Re-organising farm businesses to improve environmental outcomes - the case of native vegetation on hill country across south-eastern Australia

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Profitable grazing systems used widely since European settlement has been associated with a decline in the extent and quality of native vegetation. In this paper it is shown that, for one farming system, making profit and preserving biodiversity are compatible objectives. Dynamic solutions are available that improve the quality of native vegetation while maintaining or increasing profitability, despite the effects of the continuing cost-price squeeze on grazing businesses.

The method used is based on economic theory of the farm firm. The whole farm approach is apt. Risk and uncertainty are rife; goals are multi-faceted, including growth, survival, entrepreneurship and profit; a range of optimal plans exist; dynamics rule and static equilibrium analyses are insufficient; and the case study approach is valid.

Results are reported for 17 sheep-beef farms in Victorian hill country. Findings are extrapolated to similar hill country across south-eastern Australia. Case study methods were used. Case studies allow generalisation of findings if correctly applied. Analysis of data collected from each farm about vegetation, agronomic potential and farm business situation was used to develop four management strategies that could potentially improve farm environmental outcomes. The strategies were: (1) correcting nutrient deficiencies; (2) intensive rotational grazing; (3) deferred grazing of hill country; and (4) establishing shelter trees by managing for natural regeneration. The first two strategies also involved managing 15% of the farm primarily for biodiversity conservation.

The main finding was that 15 of the 17 farms had at least one investment option that advanced both farmer and environmental goals. Circumstances on each farm meant that profitability of the strategies varied. Correcting nutrient deficiencies was profitable on 12 farms, while at least one grazing strategy was also profitable on 12 farms. These strategies vary in degree of intensification, reliance on natural systems and attainment of environmental goals.

The results are relevant to 10 million hectares of land across south-eastern Australia, of which 4 million are native vegetation, including native pasture.

Implications for environmental policy and for further economic research are discussed.

Key words: Farm businesses, native vegetation, biodiversity conservation, grazing management, investment strategies, profitability,

1. Introduction

Almost all land used for agricultural purposes across south-eastern Australia has been significantly modified in the 200 years of European occupation. While generating significant wealth for Australia, agricultural activity has resulted in changes to flora and fauna, soils, and hydrology that are widespread and well-documented. The extent of past land clearing and continuing intensive and extensive land uses means that important biodiversity assets are under threat (VCMC 2007, Vesk and McNally 2006, Mansergh *et al.* 2006a, 2006b; Commonwealth of Australia 2002, Hobbs and Hopkins 1990). Loss of native vegetation has also contributed to salinity, soil acidity, erosion and loss of water quality (VCMC 2007, Commonwealth of Australia 2002).

Recent approaches of economists to the loss of native vegetation have been two-fold. Most often, economists have sought to calculate the private losses associated with removing development rights (Davidson *et al.* 2006a, 2006b; Sinden 2004, 2005; Lockwood *et al.* 2000; Walpole 1999). The opportunity costs of retaining native vegetation have been based on estimating future income losses or by establishing changes in land values, which reflect the expected future income from farming in areas where the land market is unaffected by purchases in pursuit of lifestyle aims.

A second approach of economists has been to focus on problems of information asymmetry between the public agency seeking environmental outcomes and the landholder who can provide them. Auctions such as BushTender are used to reveal the price that farmers place on forgoing development rights and undertaking specified actions to improve environmental management (Stoneham *et al.* 2003).

In contrast to these two approaches, the focus in this paper is on identifying and analysing options for private investment in grazing management that might also improve environmental management in the hill country of south-eastern Australia.

The area under consideration is the undulating-to-steep landscapes that once supported native grassy woodlands and dry forests in south-eastern Australia and is now largely cleared for livestock grazing. This area is estimated to cover 10 million hectares of hill country (Figure 1), of which six million is in Victoria (M. White and J. Dorrough, unpublished data). Sheep grazing is the primary land use, with some cattle and cropping.

Figure 1: Areas in south-eastern Australia to which results are relevant
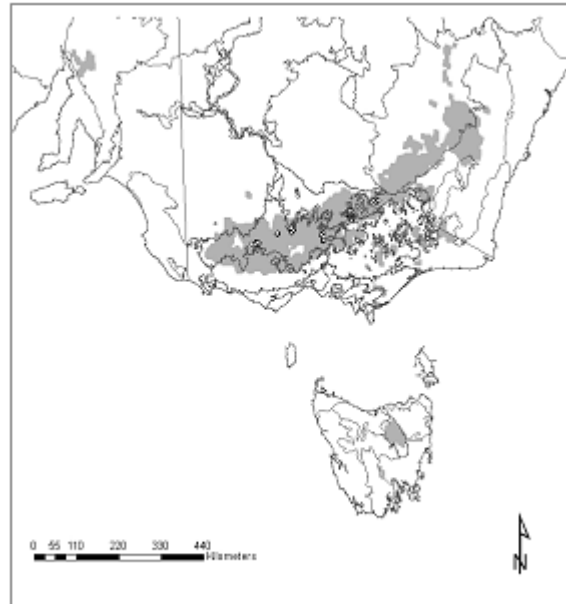
The question to answer is whether there are sound re-organisational strategies that are at least partially compatible with environmental objectives for hill country farms.

A huge 'repair' effort is necessary across the hill country if ecological functions are to be restored. To achieve this, scientists estimate that 30 per cent or more of the landscape should be covered with native vegetation (Vesk and Mac Nally 2006, McAlpine *et al*. 2002, McIntyre *et al*. 2000). This cover is five per cent or lower in many farming areas. Increases in the proportion of perennial vegetation over large areas could improve biodiversity, reduce saline recharge and increase water quality in streams (Lefroy *et al*. 2005). Diverse perennial pastures are also likely to be more resilient to climatic variability than exotic annual-based pastures that lack diversity of species.

