification. The increased nitrogen production leads to the production of nitrous oxides which reduce the buffering capacity of the soil. When sulfur contributes to acidification sulfur oxides mix with nitrous oxides to increase the acidity. Eventually, in soils with low buffering capacities, the buffering capacity is exhausted and the soil becomes more acidic.

Soil acidification has only recently received recognition as a serious threat to agricultural production. An 1983 assessment of land degradation in Australia did not refer to soil acidification. The fact that soil acidification has only recently been recognised as a threat might indicate a possible acceleration in the rate of land degradation. However, such a suggestion must be viewed with some caution, because it might be reflecting increased knowledge of the state of the environment.

The Effect of Institutional Structure

The inclusion of institutional considerations in the analysis and design of government policy is important because the institutional environment can strongly influence the effect of any single policy. The information available to economic agents and agencies partly determines the position of production relative to the production frontier, and therefore strongly influences the economic efficiency of any production decisions.

Interactions between policies, governments, and agencies can also alter the outcome of any single policy by placing additional constraints on regulatory bodies. Thus, government actions must be examined not on a policy by policy basis, but as a set of policies within an institutional setting. This idea can be illustrated using three basic economic paradigms: information, decision theory, and portfolio theories.

Information theory

Economic theory holds that given full information, economic agents will maximize their well-being by using the information provided by market prices to set production and consumption levels. Unless there are market failures such as external effects, intervention in the market by regulatory bodies results in suboptimal production decisions thereby lowering potential economic welfare. Stated differently, where all costs and benefits are borne by the producer, government intervention will reduce the well-being of the producer without providing any benefit to society. Kirby and Blyth (1987) go further by noting that even when there are market failures, the benefits resulting from the intervention must exceed the cost of the government intervention if social welfare is to be increased.

A key assumption necessary for the above result is that full information concerning the costs and benefits is available to all economic agents. The effect of less than complete information on land degradation can be demonstrated using a simple example. First, assume there are no external effects. This assumption simplifies the example, without altering the basic result. Next, define full information as the sum of information held by producers and government agencies. Using this criteria, the present value of net farm revenues (NFR) for a profit maximizing agricultural sector, operating with full information, would be the sum of production over all farms, over all time periods:

$$(1) \qquad NFR_F = \sum_{n=1}^{n} \left[\sum_{t=0} Q_{nt}(I_F)P - C_{nt}(I_F) \right] / [1 + r]^t .$$

Here production (Q), cost (C), and inputs (implicit in the equation) are determined by maximising NFR_F given individual farm constraints. This result would be located along the production possibilities frontier, and by definition would be technologically efficient. Furthermore, given full information concerning the effect of land degradation on future production, farmers acting in their own best interests would maximise returns for the sector, as well as potential social welfare. This is the paradigm that has been used in most past studies of land degradation.

In order to introduce the effect informational deficiencies have on social efficiency, assume that neither the government nor the individual farmers have access to the full set of information necessary to maximise profits over an infinite production horizon. For simplicity, assume the individual farmers have the information necessary to select the production practices which maximise production on their farm for any single year, while the government has information on the relationships between agricultural production practices, land degradation, and future production. Individual farmers require the information concerning these relationships in order to maximise production over a multi-period planning horizon. Further, assume for this example that the information available to the farmers and the government is mutually exclusive.

Admittedly, these are extreme assumptions. Farmers have information concerning the effects of erosion and the government is aware of the regional farm attributes. However, evidence available from landowner studies indicates that farmers tend to underestimate the effects of soil erosion on their farm's productivity (Rickson, Seffigna, Vanclay and McTainsh 1987; Napier and Forster 1982), while the agricultural sector's performance in controlled economies suggests that governments do not have sufficient information to manage agricultural production in a manner that maximises social welfare. Thus, the assumptions capture the general characteristics of the information that is held by farmers and government agencies.

