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AN ECONOMIC FRAMEWORK FOR EVALUATING RANGELAND RESTORATION OPTIONS

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In recent years there has been increasing concern about the degradation of Australian semi-arid and arid grazing lands. The main forms of degradation identified have been water and wind erosion and associated loss of vegetation and soil salinisation. The most obvious physical effect of degradation is either bare areas of soil or thick infestations of woody weeds. Little is known about the economic significance of this degradation or what, if anything, pastoralists or governments should do about it.

This paper examines the private benefits and costs of restoration options as well as some social implications. It concludes that, from the private standpoint, many techniques are too expensive relative to the gains in productivity they provide. An exception is prescribed fire to control woody weeds. There is insufficient information for informed private decision-making on land restoration, and further research into the physical and economic aspects of the problem is necessary.

There is also insufficient information covering the benefits and costs of government involvement in land restoration. Although this paper identifies a number of potential sources of market failure and external effects associated with degradation, no attempt has been made to quantify the social benefits and costs of restoration. For a number of the external effects involved, such as the loss of habitat for wildlife species, reduced ecological diversity of species and loss of amenity values, quantification would require evaluation techniques such as contingent valuation surveys, which are still in their infancy. Nonetheless, it is only through a better understanding of these social costs and benefits that governments will be in a position to assess the overall benefits and costs of land restoration initiatives.

Introduction

Although there is much uncertainty regarding the extent of degradation in Australia's semi-arid and arid regions, it has been estimated (see Table 1) that about 1.8 million square kilometres used for pastoral production is subject to some form(s) of degradation (Chartres 1987). The main types of degradation are water and wind erosion, damage to or loss of vegetation and soil salination (Woods 1983; Chartres 1987).

The existence of land degradation is not in itself an economic argument for private landholders or government to prevent further degradation or invest in land restoration. Justifying such action, either on a social or private basis, will require an understanding of the costs and benefits of preventing degradation and of restoring degraded rangelands (Blyth and McCallum 1987; Kirby and Blyth 1987a). But, as Sinden, Sutas and Yapp (1986) noted, there has never been a comprehensive assessment of the opportunity costs of land degradation in Australia. Individual assessments of the potential economic benefit that might accrue to specific rangeland restoration technologies are also relatively scarce and of variable quality (MacLeod 1989; MacLeod and Johnston 1989). Therefore, it is not possible to assess on the basis of existing information whether it is economically viable for private landholders to restore degraded rangeland resources. Nor is it possible at this stage to answer the equally important question as to whether or not net social benefits can be expected from government involvement in rangeland restoration. This is an issue of growing importance, given the increase in public interest in the general question of land degradation in recent years.

This paper presents a cost-benefit framework for examining the potential economic merit of private investment in rangeland restoration. This framework, if adopted by rangeland economists, will provide a more consistent and accurate assessment of rangeland restoration than has been evident to date. In this paper the framework is applied to several specific restoration techniques, providing a general guide to the economic

TABLE 1

Physical Degradation Status Of Semi-Arid and Arid Lands (1975)

Form of degradation	Area	
	'000km^2	%
Area in use	3356	100
Area not requiring treatment	1 506	45
Area affected by:		
Vegetation degradation and little erosion	950	29
Vegetation degradation and some erosion	467	14
Vegetation degradation and substantial erosion	284	8
Vegetation degradation and severe erosion	148	4
Dryland salinity	1	<1
Total area affected	1 850	55

Source: Chartres (1987).

feasibility of private restoration investments. The paper also examines whether there is a case for government involvement in rangelands restoration. While a number of external effects from degradation can be identified, the paper concludes that there is at present insufficient information about their relative importance to the wider community to draw any firm conclusions regarding the nature and extent of public involvement in land restoration. Further research to quantify the social benefits and costs is required, and some suggestions are made as to how this might be done.

Rangeland Degradation Defined

There are significant scientific and technical problems in assessing the impact of degradation on the present and future productivity of rangelands. There are many physical and biological techniques which can measure and monitor the extent and severity of the degradation and scope for restoration, but there is no general agreement on what 'degradation' is and, hence, what is to be restored.

One definition which captures the economic dimension of land degradation is that of Dumsday (1986, p.57), which includes 'those adverse effects that land uses may have on the services provided by land'. That is, degradation reduces the capacity of rangeland to produce goods and services of value to society. Within the context of the extensive livestock production that dominates rangeland use, any assessment of land degradation will be directed primarily toward measuring the lost capacity to produce livestock and their products in the longer term. Most private land users see restoration as action taken to offset or reverse processes that limit livestock production at present and in the future.

Rangelands also possess values beyond pastoral production. Their vast expanse and diverse flora and fauna are important to the wider community (Australian Conservation Foundation 1983; Harrington, Wilson and Young 1984). Livestock grazing and other non-pastoral activities, such as mining and tourism, can alter the status of resources, leading in some cases to degradation. Analyses of rangeland restoration economics should be conducted on a broader social scale and account for both lost pastoral productivity and other resource values. Despite some theoretical advances in this area, there has been little practical application of such analysis. This issue is taken up in the final section of the paper.

Evaluation of Restoration Options

The formal economic technique of benefit-cost analysis is widely accepted as providing the most effective framework for assessing the effects of alternative private land investment decisions. These include investments aimed at preventing or slowing the degradation processes or restoring the land to some former state or equivalent level of productivity. Our review of the literature on restoration options indicates, however, that there is not general agreement on the range of categories of benefits and costs and the methodology for their measurement. While this causes some difficulties in analysing the benefits and costs to private land users, the conceptual and practical measurement problems in gauging their impact on the wider community are even more pressing.

Investment appraisal criteria

Like many agricultural developments, rangeland restoration involves streams of benefits and costs over a number of years which must be compared. The traditional economic method used to do this is 'discounting' in order to maximise either the net present value of these streams, the benefit-cost ratio or the internal rate of return (Chisholm and Dillon 1971). Under certain limiting assumptions, these criteria are equivalent and will rank projects consistently. But in many instances the criteria will not provide a consistent ranking, and a choice is necessary according to the purpose of the analysis.[1]

This analysis evaluates the economic feasibility of a given restoration technique from the private pastoralists' perspective. Three investment criteria are used: net present values, benefit-cost ratios and the internal rate of return.

Private Economics of Rangeland Restoration

Any evaluation of the private economics of a restoration project should focus on the individual benefits and costs and how they are to be valued. An ideal approach would be a broad systems approach, which assesses the benefits and costs in terms of the entire economic performance of the property. Unfortunately this method is generally unworkable on account of its complexity and the unavailability of adequate data. It is also less useful as a general guide because of the extreme heterogeneity of pastoral properties in the rangelands. A multi-period variant of the partial budgeting technique (Rickards and McConnell 1971), which restricts its analysis to a component of the property such as a paddock or group of animals, is a more feasible approach.