Changes to the management of grazing can greatly increase the perenniality of vegetation on farms, and improve the quality of native vegetation (McIntyre *et al*. 2000, Lavorel and Tremont 1995; Kemp *et al* 2000).

If the effectiveness of strategies that potentially contribute to both private and public goals is confirmed, an additional avenue to achieve environmental policy objectives is established. However, farmers may still not adopt such strategies. The extent to which they will do so, without government action in support of public policy objectives, is influenced by many factors (Pannell *et al*. 2005), and is outside the scope of this paper.

Historically, governments in Australia have at different times sought to influence private investment decisions of farmers in order to achieve public policy objectives. Mechanisms include provision of cheap credit, farm adjustment programs and, more recently, initiatives to

build human capacity such as FARM$MART and FARMBIZ in which environmental considerations sometimes play a part.

Like other major investments, those that have environmental benefits may be difficult for farmers to assess and implement. While some strategies, such as applying fertiliser, are expected to deliver quick returns, others are longer-term and uncertain. The latter choices are generally more complex, involving high investment costs, medium-to-long-term changes, and uncertain payoff. Gaps in key information make good estimates of consequences for the farm business difficult. This class of choice includes investing in off-farm assets, buying a neighbouring farm, developing a totally new enterprise, and radically changing production techniques within existing enterprises.

In this paper, we explore major investments in grazing management that potentially have both private and public benefit. These options are compared to the simpler option of increasing the rate of fertiliser application, which might have adverse environmental effects.

The results of applying the four investment strategies to the 17 farms are reported. The approach allows comparisons that are based on alternative futures for these businesses. Before the economic and financial analysis of the four strategies is presented, information is given about the theoretical context; the region; selection of case study farms; the current native vegetation and pasture agronomy on the farms; the four management strategies; and the expected environmental outcomes if they are adopted.

2. Theory

In farm management economics, the complexities that medium-to-long-term investments and risk and uncertainty in farm systems introduce to decision-making have been explored by a number of authors, including Heady (1952), Barnard and Nix (1980), Boehlje and Eidman (1984), Malcolm (2004), Malcolm *et al.* (2005), Pannell *et al.* (2000), Murray-Prior and Wright (2004) amongst others. Related aspects of long-term investment decisions have also been addressed - Kaine *et al.* (2007) on adoption, Rolfe (2002) on design of market-based instruments, Stiglitz (2004) and Tisdell (1972) on availability of information, Cary *et al.* (2002) and Musgrave (1982) on farm adjustment, and Pannell (2005) on incorporating environmental matters into farm planning. The problems are also familiar from other fields of economics, such as business strategy (Porter 1980). Decisions about these investments are not simply another enterprise choice, or a simple response to new signals within existing markets. Leaving aside short-term volatility and changes in climatic conditions that affect the outcomes of short-term farming decisions, there is less known about the possible rate of change or its size in relevant markets. The nature of the decisions require far more attention to business goals (which are usually taken for granted in short-term decision-making), as well as the length of the planning horizon, and implications for asset value. Uncertainty as distinct from calculable risk (Knight 1921, Langlois 1986, Littlechild 1986) becomes a major consideration.

If long-term decision making is complex, understanding more about the internal aspects of the behaviour of the firm is also relevant. The objectives of firms, let alone family-run farms, is rarely simply about profit maximisation (Lane 1991, Leibenstein 1979, Nelson and Winter 1982). Entrepeneurship, survival and growth are equally as important to understanding firm behaviour as competitive response to price signals (Blaug 1997a, Foss and Loasby 1998). Such questions are not only applicable to large corporations, as the literature on entrepreneurial small

firms testifies (Pratten 1991, Reid and Jacobsen 1988). An Australian beef and sheep farmer captures this well: 'we have been fortunate to have the analytical skills to pick up and run with the good ideas before the majority of the industry' (Daniel 2000).

Competition needs to be seen in terms of dynamics and change, not just static equilibrium (Blaug 1997b), and hence there is a strong logic to the heterogeneity of firms (Foss 1997). This line of thinking complements an emphasis on treating the production process as a serious area of economic enquiry (Georgescu-Roegen 1972). There can be several optimal allocations, rather than just one, for any given set of resources (Kalecki 1937). Consistent with this, flat payoff functions have been identified in agriculture, which means there is potentially more than one optimal farm plan (Pannell 2006).

In light of the issues outlined above, case study methods are suitable for investigating long-term investment choices on farms. Case study methods using multiple sources of evidence are important in researching farming systems that typically are complex, influenced by many purposive and ad hoc management decisions, and occur within a context of ill-defined feed-back loops and uncertainty. Dynamic processes and change are also characteristics that can be explored by the case study method in ways that other techniques either cannot do or only do poorly. Following Yin (1989), we are using the case study method because it is suitable for investigating the contemporary phenomenon of environmental management within its real-life farm business context; when the boundaries between the phenomenon and context are not clearly evident; and multiple sources of evidence are required.

The type of generalisation that the case study method allows is different to that in a statistical analysis where results from a sample survey are generalised to a population. Well-designed case studies allow generalisation to theory. This is well-known from natural science experiments. Case study design is ideally based on a well-grounded theory and a set of testable propositions. Findings are generalised to that theoretical base according to the degree of support the findings provide to the original propositions (Crosthwaite and Malcolm 1997, Eisenhardt 1989).