Given the framework described, farmers in aggregate maximise:

(2) $$NFR_f = \sum_{n=1}^{n} [\sum_{t=0} Q_{nt}(I_f)P - C_{nt}(I_f)] / [1 + r]^t.$$

Here, I_f represents the short term information set required for profit maximization in the current period. This can be rewritten:

(2a) $$NFR_f = NFR_0 + NFR_1$$

where NFR_0 is the net return from current year production and,

$$NFR_1 = \sum_{n=1}^{n} [\sum_{t=1} Q_{nt}(I_f)P - C_{nt}(I_f)] / [1 + r]^t.$$

is the discounted revenue from future production. If land degradation exists and reduces future production or increases future costs, then discounted future revenue is decreased. It follows that, with reduced information, the individual farmers and the agricultural sector as a whole are no longer producing along the production possibilities frontier, and the resources used in agricultural production are being employed inefficiently.

It should be noted that this formulation does not assume single period profit maximisation. Farmers are attempting to maximise discounted net farm returns. However, due to informational deficiencies, rational agents are making suboptimal decisions. By introducing differences in information sets, production moves away from the production possibilities frontier, and economically suboptimal decisions result. Thus, if economic agents do not possess full information, then the government has the potential to increase economic efficiency by providing information to these agents.

In practice, neither government agencies nor farmers possess perfect information. Government institutions have greater access to technological information regarding general relationships between agricultural practices, while farmers have the information to make production decisions relating to their farms. If the government could, without cost, provide farmers with information concerning the long run effects of land degradation on agricultural production, farmers would be able to improve the long run management of their operations. For instance, thirty years ago soil physicists predicted that fertilisation of improved pastures with superphosphate could lead to increased soil acidity that might require treatment (Williams and Donald 1957), but farmers became aware of the potential acidity problem only when reduced yields on improved pastures began to become more widespread.

It should be noted that the model assumes away the cost of obtaining information. It takes time and effort, both to communicate information and to gather and digest that information. If the costs of transferring the information from the government to farmers are greater than the gains available, then no social loss occurs and the agricultural sector is operating efficiently. If, on the other hand, the increase in present net value of NFR is greater than the cost of disseminating the information, then net social welfare will increase.

Decision theory

Institutional structure is also important when evaluating or designing policies. Frequently, a policy or program is initiated with multiple objectives. This may seem to be reasonable when implementation of the policy will move the system closer to each of the objectives. However, unless the objectives are fully consistent with one another, attempting to obtain multiple objectives with a single policy instrument is inefficient. The attempt to obtain several objectives with a single policy will result in either compromising between the objectives or concentrating on a single objective at the expense of the others.

This can be demonstrated by examining the effect of adding constraints to a simple constrained-maximisation problem. If a farmer seeks to maximise profits from a plot of land by regulating the amount of cultivation, the solution is straightforward. The same is true if the farmer decides to minimise the erosion from his land. However, if the farmer decides to both maximise profits and minimise erosion, the objectives conflict. Because no criterion for resolving the conflict has been specified, there is no single solution, and the farmer's objectives provide little guidance.

It should be noted that the farmer is here attempting to obtain two objectives with a single instrument. If, in addition to cultivation, the farmer is able to alter the amount of herbicides, the generation of an optimal solution for both objectives is straightforward. Thus, more than one instrument is needed to obtain multiple objectives when the objectives are not fully consistent with one another.

<u>Portfolio theory</u>

The use of several different tools to pursue separate objectives without first examining their influence on one another can also lead to a suboptimal result. This can be demonstrated using portfolio theory, where the selection of an optimal portfolio depends on the covariance between the individual financial instruments included in the portfolio. The decision to include any single instrument depends, not on the characteristics of the instrument, but on how the instrument affects the yield and risk attributes of the portfolio.

Portfolio theory can be applied directly to policy analysis. The selection of policy tools should depend upon characteristics of the final package of tools. An individual instrument should only be added to the set of policies if it increases the likelihood of obtaining the objective(s) (that is, is effective) and/or reduces the cost of obtaining the objective(s) (is efficient).