Any benefit and cost analysis of a rangeland restoration investment should include:

(1) the specific cost of the restoration, including the initial treatment costs and any other costs incurred to reinforce the treatment, or for subsequent maintenance;

(2) any improvements in profitability of the existing activity relative to the base period, before the initial treatment was applied, if that activity is retained;

(3) any improvements in profitability resulting from the introduction of a new activity that becomes feasible as a result of the treatment, relative to the former activity during the base period;

(4) any future loss of profits from the existing activity relative to the base period caused by not implementing the treatment;

(5) the cost of buying capital items needed to expand the level of an existing activity or introduce a new activity; and

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[1] Readers interested in pursuing these issues are directed to the extensive literature that now exists. A useful starting point would be the general surveys of Prest and Turvey (1965), Mishan (1971) and Layard (1972) or the more recent work of Sugden and Williams (1986) and Chisholm (1987a).

(6) the salvage value of any capital items acquired and the net appreciation in the value of land and fixed improvements at an appropriate future date.[2]

This approach measures the difference in net profitability between the existing system and the treated system. It takes into account treatment costs and the need to optimally adjust resources to the new environment. It contrasts with a more traditional approach which typically makes a static comparison between the net return of an activity in the presence and absence of a treatment and which gives limited consideration to the adjustment costs of moving between the two states (Noble 1986; Clarke 1987). The static approach will overstate the potential net benefit to be gained from any restoration investments and, in extreme cases, will imply that projects are economically feasible when they are not.

Ideally, any private evaluation of a typical rangeland restoration project will quantify the extent, timing and value of each category of benefit and cost listed in Table 2. Unfortunately, while some of the studies on rangeland restoration techniques have adopted variants of this approach, no single study has incorporated all of these categories. A more widespread adoption of this framework by rangeland economists will provide a more consistent and more comparable treatment in future. They may also be usefully applied to scientific research trials aimed at demonstrating the feasibility of a restoration technique.

Case studies of restoration options

This section examines eight options for restoring pastures severely encroached by woody weeds and one technique for the reclamation of scalded land. The options cover a range of methods proposed for semi-arid and arid rangelands and for which a formal economic assessment has been attempted. The specific activities are: prescribed fire; chemical control; goats; chain clearing plus sowing pasture; chain clearing, burning plus sowing pasture; blade plough; land purchase; and water ponding. The individual categories of benefit and cost items included in the case studies on which this paper draws are listed in Table 3.

Data derived from the case studies have been reworked, where possible, to provide a common basis in order to compare the private economic value of the techniques, but inconsistencies among the original researchers' approaches could not be entirely eliminated, and the results must be viewed as indicative rather than definitive.[3] This assessment excludes financing

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[2] Estimation of the life of a 'project' can be a subjective process. A common convention is to project benefits and costs into the future to a point at which the activity has reached a relatively steady state. Future net benefits are captured in the net difference between salvage value of land and other assets in the treated and untreated states at the nominated terminating point.

[3] Selection of examples was based on a search of the relevant literature and/or personal contact with individuals known to the authors to have been working on an assessment of a particular technique. The reference to 'inconsistencies' is by no means intended to imply criticism, but rather to simply acknowledge that differences in approach existed. The terminating lump sum net benefits are not shown on the profiles in order to avoid scaling problems.

TABLE 2

Private Benefit and Cost Categories for a Typical Rangeland Resource Restoration Technique

Benefits
Increased livestock production - per animal
- stocking rate
Improved livestock handling
Temporary livestock sales
Increased value of land
Increased value of livestock
Decreased taxation liability

Costs
Treatment cost - initial
- follow up
- maintenance
Grazing income foregone
Additional capital - livestock
- other
Financing costs - interest
- principal
Increased taxation liability

costs and taxation considerations. Though they can have an important impact on the economic feasibility of private restoration projects, there was insufficient data in several of the original studies to allow a common base for comparison. Several projects were uneconomic from the private viewpoint even with financing and taxation considerations excluded.

The financial outcome for each option is presented in Table 4. The six columns contain the non-discounted cumulative net benefit (net present value, NPV), the NPV when the benefit and cost streams are discounted at real rates of 5 per cent and 10 per cent, benefit-cost ratios for the same two discount rates, and internal rate of return (IRR). The first column is the simple undiscounted sum of the net benefit streams for each option. The other columns use discounting procedures to bring cost and benefit streams to a common point in time.[4]. The net benefit profiles for each of the restoration options is illustrated in Figures 1 to 8. The differing time periods shown in these figures are due to differences in the periods selected in the original

[4] The choice of a real private discount rate of 10 per cent is based on real interest costs at the time of writing. The 5 per cent rate was included to reflect the longer term trend in real interest costs. A range of alternative discount rates can be tested, but the authors believe this would lend a false sense of precision to the analysis, given the necessarily tentative nature of the comparison between the options.

TABLE 3

Benefit and Cost Categories Incorporated in Case Studies

Category	Fire (a)	Chem- ical (b)	Goats (c)	Clear + sow (d)	Clear burn + sow (d)	Blade plough (d)	Buy land (d)	Water pond (e)
<u>Benefits</u>								
Extra livestock production								
- per animal	*	*	*					*
- stocking rate		*	*	*	*	*	*	*
Easier livestock handling	*							
Temporary livestock sales	*	*	*	*	*	*		
Capital sales								
- land	*	*						*
- livestock		*						*
Taxation savings								*
<u>Costs</u>								
Treatment cost								
- initial	*	(f)		*	*	*	*	*
- follow up	*	(f)		*	*	*		*
- maintenance		(f)	*	*	*	*		*
Grazing income foregone	*	*		*	*	*		
Capital purchases								
- livestock		*		*	*	*	*	*
- other assets							*	*
Finance costs								
- interest				*	*	*	*	*
- principal				*	*	*	*	*
Extra taxation								*

(a) Burgess (1987). (b) Burgess and Murphy (1989). (c) Davies (1986). (d) Murphy (1989). (e) Penman (1987). (f) The chemical study adopted a 'parametric' approach whereby chemical treatment and follow-up costs were excluded from the analysis. The maximum amount that could be spent on a chemical control program was then inferred from the net balance between the remaining benefit and cost items.