3. Methods

3.1 Summary

A total of 17 case study farms were chosen by following the principles of the case study method. The farms varied considerably in:

- Farm enterprises and how they are run;
- Pasture type, utilisation and history of management;
- Resources available to the business, and
- Characteristics of remnant native vegetation.

Some of these variables are outlined in Table 1.

We draw on a dataset from these farms that includes information about the vegetation, state of the pastures and agronomic potential (assessed by an agronomist), and current economic position.

Analysis of the data collected from the 17 farms has informed the identification of four strategies that, each alone or in combination, can potentially deliver some of the environmental gains required in the landscape without affecting profitability adversely. The strategies were: (1) targeted vegetation management and correcting nutrient deficiencies; (2) targeted vegetation management and intensive rotational grazing; (3) deferred grazing of hill country; and (4) establishing shelter trees by managing for natural regeneration. Targeted vegetation management involves managing 15% of the farm primarily for biodiversity conservation. Results of implementing these strategies on a representative farm have been previously reported (Moll *et al.* 2005).

3.2 Location

The focus for this investigation is narrowed to the Victorian portion of this area, specifically the uplands and slopes of central Victoria along the Great Dividing Range. The research was conducted in five localities in Victoria, stretching from the Ararat Hills to the east of Gariwerd (the Grampians), through Maryborough, Broadford and Violet Town to Springhurst near Wangaratta.

The area contains land systems ranging from broad alluvial plains, originally dominated by open grassy woodlands, to slopes and hills of sedimentary and granitic origin which once supported extensive dry eucalypt forests and woodlands. Quaternary basalt flows also intersect some of the southern plains and slopes and these were typically sparsely treed. Now as little as three per cent tree cover persists in areas managed for livestock production (Dorrough and Moxham 2005).

Annual rainfall varies from 530 mm yr-1 in the west to 670 mm yr-1 with approximately 60% of rain falling between May and October (Bureau of Meteorology, monthly).

3.3 Case study farm selection

Case study methods as outlined above were used to select 17 farms. The farm business was identified as the main unit of analysis, with the production system, the paddock and the site of conservation interest being important sub-units.

The testable proposition was that strategies were available for the farm businesses that both delivered significant environmental benefit for native vegetation and were profitable. Fourteen of the farms were selected on the basis that agricultural production was the prime source of income for the farm family. Hence commercial realities were a major influence on decision-making. Requirements of the agencies funding the research meant that another three farms were selected where off-farm income dominated. For these farms, farm income was expected to cover overhead costs, but it was not relied on to generate income. Following Yin (1989) and Eisenhardt (1989), the number of case studies was adequate without the additional three farms – however, these add further richness to the dataset.

Selection of farms was also designed to address ease of implementing strategies on-farm, which is an important consideration for policy. Some farms were chosen where, based on financial criteria, it was expected that environmental management decisions could be implemented relatively easily, and others selected where this was expected to be difficult (Moll *et al.* 2003). This is not further examined in this paper.

Characteristics of the 17 case study farms are shown in Table 1.

Table 1: Characteristics of the 17 case study farms

Farm	Full-time operator?	Labour units	Equity	Farm area	Grazing area	Hill area	%Hill country	Remnant vegetation (bush, scrub)	% farm area as remnant veg	DSE's	Current SR	% area with high phosphorus	Av Return on capital
		No.	%	ha	Ha	ha		ha		no		>oP12	%
1	no	0.75	89	241	237	183	77%	4	2%	1061	4.5	0%	-6.8
2	no	0.2	100	331	220	0	0%	8	3%	1087	4.9	100%	-1.9
3	no	1	100	200	184	62	34%	16	8%	1120	6.1	0%	-5.5
4	yes	1.2	84	655	480	109	23%	35	5%	3386	7.1	47%	-1.1
5	no	0.73	100	570	275	106	39%	295	52%	1838	6.7	0%	-1.0
6	yes	1.5	86	1374	1349	998	74%	25	2%	13640	10.1	30%	3.7
7	yes	1.2	100	634	612	433	71%	22	3%	4753	7.8	0%	0.3
8	yes	1.25	86	1084	1052	581	55%	32	3%	7401	7.0	51%	-1.8
9	yes	2	100	967	918	409	45%	58	6%	11000	12.0	66%	5.1
10	yes	1.5	65.1	1384	1280	1138	89%	104	8%	8000	6.3	0%	5.0
11	yes	3	100	1129	803	312	39%	70	6%	8500	10.6	90%	13.0
12	yes	2	97	1006	960	784	82%	44	4%	7600	7.9	0%	5.0
13	yes	1.2	82	288	288	114	40%	9	1%	3700	11.5	100%	6.2
14	no	0.3	97	423	405	0	0%	17	4%	4500	11.1	100%	-0.7
15	yes	2	96	4166	3831	4166	100%	335	8%	30000	7.8	39%	0.9
16	yes	2	100	1055	780	496	64%	40	4%	8100	10.4	100%	2.4
17	yes	2	69	1505	1364	1505	100%	141	9%	10800	7.9	58%	-1.0
Av all farms				1001	885	670	55%			7440	8.2	46%	1.3
Av. Wool growers	Labour units	Equity	1160	1028	796.50	58%			8801	8.9	49%	2.6	

3.4 Assessment of native vegetation and pasture agronomy

Pasture assessments by a consultant agronomist and soil tests produced considerable information about the current state of pastures. This was combined with information obtained from the farmers about grazing systems and stocking rates for each paddock to develop estimates of

production potential across each farm. Estimates of current and potential production were used to rank priority areas for production on each farm. Vegetation assessments across each property generated rich data sets about the condition and composition of vegetation. Priority areas for management of native vegetation on-farm were estimated by combining modelled layers of site vegetation condition scores (Parkes *et al.* 2003) generated through site assessments and with landscape and land-use predictor variables, the bioregional conservation status of the underlying Ecological Vegetation Classes (EVCs) based on state-wide government assessments, distance to existing remnant vegetation (assessed as known remnant vegetation off-farm and areas on-farm with moderate-to-high vegetation site condition) and the probability of eucalypt regeneration derived from models presented in Dorrough and Moxham (2005).