An Examination of Several Australian Policies

Land degradation is dynamic in nature. Past actions affect current and future events. Therefore, current and future environmental quality in Australia can be viewed as a function of past agricultural practices. These practices are in turn a function of past policies governing land use and affecting markets. Government subsidies, taxes, and regulations, where they exist, alter the relative profitability of agricultural practices, as well as the market environment. Farmers view market signals through the distortion of the governmental incentives and disincentives, accessing their options in the light of these interventions as well as the market environment.

The fact that land degradation exists does not necessarily constitute a problem requiring government action (Blyth and McCallum 1987). Previous research has identified a number of market failures which might exist and thereby provide a potential justification for government intervention (Kirby and Blyth 1987b). However, government intervention should only proceed if it can be demonstrated that the intervention can result in a net social gain (Kirby and Blyth 1987a,b; Chisholm 1987a,b). That is, government intervention can be justified if the cost of administering, measuring, and correcting the market failure is less than the social gains that result from the intervention.

Government intervention may be appropriate if designed to remedy market failure. However, not all policies affecting resource use are designed to address market failures. Many were designed to increase agricultural exports, promote 'land improvements', or meet other social objectives. These policies are the subject of this section. The effect of policies which have served to encourage deforestation, to subsidise fertilisation and irrigation, and to raise uncertainty concerning land tenure, need to be examined in order to assess their contributions to land degradation.

Land management requirements

An appropriate starting point for a discussion of Australian policies influencing agricultural practices is an examination the laws governing new settlements and land tenure. Primarily, interest in these laws centres on the requirements for significant and progressive clearing of the native vegetation, and provisions for minimum stocking rates in leasehold agreements. To a significant extent, the policies governing postwar land settlement in Australia were designed to encourage agricultural development and thereby expand exports. In some instances these policies required the clearing of a prescribed portion of a tract within a stated period of time to demonstrate the landowner's stewardship and improvement of the land (Bradsen and Fowler 1987; Campbell 1966; Moncreiff and Mauldon 1963). These policies continued through the 1960s with the continuation of closer settlements in South Australia and Western Australia (Campbell 1982).

The requirement to clear land not only restricted the farm management options available and placed farmers without a substantial reserve of capital under a considerable burden, but resulted in the conversion of a sizeable acreage of forest and shrubland into pastures and agricultural land. Moncrieff and Mauldon (1963) reported that farmers in Western Australia cleared an average of three quarters of a million acres annually between 1953 and 1962. This figure includes land cleared on both new and established farms, and is presented to indicate the scope of land clearing activity. Among the consequences of the land clearing requirements was the substitution of shallow-rooted vegetation for the pre-existing deep-rooted species, and the replacement of permanent ground cover with agricultural systems that expose the soil to erosive forces. In addition, to the extent that these requirements result in landowners clearing land at a faster rate than they could establish crops or pasture, they result in suboptimal land management practices (Moncrieff and Mauldon 1963).

A further aspect of government land tenure regulations is the past promotion of closer settlement. The closer-settlement program established farms of 'an area sufficient to sustain a family in average seasons and conditions' (Davidson 1981). Such programs have been employed over various periods in Australia's history. Unfortunately, in many cases the farms were not of sufficient size to be operated efficiently, and many of these farms failed. Young (1987) has noted that land degradation on these farms tends to be greater than on larger farms in the same area. He hypothesises that the higher level of degradation is a result of the need to overstock the land in order to make ends meet.

Campbell (1982) also has noted that in the arid regions of the Northern Territory leases contain minimum allowable stocking rates. The policy of establishing minimum stocking rates was ineffective and was eventually abandoned. Such regulations have been described as providing inappropriate signals to producers.

Input subsidies

Input subsidies lower the cost of the subsidised inputs relative to unsubsidised inputs, thereby altering the profit maximising production bundle. Production practices can be altered either in a manner which fosters stewardship of the environment or which adversely affects the condition of the land.