TABLE 4

Cumulative Net Benefit Assessed for Case Studies(a)

Treatment	Net present value(b)			Benefit-cost ratio(b)		
	0%	5%	10%	5%	10%	IRR
	$/ha	$/ha	$/ha			%
Prescribed fire	31.1	15.61	8.38	6.8	4.6	42.8
Chemical control	-43.67	-53.29	-59.46	0.3	0.2	-10.2
Goats	5.22	4.25	3.56	N/D	N/D	N/D
Clear + sow pasture	28.11	20.12	14.12	2.6	2.1	32.3
Clear/burn + sow pasture	37.07	23.84	14.18	2.2	1.8	26.2
Blade plough	3.94	-18.35	-33.87	0.8	0.6	0.8
Buy land	90.30	48.76	22.04	1.9	1.4	16.6
Waterponding	26.93	-2.78	-17.70	0.9	0.6	4.4

(a) Excluding debt servicing and taxation. (b) At discount rates shown.
N/D = not defined (nil cost items for denominator).

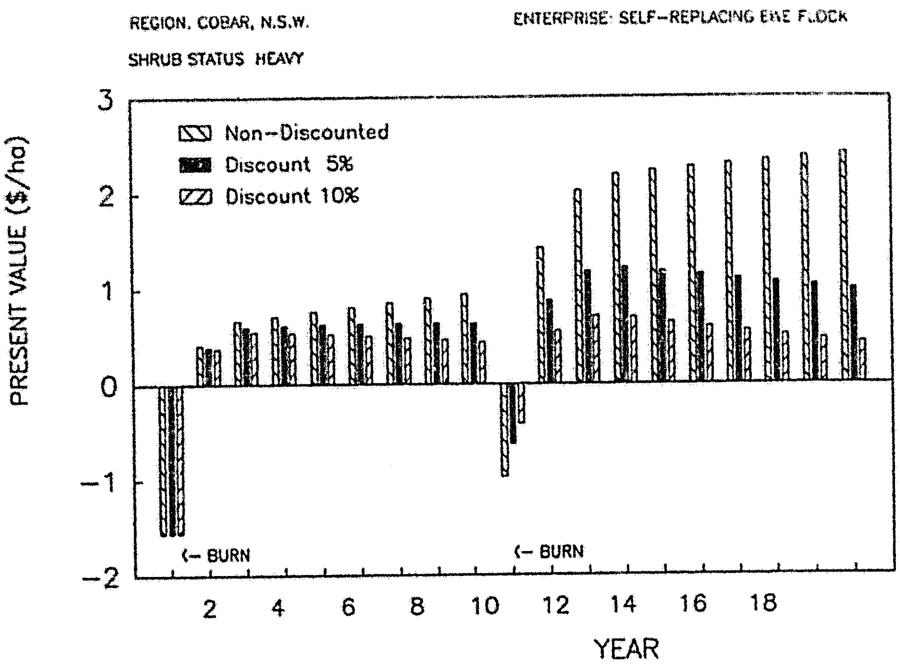
studies. A capitalisation procedure has been adopted for each case to capture the net benefits from the terminating year into perpetuity.

On the basis of the net present value of the benefit and cost streams summarised in Table 4, chemical control, blade ploughing and water ponding are not economically viable for private land users. Each has a negative net present value, largely due to the initial high treatment costs relative to the subsequent production gains expected as a result of the treatment. Even if an important benefit has been excluded, it would have to provide a very high positive impact in order to alter this conclusion.

The goat and land purchase options appear to be marginal and were included mainly to provide a better coverage of the options commonly canvassed for rangeland restoration. A more detailed analysis would be required to fully evaluate these options. For example, in the land purchase option, consideration should be given to the potential increased flexibility in enterprise selection and management afforded by a larger holding. The goat option originally considered by Davies (1986) was primarily concerned with examining the potential for substituting cashmere for wool production, with shrub control cited as a further, unquantified benefit.

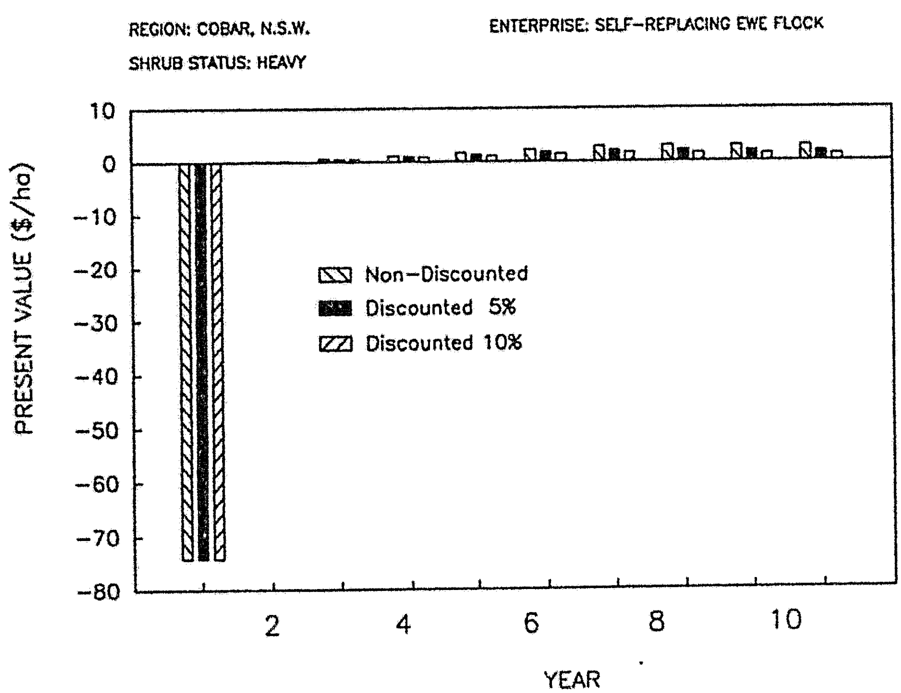
Of the remaining options, prescribed fire and clearing and pasture sowing with and without a fire treatment appear to be economically feasible, although financing costs and taxation considerations are excluded. The adjusted annual net benefit profiles for these options are illustrated in Figures 9 to 11. The effect of including the cost of financing was examined by assuming that the treatment was fully financed by a five-year loan at a real interest rate of 10 per cent. The result, presented in Table 5, suggests that only the prescribed fire option would remain economically worthwhile.