3.5 Development of four management strategies

There are many possible strategies that woolgrowers can use to increase profits. Some of these are compatible with improving the condition and extent of native vegetation. For the purposes of this analysis, each strategy had to satisfy the following criteria:

- Increase the cover and/or extent of native vegetation in identified priority native vegetation areas; and
- Potentially increase the overall condition of native vegetation on-farm, though not necessarily within 15 years.

The strategies also focused to varying degrees on dealing with other management and production issues:

- Match stocking rate to carrying capacity;
- Remedy overgrazing of hill country and waterways; and
- Reduce fertiliser application in priority native vegetation areas.

Four strategies that could potentially meet these requirements were identified. The four strategies and their goals are outlined in Table 2, along with details about how parts of the farm are to be managed.

In evaluating the strategies, information was drawn from the data collected on-farm - from the financial evaluation, agronomic assessments and vegetation surveys for each case study farm. Other research was also used, notably a long-term grazing experiment at Broadford in Victoria (DPI 2003), shelter-belt research (Bird 1991) and deferred grazing trials that are part of the Sustainable Farming Systems for Steep Hills project (DPI nd.; Nie *et al.* 2006; Zollinger *et al.* 2005).

Table 2: The four strategies by goals and the breakup of how the farm is managed

| Strategy	Goals	Area managed for		
		Wool/beef production only	Biodiversity and wool/beef production	Biodiversity only
Targeted vegetation management & Correcting nutrient deficiencies (CND)	Increase carrying capacity on most of farm Improve condition of priority vegetation	85% Most of farm	0%	15% Watercourses, remnant bush, hill tops, rare/endangered vegetation
Targeted vegetation management & Intensive rotational grazing (IRG)	Increase carrying capacity on most of farm Improve condition of priority vegetation	85% Most of farm	0%	15% Watercourses, remnant bush, hill tops, rare/endangered vegetation
Deferred grazing of hill country (DG)	Increase carrying capacity on hill areas Improve the condition of native pastures on hills Maintain existing conservation areas	42% Parts of the farm not classified as hill country	52% Hill country	6% Very small areas
Establishing shelter trees (Shelter)	Increase wool profits through shelter benefits Expand area of native vegetation, and maintain condition	85% Most of the farm is benefited from tree shelter	9% Benefits to native vegetation are limited to the additional 9% under trees	6% Small areas, however condition improved with the addition of adjacent natural regen. areas

Percentages for Deferred Grazing, and the area managed for biodiversity under Shelter, are based on averages over the 17 farms

3.6 Environmental results expected where the strategies are adopted

The future farm could look radically different if each of the four strategies was to be pursued separately. In considering management of native vegetation on farms, we can envisage a continuum with 'totally segregate' on one end and 'totally integrate' on the other (Figure 2). The first strategy in Figure 2 (CND) is towards the segregation end of the continuum because 85 per cent of the farm is intensively managed for production and not biodiversity, while the 15 per cent

managed for biodiversity is most likely fenced off and its direct contribution to production is zero or small. The third strategy in Figure 2 (DG) is the most integrated with 52 per cent of the farm being managed for both purposes. The second and fourth strategies sit between these two. Dorrough *et al*. (2007a) use empirical data to make a case that the best environmental outcomes will result from approaches that integrate conservation into the farm management system, rather than treating it as something separate in isolated parts of the farm.

Figure 2 Continuum for how conservation management is tackled on the farm
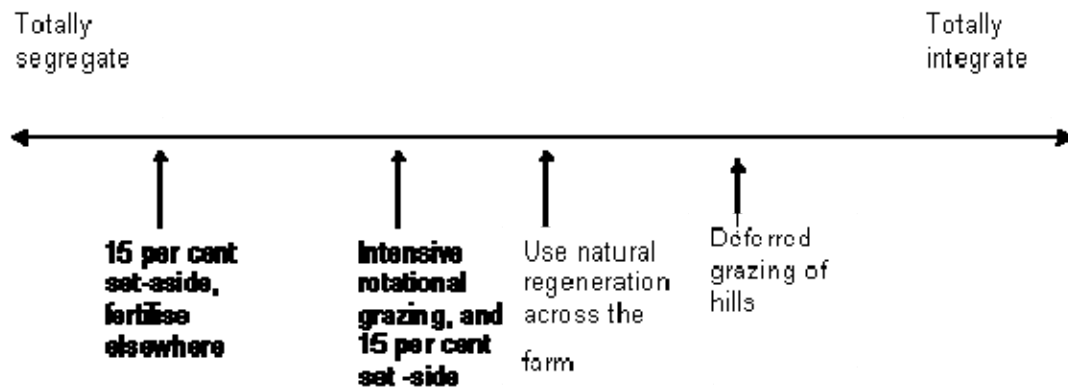
Trade-offs are likely on some farms with loss of some biodiversity assets occurring under some of the strategies. The Correcting Nutrient Deficiencies strategy is of particular interest. If fertiliser is applied to the slopes on some farms, which is where potential returns to fertiliser use have been judged by an agronomist to be among the highest on some properties, there could be loss of native understorey and reduced potential for natural regeneration of trees. This particular trade-off is explored further in Dorrough *et al*. (2007b) and by Langford *et al*. (2004).

