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PRINCIPLES FOR ASSESSING THE BENEFITS AND COSTS OF RANGELAND RESTORATION PROJECTS

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ABSTRACT

There is a growing community awareness and concern over the extent of physical degradation of rangeland resources. However, the existence of physical degradation does not necessarily provide a compelling economic argument for either private landholders or government taking measures to restore the physical productivity of rangeland resources. To establish the existence of an economic or social problem requires detailed knowledge of the costs and benefits of preventing degradation and of restoring degraded rangelands. Unfortunately, assessments of the potential economic benefit that might accrue to specific rangeland restoration technologies are relatively scarce, of variable quality, and almost invariably useless for purposes of comparison with alternative technologies.

The paper presents a cost-benefit framework for the examination of the potential economic merit of private investments in rangelands resource restoration. It is believed that adoption of this framework by rangeland research scientists and resource economists would provide a greater consistency of approach and provide for more accurate assessments of rangeland restoration investments than has been evident to date. The framework is applied to two specific rangeland restoration techniques. Issues that are relevant to extending the framework to the social investment level are then canvassed.

INTRODUCTION

Much of the Australian research into the restoration of degraded rangelands has been 'biological' in orientation. Limited attention has been given to the 'economic' realities surrounding private rangeland managers faced with decisions concerning restoration of their holdings. The same could said be of the wider issue of whether such action might be warranted from the viewpoint of the general community. Community and 'scientific' attitudes to rangeland restoration seem, at face value, to reflect the normative issue of what ideally should be done, rather than the positive question of what could be reasonably expected of individuals or the community acting in their own self-interest.

The paper addresses issues relevant to the latter question through a benefit-cost analytical framework for the examination of the potential economic merit of rangeland restoration investments. Adoption of this framework by rangeland research scientists and resource economists would provide a greater consistency of approach and provide for more accurate assessments of rangeland restoration investments. Application of the framework is illustrated with respect to two specific rangeland restoration techniques; viz. prescribed fire and waterponding. Issues relevant to extending the framework to the social investment level are then canvassed.

RANGELAND DEGRADATION DEFINED

Dumsday (1) captures the economic dimension of land degradation by including 'those adverse effects that land uses may have on the services provided by land'. That is, degradation reduces the capacity of rangeland to produce outputs that are valuable to individuals and society. Because extensive livestock production dominates rangeland use (2), assessments of rangeland degradation will focus heavily on measurement of lost capacity to produce livestock and their products in the longer term. Most private land users would see restoration investments in this light.

However, rangelands also possess values beyond pastoral production. Their vast expanse and diverse flora and fauna are important to the wider community (3). Livestock grazing and non-pastoral activities (e.g.. mining and tourism) can alter the status of rangeland resources, leading in some cases to degradation. Economic analyses of rangeland restoration projects might then be more appropriately conducted on a broader social scale taking account of 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.

AN ECONOMIC FRAMEWORK FOR EVALUATION OF RESTORATION OPTIONS

While an array of potential restoration technologies exists (4,5), their voluntary adoption on any scale will be conditional on their meeting a basic economic condition. That is, that the investments return more than the value of the resources or opportunities foregone. The formal technique of capital budgeting or benefit-cost analysis provides an effective framework for determining whether a given project meets this condition.

Investment appraisal criteria

Most rangeland restoration projects involve streams of benefits and costs accruing over a number of years which must be compared. The traditional economic method used to do this is 'discounting' (6), to calculate one of three investment return measures; viz. (a) the net present value (NPV) of these streams, (b) the benefit-cost ratio (B/C) or (c) the internal rate of return (IRR). A brief description of the NPV, B/C and IRR formulae is presented in the Appendix.

An investment is regarded as being worthwhile if the NPV of the net benefit stream (benefits minus costs) is greater than zero. This is equivalent to a B/C ratio exceeding unity when the NPV of the benefit stream is divided by the NPV of the cost stream. The IRR is the discount rate at which NPV of the net benefit stream is driven to zero. The IRR measures the effective yield on an investment and can be compared with the return on competing uses for the funds involved. For many circumstances the three criteria are equivalent and will rank projects in the same order of value. Simple standardising routines are available to ensure that the criteria rank alternative investments in a consistent manner (7).