Between 1966 and 1984 nitrogen fertilisers received subsidies ranging from 3.4 per cent (1980-82) to 46.8 per cent (1968-69). During this same period, phosphate fertilisers received subsidies in all years but 1974-75. The subsidies for phosphate fertilisers ranged from 11.4 per cent (1981-82) to 80.5 per cent (1969-70) (Rose, Moir, Farquharson and Vanzetti 1984). Theory holds that these subsidies increased fertiliser applications above the level that would have been observed if the farmers had to pay the market full cost. Clark, Johnson and Matuska (1984) estimated that a discontinuation of the subsidy for superphosphate in 1984 would have resulted in a 1-2 per cent decline in superphosphate consumption. Clark et al. estimated a price elasticity of demand for superphosphate of -0.16 to -.20. This compares with elasticities of -0.38 (BAE 1976), and -0.28 for the wheat-sheep zone and -0.45 for the high rainfall zone (Easter and Kingma 1976). Using this high rainfall zone elasticity, the bounty would have resulted in a 35 per cent increase in superphosphate use during the 1969-73 period when the subsidy was highest.

The establishment and maintenance of improved pastures is associated with soil acidification. In particular, the increase in nitrous acids resulting from the superphosphate fertilisation of legumes and applications of nitrogen fertiliser. Given the economic inducement offered to farmers, the subsidisation of fertilisers may have contributed to the soil acidification observed in the 1980s.

Water policy

While the subsidies for fertilisers have ended, those for irrigation have tended to continue. In some instances irrigators pay water rates which do not cover the variable costs of water delivered from irrigation projects constructed with federal funds (Watson and Rose 1980; Davidson 1981). In addition, the water rate structures are often designed in a way that sets the marginal price of water use close to zero (Centre of Policy Studies 1983), the rules governing water rights can induce farmers to irrigate more than they would otherwise choose (Randall 1981), and the rights to irrigation water are restricted and non-transferable in a number of areas.

If irrigation water were available in unlimited quantities to all farmers the effects of a simple subsidy for water would be similar to those for fertiliser subsidies. This is not the case. The limited availability of water, the water rate structure and the rules governing water entitlements add more complexity to water use. In Victoria and New South Wales, a farmer has an entitlement to a certain amount of water, for which the farmer is charged a flat annual fee whether this water is used or not. In addition, the farmer is frequently able to acquire more water at a given price per unit. The fact that the farmer must pay a lump sum for the initial water allotment serves to reduce the marginal cost of water use to zero for farmers who use only their basic water allotment. This results in inefficient water use when the allocation provides more water than would be used under a unit pricing schedule.

The rules governing irrigation can act to promote economic inefficiency in a number of cases. The irrigation permits are granted by the state on an annual basis and renewals are not automatic. Farmers can lose their water entitlements for a number of reasons, the most likely being failure to establish a beneficial use for the water (Randall 1981). This, coupled with the water rate structure, serves to encourage the full use of a farm's irrigation allotment.

In addition to the subsidies, the allocation of the irrigation rights has until recently been fixed and non-transferable. This has resulted in economically inefficient use of the irrigation water, because producers facing low marginal returns from irrigation were encouraged to irrigate, while producers who were able to make higher marginal returns from the use of irrigation in their crop production were unable to acquire additional water. These allocations are changing, as is the transferability of the water allocation.

Taxation policy

Tax incentives have the potential to alter the relationship between economically efficient and profit maximising options by altering the relative cost of inputs, outputs, or management practices. This is possible because of the basic differences between an economically efficient outcome and a profitable outcome. An economically efficient solution results when factors of production such as land are used in their highest and best use. Such a use can be defined as the use which results in the highest valued production, net of production, conversion, and social costs. This result is generally viewed as maximising potential social welfare. A profit maximising solution, on the other hand, maximises the sum of capital appreciation and the discounted flow of cash revenues, net of cash expenditures, for an enterprise.

While taxes can be used to move profit maximising solutions closer to economically efficient solutions, by placing taxes on undesired non-market by-products such as pollutants (Baumol and Oates 1975), they can also have the unfortunate side effect of increasing the divergence between economically efficient and profit maximising choices. Such a situation exists when tax incentives make an undesired, previously unprofitable option profitable (e.g., the clearing of environmentally sensitive, sub-marginal land for agricultural production).