3.7 Methods for economic and financial analysis

Following standard methods in farm management economics (Malcolm *et al*. 2005), budgets were prepared for each investment strategy on each farm to identify expected annual profitability in the steady state, and profitability and net cash flow over time, compared to a 'do nothing differently' situation. Profitability of a strategy was initially calculated as return in the steady state situation on marginal capital (ROMC) invested. This is extra return on extra capital invested in the strategy in a year of operation when the development phase of the investment is over and the change is fully implemented. The ROMC in the steady state is a useful 'first look' measure of profit that can be used to compare potential investments in changing systems. Net present value (NPV) at the opportunity cost discount rate has been estimated too as it represents the increase to net wealth (in today's dollars) that can be expected from an investment over the life of the plan. For example, "In x years time you'll be wealthier by $y in today's dollars if you make this investment and the opportunity (or actual) cost of funds is z% real per annum." The financial feasibility of strategies that are economically attractive is also tested using cumulative net cash flow budgets. Peak debt associated with the investment and years to reach positive net cash flow (break-even) are two indicators that inform investors about whether an investment that

may be attractive in economic terms is financially feasible. Further details of the method are given in Appendix 1.

4. Results

4.1 Native vegetation and agronomy

There were small areas of land with significant conservation value on each property, although their condition is generally poorer than similar areas on nearby public land. Habitat hectare site condition scores (Parkes *et al*. 2003) were typically around 20 for native pasture areas, and around 40 for remnant bush areas (Dorrough *et al*. 2005, 2007b). Such scores, based on a site condition benchmark of 75 for intact vegetation, allow comparisons across sites of different type and quality. The managers of each property were managing about 5% of the farm primarily for reasons that are consistent with maintaining biodiversity values (Dorrough *et al*. 2007b). These areas include fenced out creeks and revegetated areas.

Most farms had a much greater area of native pasture than the farmers generally believed they had. There was also a higher proportion of native grasses compared to exotics than the farmers expected. Native pasture made up to 40% of the area on many of the case study farms - particularly farms with high proportions of hill country (Dorrough *et al*. 2004). Sown grasses have often disappeared or are rare, and have been replaced by recolonising native grasses, but more typically naturalised annual grasses and broad-leaved weeds (Dorrough *et al*. 2007b).

In these pastures, few native plant species persist when grazing intensities are high and phosphorus fertilisers have been added. By contrast, the cover and diversity of native plant species is high when soil phosphorus is low and grazing is strategically managed (Dorrough *et al*. 2006; Nie *et al*. 2005).

Analysis of vegetation cover, soil types and management history indicate high potential to achieve natural regeneration of trees across much of the hills and slopes. However, this potential is disappearing at an exponential rate because of the loss of paddock trees that act as a seed source (Dorrough and Moxham 2005).

It was found that most of the case study farmers were managing their pastures well below biophysical potential, including those that were previously sown. Leaving aside the issue of pasture composition, management intensity and revegetation potential (see above points), production can often be increased by correcting soil nutrient deficiencies, especially phosphorous, and soil pH.

4.2. Economic analysis

The results for any particular strategy on a farm are interpreted in terms of economic and financial criteria. First, the strategy is potentially a good investment if the ROMC in the steady state is better than the opportunity cost and represents an appropriate return given the risk involved. The change to the farm plan is a good investment if:

- Expected NPV of the stream of benefits and costs over time is positive after discounting at the opportunity cost of the resources if they were invested in a similarly risky use. Note that the discount rate of 10% real that is used in the analysis incorporates a risk premium.

- The investment can be financed, ie. the size of peak debt and time until positive net cash flow is serviceable and acceptable to the investors and financiers.

Summary results are presented in the following sections. The full set of economic and financial measures for the four strategies on each of the 17 farms is presented in Appendix 2. All four strategies were applicable to 15 farms, and three strategies to two farms – a total of 66 possibilities.

4.3 Profit

Expected annual Return on Marginal Capital (ROMC) in the steady state exceeds 10% real for all the investment strategies on most farms (Table 3). See Appendix 2 for the ROMC for all strategies on each farm. All of the strategies are thus worthy of further investigation. If the investment was expected to earn less than 10% real, as is the case for some strategies on some farms, it would probably not be made. Better options would be found.

Table 3. The number of farms within each of three classes of Return on Marginal Capital across the four investment strategies.

ROMC	CND	IRG	DG	Shelter
≥ 10%	12	9	11	17
7 – 9%	0	4	1	0
< 7%	5	4	3	0

Note - Deferred grazing was an inapplicable strategy on two farms

The expected net present values discounted at the required real rate of return over the life of the strategies are in Table 4. Each strategy other than shelter belts are predicted to earn more than 10% real return on marginal capital on some farms .The CND strategy is likely to be profitable on 12 farms, DG on eight farms, and IRG on six farms. The Shelter strategy, which passed the annual ROMC test, proves to be a poor investment on all farms when evaluated as NPV over the life of the investment. This is because it requires de-stocking for at least five years in order for shelter trees to establish.