PRIVATE ECONOMICS OF RANGELAND RESTORATION

An ideal procedure would be to take a broad systems approach which assesses benefits and costs in terms of impact on the economic performance of the whole property. Unfortunately this method is rarely feasible because of its complexity and/or limited availability of adequate data. Its value as a general guide is further limited by the extreme heterogeneity of pastoral properties in the rangelands. A multi-period variant of the partial budgeting technique (8), where analysis is restricted to a component of the property (e.g. a paddock or group of animals), is a more feasible approach.

The categories of benefits and costs to be considered 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

(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 (See Appendix).

The evaluation of a hypothetical restoration project involving livestock production would attempt to quantify the extent, timing and value of each category of benefit and cost listed in Table 1.

Table 1. Private benefit and cost categories for a hypothetical rangeland resource restoration technique

Benefits:	Costs:
Increased livestock production	Treatment cost
- per animal	- initial
- stocking rate	- follow up
Improved livestock handling	- maintenance
Temporary livestock sales	Grazing income foregone
Increased value of land	Additional capital
Increased value of livestock	-livestock
Decreased taxation liability	- other
	Financing costs
	- interest
	- principal
	Increased taxation liability

This approach measures the difference in net profitability between the existing system and the treated system, taking into account both treatment costs and the need to optimally adjust resources to the new environment. It contrasts with a common approach that typically makes a static comparison between the net return of an activity in the presence and absence of a treatment with limited consideration given to the costs of moving between the two states. The static approach usually overstates the net benefit accruing to a restoration investment and, in extreme cases, can imply that projects are economically feasible when they are not.

Case Studies of Restoration Options

The benefit-cost procedure is demonstrated by an application to two rangeland restoration options. These are (a) prescribed fire for the restoration of rangeland pastures that have been severely encroached by unpalatable shrubs, and (b) waterponding to reclaim scalded land. These examples are drawn from the available literature and represent cases where a formal assessment was attempted that is reasonably consistent with the framework presented in the preceding section (9,10). The categories of benefit and cost items included in the original studies are listed in Table 2.

Table 2. Benefit and cost categories incorporated in case studies

Treatment:		Prescribed Fire[a]	Waterponding[b]
Benefits:			
Animal production gain	- per animal	*	*
	- stocking rate	*	*
Easier livestock handling		*	
Temporary livestock sales		*	
Capital sales	- land	*	*
	- livestock	*	*
Taxation savings			*
Costs:			
Treatment cost	- initial	*	*
	- follow up	*	*
	- maintenance		*
Grazing income foregone		*	
Capital purchases	- livestock	*	*
	- other assets		*
Finance costs	- interest		*
	- principal		*
Extra taxation			*

[a] Burgess (1987).
[b] Penman (1987).

Data derived from the original studies was reworked to a common basis to provide a comparison of the treatments. However, minor inconsistencies between the respective approaches adopted by the original researchers could not be eliminated and so the results must be viewed as indicative rather than definitive. An initial assessment for each treatment is made on the basis of nil inclusion of financing costs or taxation considerations. While these two items will exert an important impact on the economic feasibility of private restoration projects, there was insufficient data presented in the original studies to allow a common base for comparison.

The financial outcome for each of the options is presented in Table 3. The six columns respectively contain the non-discounted cumulative net benefit, NPV of the benefit and cost streams discounted at real rates of 5 and 10 percent, B/C ratio for the same two discount rates and the IRR. The first column is the simple non-discounted sum of the net benefit streams for each option. The other columns use discounting procedures to bring benefits and costs streams to a common point of time for comparison. The 10 per cent discount rate is based on real interest costs at the time of writing and the 5 per cent rate was included to reflect the longer term trend in real interest costs.