In Australia, tax policies have provided incentives to taxpaying farmers to convert bush and forest into pasture and agricultural land, invest in capital intensive soil conservation measures, and harvest and manage timberland (Table 1) (Roberts 1989; Haynes and Sutton 1985). Because the tax system has offered incentives for landowners to convert bush into cropland and pasture, and still provides incentives to harvest timber (Section 75A and Stanton Provision, Table 1), it encourages the exposure of soil to wind and water leading to increased erosion, and reduces evapo-transpiration which can result in rising water tables. Thus, some Australian tax incentives may have encouraged practices which increase land degradation.

TABLE 1

Tax Incentives Influencing Agricultural Production and Land Degradation

Section 75A:	Provided a 10-year deduction for specified capital expenditures related to clearing and preparation of land for primary production. This provision has been withdrawn.
Section 75B:	Provides a 3-year deduction for specified capital expenditures relating to the conservation and conveyance of water.
Section 75D:	Provides an outright deduction for specific capital expenditures relating to the prevention or control of land degradation.
Section 124J:	Provides a tax basis equal to the estimated value of the timber purchased with a block of land. This basis is deductible upon the sale of the timber
Stanton Provision	Exempts from income tax income derived from lump sum sale of timber from unmanaged native forest owned prior to 1985.

The question remains whether the incentives promote a movement towards economic efficiency. It can be argued that they do if the value of agricultural and associated production on the converted lands exceeds the production, conversion, and off-site social costs. If in fact the value of production exceeds the total costs, this raises questions concerning thejustification of the incentives, given that the producers could convert the land to agriculture and profit without the tax incentives. However, if agricultural production does not exceed the total costs of that production, then land degradation has been increased and, in addition, the tax incentives have decreased economic efficiency.

Tax incentives can also result in a misallocation of resources by encouraging one practice over anoth r or by encouraging use of one input over use of another. This may occur in the case of soil erosion control practices. Often a soil management plan calls for the installation of erosion control structures and a change in farm management practices. However, the current tax laws provide incentives for landowners to undertake capital expenditures as a means to control soil erosion, but provide no incentives for altered management practices. This causes a decrease in the cost of capital intensive measures relative to management intensive solutions, and may result in over-investment in capital-intensive erosion control measures.

Tax policies with the objective of reducing land degradation need to address the landowners contributing to the degradation. The current taxation policies provide different incentives to producers facing different tax rates. For instance, tax incentives have no effect on producers who do not pay taxes, but offer substantial benefits to producers in the highest tax brackets. This might be satisfactory if land degradation were concentrated on farms owned by high income producers, but would be inefficient if low income farms are subject to land degradation.

Quantifying the Relationship Between Policy and Land Degradation

The previous sections discussed the general relationships between agricultural institutions, agricultural practices and land degradation. While an understanding of the general relationships is useful, the fashioning of appropriate policies for agricultural production and land degradation requires additional information. What remains to be established is the significance of these relationships, or - if it is not possible to estimate the extent of the relationships - their order of magnitude.

The qualitative relationship between agricultural policy and agricultural practice can be established using economic theory; however, the significance of these policies for land degradation has more often than not been asserted rather than established. The project will use case studies to quantify the on- and off-site economic costs of land degradation and identify the physical, economic and institutional factors leading to land degradation in the lower Murray-Darling Basin. This section outlines a program of research designed to quantify the relationships between institutional factors, agricultural practices, and land degradation.

The discussion to this point suggests a number areas of research needed for the formulation of efficient and effective policy, particularly the incorporation of institutional factors into economic analyses. One area not discussed has been the potential for two farms to respond differently to the same institutional influences. These differences can result because of interactions between the institutions and characteristics of the individual farms. Examples of these interactions include: income levels affecting tax rates; education levels affecting the assimilation of information; and soil characteristics affecting the relevance of erosion control programs.

The fact that farms can respond differently to the same institutional factors causes difficulties in using case studies to estimate the aggregate response of the agricultural sector to institutional factors. Therefore, care must be taken in using a farm-level analysis to examine sector-level effects. However, a careful examination of the decision making process for an individual farm can reveal the key determinants leading to the selection of management options. By knowing these key determinants, the data collection requirements are reduced, and an investigation using a larger sample becomes more feasible.