FIGURE 1 - Benefit-Cost Profile: Prescribed Fire



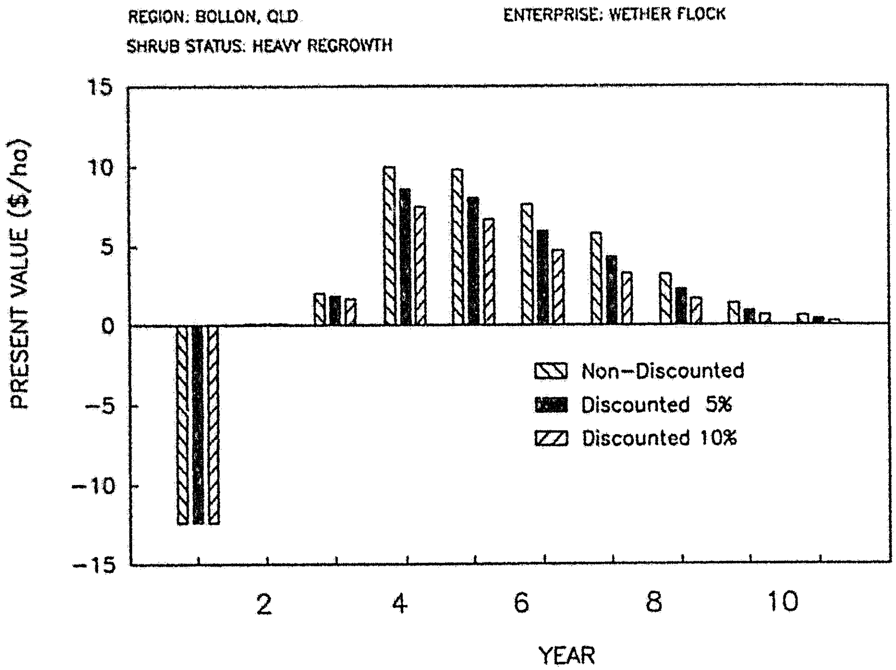
SOURCE: BURGESS (1987).

FIGURE 2 - Benefit-Cost Profile: Chemical Control (Tordon)



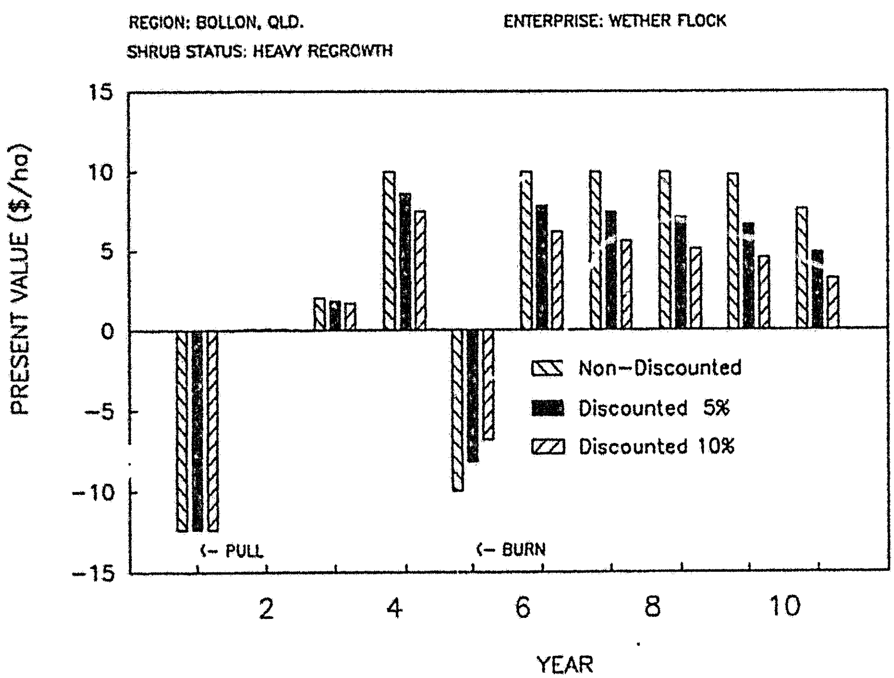
SOURCE: BURGESS AND MURPHY (1989).

FIGURE 3 - Benefit-Cost Profile: Mechanical Clearing Plus Sowing Buffel Grass



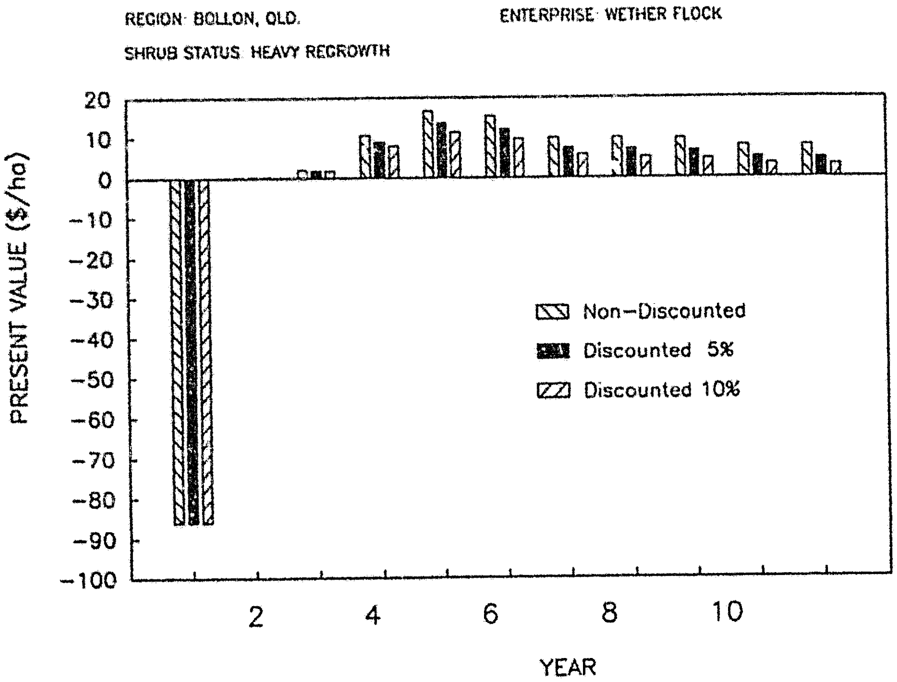
SOURCE: MURPHY (1989).