Table 3. Cumulative net benefit assessed for case studies

	Net present value[a]			Benefit-cost ratio[a]		IRR
	0%	5%	10%	5%	10%	
Treatment:	$/ha	$/ha	$/ha	B/C	B/C	%
Prescribed fire[b]	31.10	15.61	8.38	6.8	4.6	42.8
Waterponding[b]	26.93	-2.78	-17.70	0.9	0.6	4.4
Prescribed fire[c]	26.01	11.80	5.35	2.8	2.0	n/a

[a] At discount rates shown.
[b] Excluding debt servicing and taxation.
c Including debt servicing.

Both restoration options have positive cumulative net benefits when no discount factor is applied to the individual cost and benefit streams. However, when the streams are discounted at 5 or 10 percent to allow for a valid basis of comparison with alternative uses of funds, only the prescribed fire technique remains an economic option to a private land user. The impact of including the cost of financing for the prescribed fire treatment was examined by assuming that the treatment was financed 100 percent by a term loan of five years duration carrying a real interest rate of 10 percent. The result (Table 3.) indicates that the option would remain economically worthwhile.

The basis for this result lies in the initial low treatment cost and significant production response attributed to prescribed fire management relative the high cost and modest response for waterponding. However, these results are only indicative of the value of the respective treatments, a definitive statement requiring careful consideration of each category of benefit and cost outlined in Table 2 and the risk of the treatment not succeeding. Risk has been a relatively neglected issue in the rangeland restoration literature and requires more attention in future studies.

A recent study (11) reviewed a range of restoration techniques based on conventional agronomic approaches to shrub encroachment (chemicals, blade ploughing, mechanical clearing) and concluded that, like waterponding, these represented poor economic value for broad area application under the present cost-price regime. However, there may well be `niches of opportunity' that are physically amenable to treatment and that are economically viable. There are no formal economic analyses of such cases apparent, although several reports suggest positive net economic benefits in certain circumstances (12,13,14).

PUBLIC ECONOMICS OF RANGELAND RESTORATION

Social benefit-cost analysis, while similar in logic to private benefit-cost analysis, differs in that it appraises all benefits and costs of a proposed course of action from the viewpoint of the community. 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 public intervention.

Market failure

The objectives of private land users and the general community are often similar and rangeland usage that maximises 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 and the collective action of individuals responding to market signals, may lead to sub-optimal land usage for the community. This is frequently cited as justification for public intervention in rangeland decision making to ensure that community interests are safeguarded (7,15). Potential sources of market failure, which are of direct importance to the social merit of rangeland restoration, are now discussed.

Externalities

Externalities exist when individuals decide on a course of action without considering the impact it has on other parties (16). While the effects of rangeland degradation are mostly on-site (5,17), 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 (3).

For example, productivity may be reduced through spread of vermin and noxious weeds or by dryland salination 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.

A range of techniques has been developed to quantify environmental values in monetary terms, although their application has been limited in Australia. One classification (18) places environmental 'goods' into one of 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 impact of rangeland degradation on wider social issues, such as species preservation has no close market analogues, so contingent valuation methods would be required (19). These involve 'questioning' individuals to obtain their personal valuations of changes in the availability or quality of non-priced goods (20).

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. Future generations may regret past irreversible land use decisions and so the preservation of some land may carry a positive 'option' value beyond that measured by its immediate consumption value (21).

Chisholm (15) distinguishes this 'option' value from 'existence' values which are the intrinsic values placed on the knowledge 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 (21).

Economies of scale

Diseconomies of small scale may prevent certain restoration techniques being adopted by individual land users (15). 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.

Scale economies are also important when there is 'density dependence' in damage functions (22). 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.

Imperfect capital markets

If private land users are unable to capture the full value of the capital improvements associated with rangeland restoration, they are unlikely to invest in restoration to the socially desirable level. Given that most rangeland holdings are leased, this issue is significant.

Several states have moved to establish long-term pastoral leases after many years of highly variable lease periods and conditions, including short terms and uncertain resumption clauses (23). While lease covenants allowed landholders to capture some of the value of capital improvements upon sale, they rarely allowed for increased value of the basic land resource. This policy would have been a strong deterrent to restoration investment and probably a significant cause of much of the existing degradation of pastoral leases.