If the principal factors leading to a decision can be identified then the interactions between institutional factors might also be identified. The identification of the interaction effects on decision making at the farm level is a necessary ingredient for the formulation of effective and efficient government policies.

The proposed project will address four areas of research at the farm-institutional level:
1) institutional differences facing agricultural operations in the New South Wales, South Australia, and Victoria, the three states sharing the lower Murray-Darling Basin;
2) the effect of these institutional differences on the selection of agricultural practices;
3) the on- and off-site costs associated with land degradation on these farm operations; and
4) the costs of land degradation attributable to institutional factors on these farm operations.

The project will also develop a methodology which can be extended to provide reasonable estimates of the on- and off-site costs of land degradation over broad geographical regions. The basic premise behind the methodology is that, if the key factors determining an individual farmer's management decisions can be identified as well as the decision making processes, then the data needed to estimate the response of a group of farmers to a policy are also identified. Once the data requirements have been identified, the observations from this study can be expanded to capture the distributional characteristics of the farms. If distributions of the degradation level and soil type could be related to land use, income levels, farm size, and production costs, then not only could current damages be estimated, but statistical inferences could be made concerning the sector's response to policy alternatives. In addition, the accuracy of the estimates could be increased by expanding the number of the farms sampled.

Data from research, demonstration, and experimental farms will be used to provide the cost and returns from farm operations, estimate the on- and off-site costs of land degradation, evaluate alternative agricultural practices and determine the key factors entering the decision process. Data from the New South Wales Land Degradation Survey, the Victorian Department of Conservation, and the South Australian Department of Agriculture will be used to provide information concerning the extent of land degradation within the lower Murray-Darling Basin and to expand the farm level data to a basin-wide data base (Graham 1989). These results will establish the geographical relationship between the incidence of agricultural policy and land degradation, information that is required for the design and implementation of effective agricultural and resource policy.

It is hoped the information provided by the project will supply the data needed to quantify the interactions between policies at the federal and state level. The state and federal legislation establishing agricultural, settlement, and environmental policies and implementing the specific programs will be examined to define their objectives. An index relating the effectiveness of each policy in obtaining its objective will be developed, and this index will be used to assess the success of each policy in obtaining its objective. Because the federal policies might have a different effectiveness within different states, the effectiveness of federal policies will be assessed for each state. These measures will be used to develop a variance-covariance matrix measuring the interactions between different policies.

Admittedly, the difficulties in defining an objective index and in locating data to construct a measure of the effectiveness for each policy, and differences in environmental characteristics will make this a difficult task. However, the information that could be obtained from its successful completion makes an attempt to reach this goal compelling.

Conclusion

Because government policies, agricultural practices, and environmental quality are inter-related, their relationships need to be established in order to conduct appropriate economic analysis of alternative policies. Establishing a relationship between land degradation, input subsidies, leasehold covenants, and land conversion incentives would provide a connection between economic analysis and policy formulation that is currently unavailable.

This paper has provided a discussion of the variables contributing to land degradation and the general inter-relationships between these variables. Methodologies for investigating these inter-relationships have been presented. Results from these investigations will provide information concerning the trade-offs between agriculture and the environment that can fruitfully be applied in economic evaluations of proposed government policies.

References

BAE (Bureau of Agricultural Economics) (1976), Phosphatic Fertilisers: Submissions to the IAC Inquiry, Ind strial Economics Monograph No. 15, AGPS, Canberra.

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

Bradsen, J. and Fowler, R. (1987), 'Land degradation: legal issues and institutional constraints', in A. Chisholm and R. Dumsday (eds), Land Degradation: Problems and Policies, Cambridge University Press, Sydney, pp.129-67.

Blyth, M. and McCallum, A. (1987), 'Onsite costs of land degradation in agriculture and forestry', in A. Chisholm and R. Dumsday (eds) Land Degradation: Problems and Policies, Cambridge University Press, Sydney, pp.79-98.

Campbell, K.O. (1966), 'Problems of adaption of pastoral businesses in the arid zone', Australian Journal of Agricultural Economics 10(1), 14-26.