Table 4: The number of farms with either positive (>0) or negative (<0) Net Present Value (NPV) at 10% real discount rate for each of four investment strategies

NPV	CND	IRG	DG	Shelter
≥ 0	12	6	8	0
< 0	5	11	7	17

Note - Deferred grazing was an inapplicable strategy on two farms

Turning from the perspective of the strategies to that of the farm business, 15 of the 17 farms had at least one profitable investment option (Table 5). On only two farms (6 and 14) were there no options that were profitable, ie. all strategies had a negative NPV at a 10% discount rate. Of the other 15 farms, two farms (no's 10, 15) had a choice of three profitable strategies, while seven (no's 1,3,4,5,9,12,17) had a choice of two strategies, and six farms (no's 2,7,8,11,13,16) had the

possibility of just one profitable strategy – CND on three farms and DG on three others. There is little overlap between the two grazing strategies (DG, IRG). On only two farms were both these strategies profitable. This meant that a grazing strategy, irrespective of type, was a good investment, though not necessarily the best investment, on 12 farms (Table 5). On four of these 12 farms CND is a significantly better strategy in economic terms (no's 1,3,4,15) than a grazing strategy (Appendix 2).

Overall, changes to the systems that advanced both farmer and environmental goals were profitable at a real discount rate of 10% in 26 out of the 49 possibilities, excluding Shelter. Twenty three of the possibilities were not profitable, which expands to 40 if the 17 possibilities for investing in shelter are added. The point is that strategies existed for farm re-organisation that are compatible with economic and environmental goals.

Table 5: Strategies that are good investments (NPV ≥ 0 at 10% real discount rate) by farm

Farm	No. of profitable strategies	CND	IRG	DG
10	3	yes	Yes	yes
15	3	yes	Yes	yes
1	2	yes	Yes	no
3	2	yes	Yes	no
4	2	yes	Yes	no
5	2	yes	Yes	no
9	2	yes	No	yes
12	2	yes	No	yes
17	2	yes	No	yes
2	1	yes	No	n.a.
7	1	yes	No	no
8	1	yes	No	no
11	1	no	No	yes
13	1	no	No	yes
16	1	no	No	yes
6	0	no	No	no
14	0	no	No	n.a.
Total profitable		12	6	8
Total unprofitable		5	11	7

4.4 Financial feasibility

Financial feasibility is less likely to be the major concern for most of the farms in the cases studied, because each farm has several strategies to choose between where peak debt and years to break even were both relatively low (Appendix 2). For those who had to borrow funds, their cash flows would need to be sufficient to cover the extra cash for debt servicing for between four and eight years. Seventeen of the strategies fell within this range while another 8 were above this, though marginally - all profitable strategies took less than 10 years to break even (Table 6).

Table 6: Years to break even by profitable strategy and number of farms

Years to break even	CND	IRG	DG
> 15	0	0	0
8 – 15	5	2	1
< 8	7	4	8
Total	12	6	9

Peak debt exceeded $100,000 for only four of the profitable strategies (Table 7). These were on four farms (no's 10,12,15,17) (Appendix 2). For three of these farms, there was at least one other profitable strategy with a lower peak debt that they could choose (Appendix 2).

Table 7: Peak debt by profitable strategy and number of farms

Peak debt	CND	IRG	DG
≥ $200,000	0	1	1
$100 – 199,000	0	1	1
< 100,000	12	4	7
Total	12	6	9

Note - Deferred grazing was an inapplicable strategy on two farms

5. Discussion

5.1 Interpreting the results

The results point to ways of re-organising grazing farm businesses in the hill country of south-eastern Australia to increase profit in financially feasible ways and contribute towards achieving wider environmental goals. The results are consistent with the proposition tested using the case study method. Despite the wide variation in many of their characteristics, for most of the farms investigated there was at least one profitable and financially feasible strategy that was expected to significantly improve environmental conditions. This finding opens up possibilities for redirecting agricultural investments in these hill country landscapes towards production systems that can be sustained.

No strategy is better than the others across all farms. Each strategy was unprofitable on some farms. Overall, Correcting Nutrient Deficiencies and Deferred Grazing are expected to be the best strategies, if implemented on the right farm. These two strategies require the least adaptation of current farming operations, and can be done at relatively low extra cost in many cases.

De-stocking for a considerable length of time was the major reason for the Shelter strategy being a poor investment. More likely natural regeneration would be staged over many years, gradually increasing the total area supporting regenerating trees. This would be possible using electric fencing on small parts of the property that are currently lightly stocked. This option warrants a closer look.

The findings are based on strategies that manage 15 per cent of the farm for biodiversity, not the 30 per cent regarded as essential for adequate ecological function. Results were tested for sensitivity to increasing the area managed for environmental aims to 30 per cent. When strategies were tested that meant 30 per cent of farm area was managed to meet environmental aims, returns on marginal capital from the change were low No farm passed this sensitivity test, which confirms the finding in south-east Queensland from similar studies (McIntyre *et al*. 2000).

The results of the analyses presented in this paper do not tell us what farmers will do. To the extent that farmers adopt these strategies, there is likely to be considerable variation in where, when, how and why they do so. Many different factors influence take-up of new technologies by farmers (Pannell *et al*. 2005). The variation in results presented here suggests that farming in these landscapes may not go solely down the path of intensification through fertiliser use and associated set-aside. However, neither will the path of integrating conservation into the production system, through changing grazing system, dominate the landscape. A combination of strategies would work in many cases.

Further work is required to monitor the farm business and environmental outcomes as farmers initiate these strategies. Most importantly there is still little information to assess the relative ecological outcomes of each strategy. The techniques underpinning some of the strategies need to be investigated; for instance is supplementary feeding necessary for Deferred Grazing, and can stock be reintroduced more quickly in the Shelter strategy. Dorrough *et al*. 2007b) show that the time when stock can be reintroduced varies across the landscape and in response to rainfall. Effects on relative profit of adjusting salvage value to account for how some strategies continue to improve the value of the native pasture after the initial investment (Crosthwaite and Malcolm 2000) could be tested further.