FIGURE 4 - Benefit-Cost Profile: Mechanical Clearing Plus Follow-Up Burn



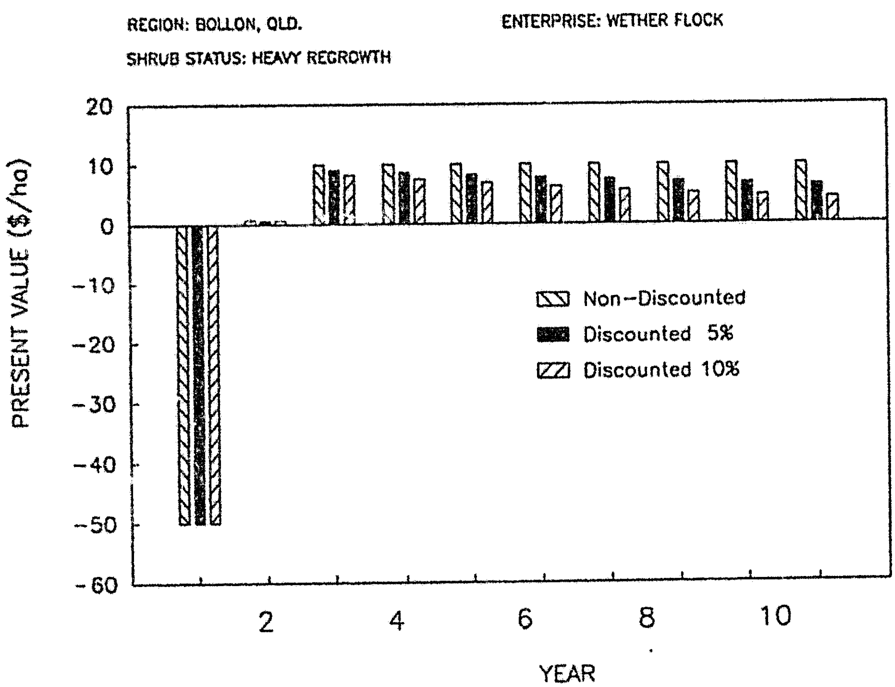
SOURCE: MURPHY (1989).

FIGURE 5 - Benefit-Cost Profile: Blade Plough



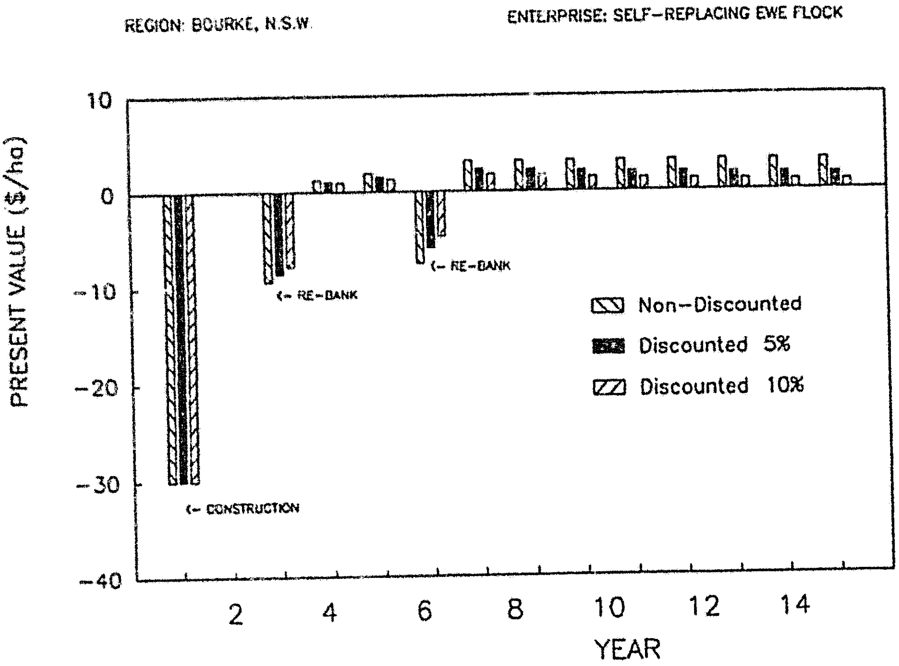
SOURCE: MURPHY (1989).

FIGURE 6 - Benefit-Cost Profile: Land Purchase



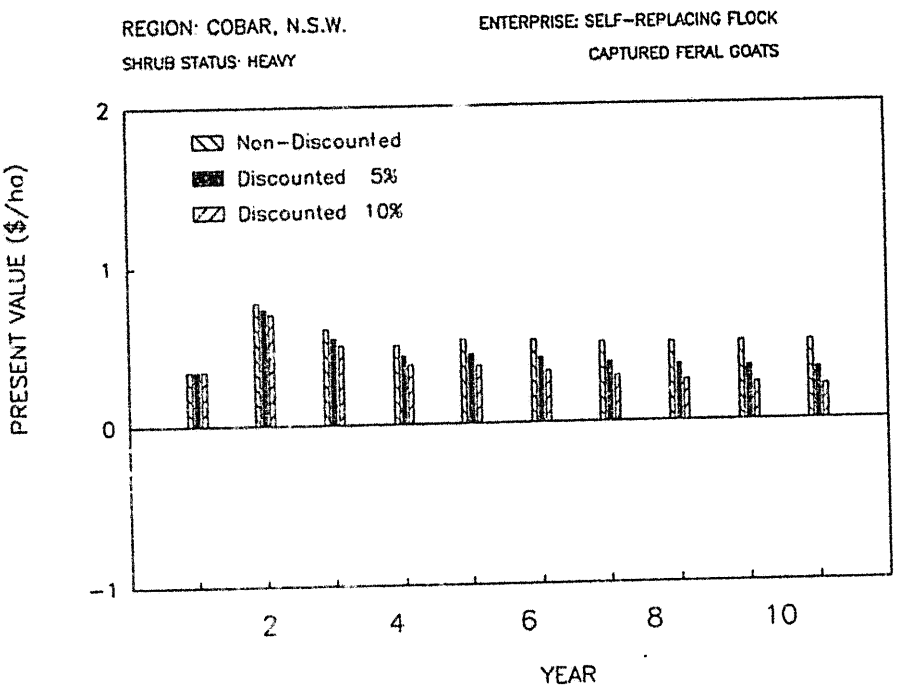
SOURCE: M''RPHY (1989).