___ (1982) 'Land policy' in D.B. Williams (ed.), Agriculture in the Australian Economy, 2nd edn, Sydney University Press, Sydney, pp.225-39.

Centre of Policy Studies (1983), Victoria's Irrigation Systems: Study of the Distribution of Costs and Benefits, Centre of Policy Studies, Monash University, Melbourne.

Chisholm, A. (1987a), 'Abatement of land degradation: regulations vs. economic incentives', in A. Chisholm and R. Dumsday (eds) Land Degradation: Problems and Policies, Cambridge University Press, Sydney, pp.223-47.

___ (1987b), 'Rational approaches to nvironmental issues', in A. Chisholm and R. Dumsday (eds), Land Degradation: Problems and Policies, Cambridge University Press, Sydney, pp.341-56.

Clark, J., Johnson, B.G. and Matuska, A.M. (1984), The BAE's Farm Model and its Application to a New Technology, AGPS, Canberra.

Davidson, B. R. (1981), European Farming in Australia: an Economic History of Australian Farming, Elsevier Scientific Publishing Company, New York.

Easter, C.A. and Kingma, O.T. (1976) 'A regional analysis of superphosphate use', Attachment C in BAE (1976).

Graham, O. (1989), Land Degradation Survey of NSW 1987-1988: Methodology, Technical Report No. 7, Soil Conservation Service of New South Wales, Chatswood.

Haynes, J.E. and Sutton, M. (1985), Taxation Measures and Soil Conservation, Occasional Paper No. 93, Bureau of Agricultural Economics, AGPS, Canberra.

Kirby, M. and Blyth, M. (1987a), 'Economic aspects of land degradation in Australia', Australian Journal of Agricultural Economics 31(2), 154-74.

___ and ___ (1987b), 'An economic perspective on government intervention in land degradation', in A. Chisholm and R. Dumsday (eds), Land Degradation: Problems and Policies, Cambridge University Press, Sydney, pp.213-22.

MacLeod, N.D. and Johnston, B.G. (1990), An economic framework for considering rangeland restoration options. Paper presented to 34th Annual Conference of the Australian Agricultural Economics Society, Brisbane, 13-15 February.

Moncrieff, I.J. and Mauldon, R.G. (1963), 'The effect of land clearing regulations on the rate of farm development: a case study', Australian Journal of Agricultural Economics 7: 172-79.

Napier, T.L. and Forster, D.L. (1982), 'Farmer attitudes and behavior associated with soil erosion control', in H.G. Halcrow, E.O. Heady, and M.L. Cotner (eds), Soil Conservation Policies, Institutions, and Incentives, Soil Conservation Society of America, Ankeny, Iowa, pp.137-50.

New South Wales Water Resources Commission (1985), Waterlogging and Land Salinisation in Irrigated Areas of New South Wales.

Randall, A. (1981), 'Property entitlements and pricing policies for a maturing water economy', Australian Journal of Agricultural Economics 25(4), 195-220.

Rickson, R., Saffigna, P., Vanclay, F. and McTainsh, G. (1987), 'Social bases of farmers' responses to land degradation', in A. Chisholm and R. Dumsday (eds), Land Degradation: Problems and Policies, Cambridge University Press, Sydney, pp.187-200.

Roberts, D. (1989) 'Trees and taxation', Australian Journal of Soil and Water Conservation 2(1), 11-13.

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

Watson, W.D. and Rose, R.N. (1980), Irrigation issues for the eighties: focusing on efficiency and equity in the management of agricultural water supplies. BAE paper presented at the 24th Annual Australian Conference at the Agricultural Economics Society meetings, Adelaide, 12-14 February.

Williams, C.H. and Donald, C.M. (1957), 'Changes in organic matter and pH in a podzolic soil as influenced by subterranean clover and superphosphate', Australian Journal of Agricultural Research 8: 179-89.

Young, M. (1987), 'Land tenure: plaything of governments or an effective instrument?', in A. Chisholm and R. Dumsday (eds), Land Degradation: Problems and Policies, Cambridge University Press, Sydney, pp.175-86.