5.2 Implications

Questions about whether or not there are profitable farming systems that can incorporate improved environmental management are relevant to the public policy issues around native vegetation. This has been the focus for the research. Analysing potential changes on 17 farms was a means to identify and test for viable strategies that could potentially contribute to public policy and private business goals into the medium-term future.

Government now typically intervenes to achieve biodiversity outcomes largely without considering the possible success of strategies at the whole-farm level. Given the findings presented here, there is a case for a modified approach.

Valuable understanding and insight is gained by using the whole-farm approach and investigating the human, technical, economic, financial, risk and institutional elements of the farm business, and specifically considering the potential to re-organise farm operations to improve profits and native vegetation outcomes. We have sought to demonstrate the value of doing so in this paper. It has been shown elsewhere that the cost to government of seeking large landscape-scale changes in the hill country of south-eastern Australia would be significantly less through promoting these strategies than through compensating farmers for lost opportunities (Crosthwaite *et al*. 2008).

However, the farm strategies approach alone could not achieve the 30 per cent cover of woody vegetation that scientists have assessed as necessary at the landscape scale to fully restore ecological function, though it will clearly improve this functioning. In addition, the whole-farm

approach is no guarantee that biodiversity assets of high public value will be protected or that threats to them will be reduced. This requires a range of targeted policy mechanisms with some allowance for redundancy (Young *et al*. 1996) and also certainty (Bowers 1999). Market-like instruments such as BushTender are one possible approach; they incorporate several mechanisms within the framework of a management agreement between principal and agent, including information provision, payments to farmers, and enforceable obligations.

While purchase of conservation services by government will undoubtedly increase, it is difficult to envisage the funds being available for this to occur on a scale that will make a significant difference to ecological functioning or the status of native vegetation across the wide hill country landscapes. Adoption of new farm development strategies is required in order to significantly increase the area and quality of native vegetation while maintaining profitability. Finding ways to 'trigger' the development and adoption of such strategies is likely to be an important part of the package of measures taken by government. It may well be adopted in measures aimed at climate change mitigation and adaptation in agriculture, because farm adjustment is already a major issue in that policy arena.

6. Conclusion

There are management strategies available on each farm in the hill country of south-eastern Australia that can be expected to significantly improve environmental outcomes while being profitable.

This has been demonstrated by combining ecological assessments, agronomy and farm business analysis in a series of case studies developed according to the principles of the case study method.

The solutions that were expected to be profitable varied from farm to farm, but at least one strategy was profitable for every farm. This finding reinforces the value of analysing the dynamics and heterogeneity of each farm. General prescriptions risk limited success.

Finally, the variation in profitability suggests that broad-brush approaches to policy that ignore the differences between farms are inadequate.

Acknowledgments

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Appendix 1 – Economic method and assumptions

Discounted cash flow budgets were used to generate net present value (NPV) at 10% real discount rate using a 15 year investment period. A 10% real discount rate was chosen because it allows a real return to the investor of 6%, plus an allowance of 4% for additional risk. This analysis is in real rather than nominal terms. A 10% real discount rate is the same as using a 15% nominal discount rate, with inflation expected to be 5% per annum. It is noted that choice of discount rate can potentially have a large influence on final results; a higher rate would favour strategies that had low initial investment costs relative to higher net income in later years.

If the debt burden reaches a high level, then the repayments can become onerous. The length of time before the strategy breaks even is also a concern. The importance of cash flow for decisions will also depend on the farmer's risk preferences. The cumulative net cash flow budgets for testing possible impact on farm finances used nominal dollars and interest rates with a 3% inflation rate. Extra profits are calculated before tax.

Other assumptions.

An allowance for labour of $31,000 pa is assumed to be paid for each full time labour unit on the property. There are net increases in labour and overhead costs required for undertaking each management strategy.

A gross margin of $20/dse of livestock is assumed, based on typical costs and on current market data, as reported in the Livestock Market Reporting Service. Per unit activity gross margin is influenced mainly by wool price, and varies in the range of $18-22. It does not change greatly compared to total activity costs, fixed costs and management requirements. Historic performance of each case study farm is not relevant; rather the focus is on future production systems that might be implemented on those farms.

Extra gross margin (GM) for the sheep enterprise is calculated by multiplying change in stocking rate and area, by GM/DSE. If the potential increase in stocking rate is more than 200 DSE within a year, stock are bought in at $40 /DSE to utilise extra pasture growth.

Salvage value is calculated at the end of the 15 years as a proportion of any extra capital expenditure on fencing, trees, livestock, fertiliser and watering points. Salvage value of native pastures is ignored, although it should be noted that changed grazing regimes have the potential to improve the value of the native pasture after the initial investment is made (Crosthwaite and Malcolm, 2000).

For the first two strategies Correcting Nutrient Deficiencies (CND) and Intensive Rotational Grazing (IRG), the areas were calculated from the prioritisation model used in the project (Dorrough 2005). Fence length required for native vegetation areas was estimated to be the same as that calculated for natural regeneration areas (see below). Fencing used is classified as 'light merino' @ $2500/km including labour. Areas fenced for native vegetation are valued as fodder reserves after year 5, and valued one year in every four as a valuable source of drought feed. Under IRG, no extra fencing over and above new fencing that is required for 'cells' is required for native vegetation areas, unlike the CND strategy, which requires extra fencing for these areas.