FIGURE 7 - Benefit-Cost Profile: Water Ponding



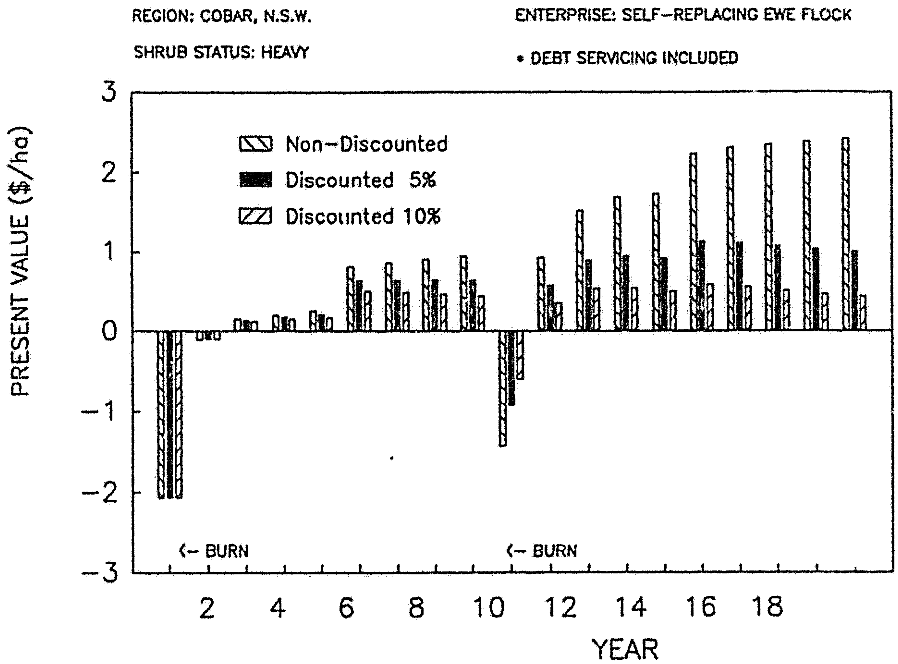
SOURCE: PENMAN (1987).

FIGURE 8 - Benefit-Cost Profile: Cashmere Goats



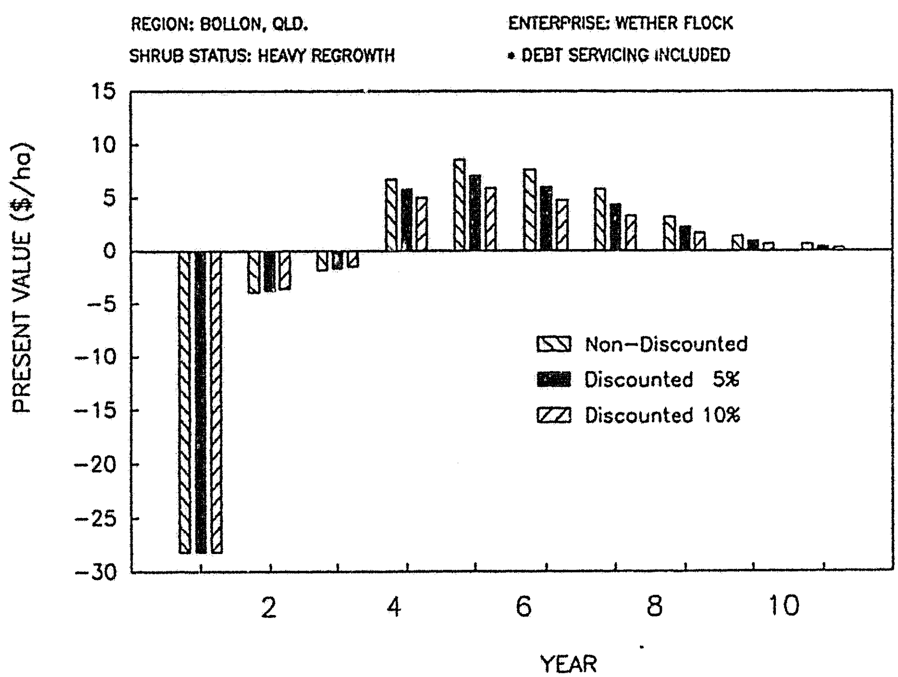
SOURCE: DAVIES (1986).

FIGURE 9 - Benefit-Cost Profile: Prescribed Fire (Including Debt Servicing Costs)



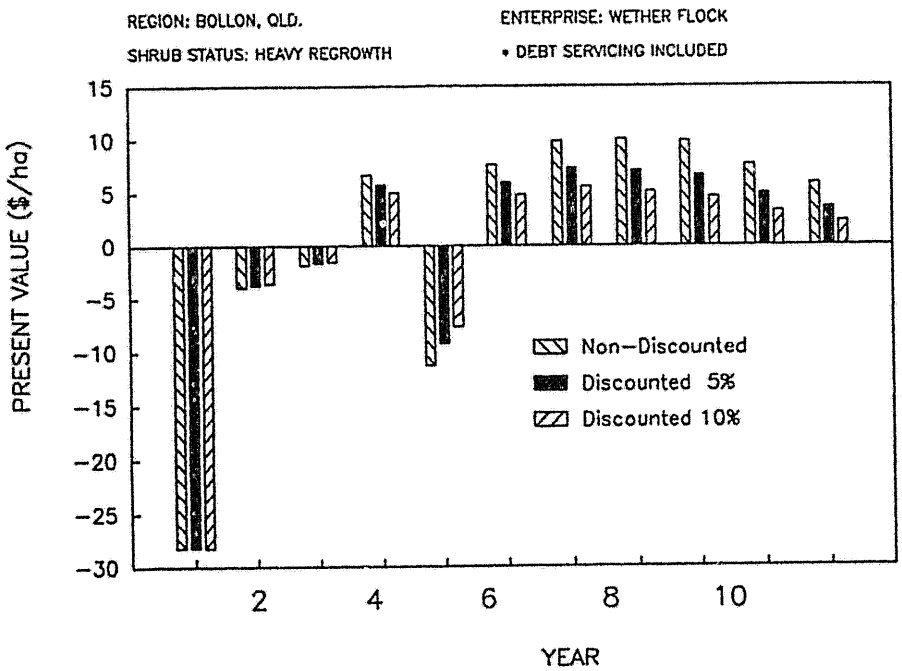
SOURCE: BURGESS (1987).

FIGURE 10 - Benefit-Cost Profile: Mechanical Clearing Plus Sowing Buffell Grass (Including Debt Servicing Costs)



SOURCE: MURPHY (1989).

FIGURE 11 - Benefit-Cost Profile: Mechanical Clearing Plus Follow-Up Burn (Including Debt Servicing Costs)



SOURCE: MURPHY (1989).

This result is due to the low initial treatment cost of prescribed fire relative to mechanical clearing. The final choice of treatment would depend on several factors, including the risk of the treatment failing and its suitability for a particular region. For example, prescribed fire is potentially a more risky option than mechanical clearing because 'ideal' conditions for prescribed burning are only occasionally available, but for many regions, such as the semi-arid woodlands of western New South Wales, it is the most feasible treatment given the lack of suitable pasture (Noble, Cunningham and Mulham 1984).

TABLE 5

Cumulative Net Benefit Assessed for Selected Case Studies(a)

	Net present value(b)			Benefit-cost ratio(b)		
Treatment	0%	5%	10%	5%	10%	IRR
	$/ha	$/ha	$/ha			%
Prescribed fire	26.01	11.80	5.35	2.8	2.0	22.9
Clear + sow pasture	-0.15	-6.92	-11.89	0.8	0.7	-0.1
Clear/burn + sow past.	12.14	-1.57	-10.50	0.9	0.8	4.3

(a) Including debt servicing and excluding taxation.

