

Farmer decisions, public policy and risk information in management of native pastures

By

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**Paper presented to the Annual Conference of the Australian Agricultural and
Resource Economics Society, Manly, February, 2006.**

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1/ Introduction

Discovering new knowledge or writing legislation does not necessarily change things – people actions on the ground, change the condition of natural resources. Farmers manage resources in situations of much uncertainty (markets, droughts etc.). The response of the farmers people who make decisions about how to use and manage the resources is important if long term public good outcomes are to be achieved. Regardless of whether a proposed solution to a resource conservation question is to be based on regulatory or market mechanisms, policy will be better informed if know about how and why farmers may act in situations that are potentially significant for natural resources (Crosthwaite -, Crosthwaite and Malcolm 1999). Equally important, farmers, who manage most of Australia's land and natural resources dedicated to agriculture, will make better decisions about resources if they are able to use appropriate methods of analysis of farm management decisions.; in particular, give proper consideration to whole farm, long-term dynamic and risk aspects of the decisions are pertinent issues. This is the focus of this paper. Specifically technically and economically sound analysis of farm management decisions about native vegetation that are both timely and practical.

Looking backward, the history of agriculture in Australia is littered with examples of the farmer managers of land resources being subsidized by the public sector to do things that with better scientific information and proper farm and public economic analysis would not have been done, e.g. numerous irrigation schemes, clearing of marginal cropping lands, replacement of some areas of native vegetation with what turned out to be less productive, less durable species. Possibly, with what was known at the time, the conclusions of proper farm, economic and environmental analysis of some of these decisions could have all been the same – leave well alone. This observation is not simply a case of having good foresight backwards. Certainly, sometimes the science was not sufficiently worked out and things were done that seemed for the best in the light of what was known; equally, there are many cases where the folly was predictable given the state of scientific, and farm and public economic knowledge of the time. In still other cases, technology changed the economics. Regardless, there are plenty of examples of decisions about private and public resource use that could have been, or would be, better, with better information incorporated

in the decision process. As Smith (2000) noted in reflections on the inter-war period, ‘the adoption of the new species, and largely abandoning the old, was *not* driven by Eurocentric approaches, but by scientific research and economic justification’ [of the time authors] and that ‘the late 20th century problems of dryland salinity, acidification and soil–water relationships such as recharge had not been identified’.

Information inadequacies resulting in farming systems performing in ways that do not suit some specific public interests is a form of market failure. That is, farm and market agents making decisions about the day to day things that are done with farm resources are not as well informed, or making as good decisions, as people concerned about resource use would like them to be! As information theory holds, less informed markets lead to less efficient use of resources than could be achieved with better informed markets (Stiglitz 2004). Whilst there will always be imperfect information, and thus unsatisfactory market outcomes, because there are aspects of the farming world that will forever be imperfectly known, for example, complex agricultural and environmental response functions or future prices and discount rates, there is also information about the farm-farmer-environment complex that is potentially knowable and capable of improving decision making.

It is well known to farm management economists that the potential contribution of native pasture to business profitability becomes clearer in the context of the whole farm. Increasingly, scientific researchers and agricultural technologists too are seeing native pasture in this context, and valuable new knowledge is being generated. Increasingly policy-makers, and policies, recognize that running a farm business involves a complex mixture of human, technical, economic, financial, risk and institutional elements. These elements are formed into a productive whole business by farm families with a wide range of goals, abilities, and resources, and a wide range of capacity and willingness to respond to (re-organize) the ever-changing agricultural circumstances and societal pressures that confront them.

The argument presented in this paper is that by proper analysis (see Malcolm 2004) of the practical questions concerning the utilization and conservation of native vegetation farm management economics has the tools to allow better informed decision making . This contributes to better private and public outcomes for natural resources.. Note that ‘analysing properly and practically’ means in ways that are theoretically sound yet fully recognize the reality that decision-makers have limited time or other resources to conduct formal decision analyses. We argue that

improved decision analysis should not involve more time or effort, rather the availability and use of better information and different thinking can often bring about a marked improvement in the quality of information used in a decision.

2/ Native pasture in Australian agriculture

From the time of European settlement in Australia, native pasture contributed directly to the Gross Domestic Product through feeding the livestock, mainly the sheep, upon whose backs the national economy was said to ride. For over 100 years, wool exports was the dominant source of export earnings (exceeding gold exports after the 1860's), and the role of native grasslands in underpinning the profits, cash, wealth and export earnings of the grazing industries was extremely significant to Australia's economic growth.