The CND strategy is based on the following assumptions. Maximum utilisation of existing pastures is currently occurring on all paddocks. A program is devised to achieve Olsen P levels of at least 12 over 10 years as well as to correct lime and other nutrient deficiencies. Apart from paddocks with a vegetation condition above 20, the fertiliser program targets the whole property, including hill country Application depends on soil test results, but an example might include maintenance applications of phosphorus at 8 kg P/ha, capital dressings of phosphorus at 25 kg P/ha, potassium at 30 kg potassium/ha, and lime broadcast at 2.5 t/ha. Stocking rates under the fertiliser strategy are estimated from unpublished reports for each farm prepared by the agronomist engaged by the project. The cost of the suggested fertiliser program is based on the average current fertiliser budget for each property, and is therefore calculated independently for each case study farm.

The IRG strategy is based on expected increases in carrying capacity of 35 – 37% over 4 years, with set stocking providing a baseline, as found in the Broadford grazing trials (DPI 2003),. These increases vary slightly depending on existing levels of phosphorus in the soils. Fencing and provision of water in each paddock is costed at $60/ha (from practical experience).

In the Deferred Grazing (DG) strategy, stock are removed from 25% of the total hill areas for four months each year. It is assumed that no supplementary feeding is required. Land-class fencing is carried out on hill areas of the property, using electric fencing at a cost of $1,550 /km. A 25% increase in carrying capacity is achieved over 5 years, due to better pasture growth and utilisation on hill country.

For the Shelter strategy, it is assumed that 15% of the total farm area is established to trees using natural regeneration. Shelter area fencing is calculated from boundaries of priority areas, using logical fencing (straight lines). Electric fencing is costed at $1550/km and valued at 75% of purchase price in year 5, when it is pulled down and used elsewhere once trees are established. There is an initial destocking over first 5 years, then stock levels are back to "normal". Mortality reduction and extra pasture growth begin proportionally after 5 years after planting, with full effect at year 14. Lamb mortality is reduced by up to 5% and mortality of shorn sheep is reduced by up to 0.5%. There is an increase of 10% in gross margin due to combined extra pasture growth and savings in feed intake. Feed savings and pasture growth benefits are assumed to occur on double the area with trees established, rather than on the whole farm.

Appendix 2

Table 8: Expected economic and financial performance of four strategies across 17 farms

	Strategy 1. Correcting nutrient deficiencies				Strategy 2. Intensive rotational grazing			
	Economic measures		Financial measures		Economic measures		Financial measures	
Farm	ROMC at SS	NPV @ 10% real	Peak Debt	Yrs to break even	ROMC at SS	NPV @ 10% real	Peak Debt	Yrs to break even
	%	$	$		%	$	$	
1	57	36,386	-9,768	4	23	4,474	-14,363	6
2	18	7,907	-41,582	9	-2	-26,007	-31,987	15
3	32	36,485	-16,055	6	32	4,142	-5,721	6
4	36	71,091	-24,791	5	30	15,351	-22,190	5.5
5	52	25,293	-1,670	5	52	21,496	-12,352	6
6	-2	-110,257	-222,253	15	9	-72,433	-213,875	12
7	24	53,150	-44,592	7	11	-17,839	-53,767	10
8	18	38,611	-52,147	8	10	-24,743	-113,020	10
9	25	19,473	-41,647	8	13	-4,005	-95,141	8
10	31	126,873	-60,341	7	19	17,211	-133,970	8
11	-22	-67,713	-178,189	15	7	-48,321	-123,090	12
12	24	10,266	-108,742	9	7	-75,758	-154,172	14
13	0	-54,051	-158,328	15	1	-32,739	-49,144	15
14	-38	-55,194	-147,054	15	-1	-52,617	-74,965	15
15	27	410,884	-188,298	6	15	5,716	-393,721	8
16	0	-160,135	-510,510	15	-3	-129,964	-174,081	15
17	21	18,417	-113,758	9	9	-65,606	-172,231	11

	Strategy 3. Deferred grazing				Strategy 4. Shelter via natural regeneration			
	Economic measures		Financial measures		Economic measures		Financial measures	
Farm	ROMC at SS	NPV @ 10% real	Peak Debt	Yrs to break even	ROMC at SS	NPV @ 10% real	Peak Debt	Yrs to break even
	%	$	$		%	$	$	
1	-1	-14,822	-20,105	13	29	-3,772	-7,584	15+
2	n.a.	n.a.	n.a.	n.a.	25	-12,056	-24,136	15+
3	3	-5,502	-10,416	10	27	-1,867	-3,717	15+
4	6	-5,925	-14,546	9	35	-8,111	-17,277	15+
5	10	-3,358	-13,133	15	33	-2,856	-6,721	15+

6	11	-20,750	-137,051	9	24	-61,446	-159,025	15+
7	12	-6,842	-40,336	8	40	-14,614	-31,990	15+
8	8	-18,229	-54,210	9	50	-21,669	-51,952	15+
9	28	7,709	-26,222	6	30	-35,922	-99,537	15+
10	35	120,010	-51,459	5	32	-49,350	-124,239	15+
11	57	18,861	-10,177	4.5	19	-56,523	-141,304	15+
12	26	57,298	-50,452	6	101	-32,218	-88,065	15+
13	121	25,098	-4,038	3	61	-20,750	-49,031	15+
14	n.a.	n.a.	n.a.	n.a.	62	-30,009	-72,301	15+
15	15	49,843	-363,218	8	32	-75,251	-229,475	15+
16	17	13,446	-49,472	7	26	-41,182	-111,006	15+
17	31	134,728	-74,156	5.5	54	-28,954	-100,898	15+

Notes:

- ROMC at SS = return on marginal capital in the steady state ie. once the development phase is over
- NPV @ 10% = net present value at 10% discount rate
- IRR = internal rate of return (at which NPV would equal zero)
- Peak debt = maximum cumulative debt

Yrs to break even = year that cumulative cash flow becomes positive