While most restoration techniques examined represent poor economic value for broad area application, there may well be small 'niches of opportunity' within the rangelands that may be physically amenable to treatment and that are economically viable. Unfortunately no formal economic analyses of such applications are available, though a few reports suggest positive net economic benefits in certain circumstances (Cunningham 1978; Walker 1982; Condon 1986).

These results are only indicative of the potential value of the respective treatments. A definitive statement of the private economic value of rangeland restoration requires a more detailed analysis. Each treatment needs to be comprehensively considered in terms of the cost and benefits outlined in Table 2 as well as the risk of the of the treatment not succeeding. Risk has been a relatively neglected issue in the literature so far, and requires more attention in future studies.

Public Economics of Rangeland Restoration

Social benefit-cost analysis is similar in logic to private benefit-cost analysis. It differs in that it appraises all benefits and costs of a proposed course of action from the viewpoint of the wider community (Mishan 1971). It also separates the incidence and impact of different benefit and cost items between individuals and groups. For example, unlike the private case, social benefit-cost analyses commonly cover cases where benefits and costs accrue to quite different groups within society, with the result that intergroup comparisons are involved.

A positive net social benefit is accrued when the benefit to one or more groups from an action exceeds the compensation required by other groups in order to be no worse off. So when a social benefit-cost analysis is conducted several additional factors need to be considered, including issues of 'market failure' and the net benefits to be gained from intervention.

Market failure

In the absence of any externalities (see below), and if land and capital markets are functioning efficiently, the value of rangeland will be determined by the net present value of benefit and cost streams when the rangeland is put to its most profitable private use. Providing that adequate property rights and information exist, individuals wanting to maximise their present and future income would be expected usually to avoid degrading management practices and, where it is profitable, to adopt restoration techniques (Edwards 1986; Chisholm 1987a).

Many cases emerge where the objectives of private land users and the general community are similar. In these cases, rangeland usage that maximises the present net worth of individuals will collectively maximise the present value of net benefits to the community. But instances of 'market failure' can arise where private and social interests diverge. The collective action of individuals responding to market signals, under these circumstances, may lead to sub-optimal land usage for the community.

The existence of market failure is commonly cited as justification for public intervention in rangeland decisions to ensure that community interests are safeguarded (Workman 1984; Young, Gibbs, Holmes and Mills 1984; Auld, Menz and Tisdell 1987). But public intervention may fail to improve the net level of community welfare if the costs of intervention exceed the benefits (Kirby and Blyth 1987b). The potential sources of market failure, which are of direct importance to the social merit of rangeland restoration, are now discussed. Chisholm (1987b) identified several sources of market failure, including imperfect information, imperfect capital markets, intergenerational equity, externalities or spillover effects, irreversibilities and economies of scale. These are discussed below.

Externalities

Externalities exist when individuals decide on a course of action without considering the impact it has on other parties (Bator 1958). Though the effects of rangeland degradation are mostly on-site (Noble et al. 1984; Chartres 1987), there are several important sources of off-site costs. If these spillover costs were considered by private land users, different and socially more preferable decisions could result (Musgrave 1983; Chisholm 1987b; Upstill and Yapp 1987).

There are many examples of externalities associated with rangeland degradation. Productivity may be reduced through spread of vermin and noxious weeds or by dryland salinity of adjacent areas. The quality of watercourses may deteriorate through stream salinity or flood damage. The aesthetic quality of the landscape may be diminished, wildlife habitats lost or ecological diversity reduced.

Little is known about the relative importance or value of these effects. Problems such as vermin and noxious weed spread and dryland salination affect the productivity of the land and will directly concern land users. The wider environmental effects may be of greater interest to the wider community, although little is known about the Australian community's values in this area.

A range of techniques has been developed to quantify environmental values in monetary terms, although their application has been limited in Australia. Young (1989) classified environmental 'goods' into three categories:

(1) well functioning markets, such as a national park, where the user can be charged a price which reflects the demand and supply conditions for the good;

(2) unpriced environmental goods, such as a wilderness, where the existence of complementary or substitute goods may allow the value of the good to be estimated;

(3) other unpriced environmental goods, such as threatened species, for which only hypothetical or experimental markets can be used to estimate a contingent value.

The method of valuing externalities needs to be tailored to the good in question. The impact of land degradation on productivity and the quality of watercourses can be valued by using opportunity cost methods. The external costs of vermin, noxious weeds and dryland salination can be estimated by the cost of returning the land to its previous productive levels or the cost of repairing infrastructure damaged by excess runoff and soil movement.

The effect of land degradation on wider social issues, such as the preservation of species, does not have any close private market substitutes or complements, so contingent valuation methods would need to be used. This involves questioning individuals in a survey or experimental setting, to gain their personal valuations of changes in the availability or quality of unpriced goods (Johnston 1982). Potential problems of bias, such as overstating willingness to pay when actual payment is not extracted, can be minimised by careful questionnaire design and testing (Cummings, Brookshire and Schulze 1986; Loomes and Walsh 1986). Jakobsson and Dragun (1989) reviewed contingent valuation surveys and encouraged their use in the environmental area.

Irreversibilities

Rangeland degradation can lead to irreversible effects such as physical and chemical damage to the soil, loss of flora and fauna and, in some extreme cases, the loss of complete ecosystems. An important consideration is that future generations may regret past land use decisions (Krutilla and Fisher 1975; Chisholm 1987b). The preservation of some land, the use of which is technically or economically irreversible, may carry a positive value beyond that conventionally measured by its immediate consumption value. This 'option value' could be thought of as an insurance premium to retain the possibility of using non-degraded resources in the future.

Chisholm (1987b) distinguishes this option value from existence values. An existence value is the intrinsic value placed on the knowledge simply that a resource exists in a natural or unspoiled state. Both option and existence values are important considerations for the amenity value of rangeland such as natural landscapes or rare species of fauna and flora. These values are likely to increase as the stock of non-developed natural resources declines and as income, education and the degree of urbanisation of society change (Krutilla and Fisher 1975).

A social benefit-cost analysis should consider any irreversible effects of a decision. Otherwise, socially unwarranted land usage may be adopted, and avoidable costs may be incurred.

Economies of scale

Economies of scale occur when the unit cost of producing goods or services decreases with increasing volumes of output (Tisdell 1982). In an economy this situation occurs when a given level of production or service can be provided by one or several large scale producers at a lower total cost than the aggregate cost of distributing production between a large number of individuals operating on a small scale.