Imperfect information

The limited information evident on the private and public benefits and costs of rangelands restoration can lead to underinvestment in such projects. However, a case for public intervention (e.g. research or extension) to provide additional information requires proof that the private sector will not autonomously invest sufficient resources in information gathering.

At the private level, at least, there would seem to be a strong incentive for land users to seek information on the economic feasibilty of restoration projects. Free rider problems associated with non-alienability of rights to privately obtained knowledge would also be expected to lead to pressure for publicly sponsored information gathering and dissemination. The fact that restoration research has previously received so little attention warrants explanation, possibly tracing back to the lease tenure problems noted above.

Society will also be interested in the social benefits and costs of additional research into rangeland restoration technology. Until reliable information is available on the importance of the externalities identified in the preceding sections, the appropriateness of government intervention to correct past rangeland degradation will remain speculative.

Regulatory failure

While market failure is important to social benefit-cost analysis, so too is is the concept of 'regulatory failure' which occurs when public intervention fails to result in net gains in community welfare (24). If the benefits of intervention to remove market failure are less than the costs, there is a greater social loss than would occur with a non-regulated private market outcome. This is consistent with the argument of Blyth and McCallum (25), that the existence of degraded land alone does not provide sufficient evidence of market failure.

The real economic issue is whether restoration investment would be socially beneficial given all considerations, including the cost of regulation. A social benefit-cost analysis will ideally compare the effectiveness of different forms of regulation on private land use relative to the net gain achieved by a non-regulated system. Chisholm (15) 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

An economic framework has been presented to assist private and public decision making with respect to rangeland restoration technologies. Adoption of this framework by rangeland research scientists and resource economists would provide a greater consistency of approach and provide for more accurate assessments of rangeland restoration investments than has been evident to date.

Use of the framework was demonstrated via two case studies, which suggest that the private economic value of rangeland restoration is variable. Because the analysis was based on secondary use of limited data the conclusion remains indicative. Further research is needed to define more adequately the benefit and cost profiles, and the risk associated with different restoration options. This requires quantification of the key biological and financial relationships involved with rangeland restoration, to provide a more precise estimate of the level and timing of private benefits and costs. This would be best achieved through close cooperation between rangeland scientists, resource economists and practical land managers.

Research into the public value of rangeland restoration remains a neglected area. More effort should be made to investigate this issue with priority given to quantifying the economic significance of the externalities involved. While such market failure may call for public intervention, the possibility of regulatory failure is an important consideration. With 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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APPENDIX

INVESTMENT APPRAISAL CRITERIA (NPV, B/C RATIO, IRR)

The NPV, B/C ratio and IRR are three commonly applied methodologies for appraising alternative investment projects whose benefits and costs accrue over periods of time.

<u>Net present value</u>
The net present value of differences between the benefit and cost streams of a multi-period investment project, commencing at the present time (year 0) and ending in year N, can then be determined using the following general formula:

$$(1) \qquad NPV = \sum_{n=0}^{N} (B_n - C_n)/(1+i)^n + S_N/(1+i)^N$$

where: NPV = net present value.

B_n = benefit received in the nth year.

C_n = cost incurred in the nth year.

S_N = salvage value of assets at the terminal year (see note below).

i = discount rate.

Note: Estimation of the life of a restoration 'project' is subjective. A common approach is to project benefits and costs to a point at which the activity has reached a 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.

<u>Benefit-Cost Ratio</u>
The B/C ratio is a simple algebraic manipulation of the NPV formula; viz;

$$(2) \qquad B/C = [\sum_{n=0}^{N} (B_n)/(1+i)^n + S_N/(1+i)^N]/[\sum_{n=0}^{N} (C_n)/(1+i)^n]$$

<u>Internal rate of return</u>
IRR is calculated by finding a value for i that satisfies the formula:

$$(3) \qquad \sum_{n=0}^{N} (B_n - C_n)/(1+i)^n + S_N/(1+i)^N = 0$$

The main advantage of the IRR method that there is no requirement to specify an interest rate before performing the calculation. The main disadvantage is that it is more difficult to calculate than the NPV or B/C ratio.