Economies of scale can be a source of market failure at several levels of rangeland management. At the operational level, economies of scale may prevent certain restoration techniques being adopted by individual land users (Chisholm 1987b). Though there can be scope for small groups of individuals to cooperate in activities like technical workshops, buying groups and machinery syndication, benefits may also be derived from public intervention for large scale projects. The costs and benefits of public provision need to be compared with the private alternatives.

Tisdell, Auld and Menz (1984), in a study of weed control economics, introduced the concept of 'density dependence' in damage functions. For example, the aggregate loss from native shrub encroachment may be greater when damage is spread at relatively low densities across the landscape than when the same level of damage is confined to a smaller area. As many forms of control involve costs which are directly proportional to area rather than to damage intensity, it may be non-economic for broad area control to be applied by individuals. Public action, which can exploit economies of scale, may be warranted.[5] Such programs can be fully or partly funded by levies on individual land users.

Imperfect capital markets

If graziers believe they will be unable to capture the full value of the capital improvements associated with rangeland restoration, they may not invest in restoration to the socially desirable level. Since most rangelands are leased, this issue may be significant.

A number of states have recently moved to establish long term leases for rangelands. This decision follows a long period of highly variable lease periods and conditions when many were issued for the relatively short term of 10 or 15 years often with resumption clauses. These leases also contained covenants which allowed graziers to capture the value of capital improvements upon sale, but not increased value of the basic land resource. Such a policy has deterred rangeland restoration in the past and could have contributed strongly to the degradation in the zone. Since most states are moving to 99-year or perpetual leases and have removed restrictions on re-sale of leases, this source of market failure should have diminished.

Imperfect information

There is a lack of information on both the private and public costs and benefits of rangelands restoration which may be hampering efficient private and public decision making on this issue.

The case for government intervention based on imperfect information depends on proving that the private sector will not invest sufficient resources in information gathering to allow informed decisions on rangelands restoration. For private decisions on the economic feasibility of restoration, graziers have a strong incentive to collect information and, should this be deficient, to encourage the necessary research among public research agencies to fill the information gaps. Thus, research into the private costs and benefits of rangeland restoration should be well supported, provided that governments continue to intervene to overcome any difficulties with the collection of funds.

But there are many unanswered questions concerning the economic feasibility and risk associated with rangeland restoration. This raises the question of why restoration research has received relatively little attention. One explanation may be that until the recent change in lease conditions, private graziers had little incentive to invest in restoration. The net economic benefits were likely to have been marginal and the value of improvements in land conditions would not accrue to them upon resale of their leases. This situation has now changed, and there appears to be growing interest in applied research into these issues.

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[5] This is a classical case for the justification of public support for the biological control of certain pest species such as rabbits and exotic weeds. Biological control costs are largely independent of the area covered, and so unit cost will fall as the size of area treated increases (Auld et al. 1987).

Regulatory failure

In addition to ensuring that an appropriate level of private rangeland research is undertaken, governments will be interested in the social benefits and costs of research into restoration. Of particular significance in this regard is additional research into the importance of external effects, potential irreversibilities and economies of scale. Until better information is available on the importance of these effects, the appropriateness of government intervention to correct rangeland degradation remains speculative.

Kirby and Blyth (1987b) reviewed in detail the concept of regulatory failure, which occurs when government action to redress market failure fails to result in net gains in community welfare. The principal tenet of the regulatory failure argument is that when the benefits are less than the costs of public intervention, the outcome leads to a greater divergence from the theoretically most efficient allocation of resources than would occur under a non-regulated private market outcome. Therefore, the existence of market failure is not a sufficient ground for public intervention. A net gain must accrue to justify intervention. This is consistent with the argument of Blyth and McCallum (1987) that the existence of degraded land alone does not provide sufficient evidence of market failure. The real economic issue is whether the rate of degradation is socially optimal given all considerations, including the cost of regulation. A social benefit-cost analysis will ideally include the net benefit, both on-site and off-site, of allowing resource degradation to proceed at its present rate, when compared to restoration. It should also include the cost of repair and abatement of off-site damage.

The traditional approach to public intervention is to legislate so as to 'internalise' the external effects. This forces private land users to act as if they were bearing the full social cost of their action.[6] But some significant problems can emerge when seeking such solutions. The large number of private individuals involved, the scale and isolation of the region, the associated administration, policing and compliance costs and 'free rider' problems can reduce the effectiveness of public intervention policies (Demsetz 1967; Cheung 1971; Chisholm 1987a).

A social benefit-cost analysis needs to compare the effectiveness of different forms of regulation on private land use relative to the net gain achieved by a non-regulated system. Chisholm (1987a) argues that an efficient level of conservation will occur when the sum of the total damage, both on-site and off-site plus abatement and restoration costs, is minimised. Whether this is best achieved by taxes, subsidies or regulation depends on a benefit-cost evaluation of the options and better information on the severity of the social problem. Much more work is needed on these issues.

Conclusions

Case studies suggest that the economic attractions of rangeland restoration, with exceptions such as prescribed fire, may be limited. This particularly applies when the cost of financing the restoration is included. Since the analysis was based on limited data, however, the conclusion is only

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6 An extensive literature exists on the potential role of government intervention via fiscal and regulatory action to correct sources of market failure due to externalities. Interested readers are initially directed to the work of Coase (1960), Turvey (1963) and Chisholm, Walsh and Brennan (1974).

indicative. Further research is needed to define more adequately the benefit and cost profiles and the risk associated with different restoration options.

More work needs to be done on quantifying key biological and financial relationships of rangeland restoration and to provide a more precise statement on the private benefits and costs. This can be achieved only through close cooperation between rangeland scientists and resource economists, and may require closely coordinated multi-disciplinary research.

When the analysis is extended to a wider social context there is the potential for market failure when decisions on rangeland usage are left to private land users. While such market failures often call for public intervention, the possibility of regulatory failure is also an important consideration.

The preceding review has identified a number of potential sources of market failure. Divergences between private and social values can arise from a number of sources. The most important external effects appear to be:

(1) spillover affects associated with vermin and noxious weed spread and dryland salination;

(2) spillover effects of water and wind erosion on soil losses and associated downstream effects;

(3) loss of habitat for wildlife species and reduced ecological diversity of species; and

(4) impaired aesthetic characteristics of the landscape.

Research into the public aspects of rangelands restoration remains a neglected area, and more effort should be made to investigate these issues. Priority should be given to quantifying the economic significance of the externalities involved by using opportunity cost, contingent valuation and other techniques. By gaining a better understanding of the social benefits and costs of restoring degraded land, the potential scope and nature of future government involvement in the issue can be more clearly defined.

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