Over time, non-indigenous species of grasses played a growing role – a role that proceeded apace with the 'sub and super' revolution from the end of WWII until the wool, meat and dairy market collapses of the late 1960s and 1970s. The 'improved' introduced pasture push lost considerable momentum following removal of the subsidy on super phosphate in the mid-1970s, accompanied by a long run of low commodity prices, and serious droughts, affecting the pastures of the grazing industries in the 1980s and 1990s and early 2000s. Throughout these latter periods however, there were large research programs investigating the persistence and technical productivity of introduced species, with a lesser but still notable investment into researching native grass species. There was also some concerted effort put into the role of grazing management in enhancing the productivity of grasslands – for both introduced and native species.

In recent times plant breeding advances have seen the development of elite pasture species that bring changes to the timing and quantity and quality of dry matter supplied in intensive grazing systems based on introduced species. As well, nowadays, more is known than ever before about the role of native pastures in whole farm systems encompassing native and introduced species, and how best to manage native pastures to enhance their contribution to total agricultural production and to the GDP. More is also known about the significant role of native perennial species in maintaining soil cover, reducing erosion and salinity recharge in areas where annual grasses would otherwise dominate, and introduced species are unlikely to persist. This new knowledge ranges across the whole continuum from stands of diverse native pasture species to pastures comprising largely introduced plant species, across a considerable range of climates, topographies, grazing activities, and farming systems (in various publications, e.g. Garden *et al*

2003, Jones 1996, Lodge 1994, Millar and Curtis 1995, Kemp et. al. 1996, Simpson and Langford 1995, 1996, Zollinger 2005).

Researchers with NSW Agriculture, Simpson and Langford (1995, 1996, 2004) have emphasized the whole farm approach to understanding the role of native pasture, with tailoring of decisions about pasture and grazing management on different parts of the farm according to the key physical characteristics of the particular land areas, along with a focus on how the whole farm system will operate. They argue that the diversity of land classes classified according to soil types, acidity and fertility status, and aspect, and the diversity of pasture types and activities, means that the traditional replacement strategies based on introduced species and heavy fertilizer applications are not appropriate for *all* areas on a farm. Generally there is plenty of scope within farm systems for economically justifiable productive and sustainable use of pastures based on native grasses. The main strategies for native pasture identified by Simpson and Langford under current conditions are:

- maintain native grasses, but boost legume content with careful fertilizer use
- maintain native grasses without introducing legumes or fertilizer

Simpson and Langford's (1995) extension publication has been recently revised to incorporate how to manage native grasslands primarily for conservation (Langford & Simpson 2004).

The production focused research into grass species and pasture management outlined above has coincided with a significantly increased awareness of the conservation value of native grasslands on farms. Native grasslands are one of the most threatened ecosystems in Australia, and the remnants remaining on private land have varying degrees of conservation value, with most being somewhat diminished in quality compared to those on public land. There have been several research programs investigating the conservation management of native grasslands, and how to maintain their conservation value. Together these programs were modest in size by comparison to the programs investigating introduced pasture species. Dorrough *et al* (2004) summarise the literature relating to grazing management, fertiliser use, fire and other aspects of grassland management. They emphasise the role of perennial grass and shrub species in providing habitat for fauna and a supporting matrix for other plant species.

The integration of native grasslands into farming systems has received less attention than conservation management *per se*. Dorrough *et al* (2004) indicate that in south-eastern Australia there is little empirical research into how choice of grazing strategy affects biodiversity, and that

information about biodiversity itself is primarily descriptive. With little research having occurred into the ecological processes in native grasslands, much remains to be learned about the relationship between agricultural practices and their effects on the conservation values of native vegetation.

In the light of what is now known about native pasture in Australia, from the viewpoint of whole-farm economics, the situation is not always an either/or 'use-it, change-it or conserve-it' choice. In some situations, national economic objectives and the national environmental/remnant-vegetation conservation objectives are as one. First, in many farm systems, because of the characteristics of the native grasses and of the farming system, the areas of native pasture remaining are often significant contributors to the profitability of the whole farm system (Crosthwaite 1997, Crosthwaite and Malcolm 1999). Second, there are always many good reasons for the way a farm business is being run. In some cases, investing scarce capital to replace *remaining* areas of native pasture with introduced pasture species is simply not the best investment choice the farmer faces (Crosthwaite and Malcolm 1999). This is especially true now that much more is known about managing native grasslands for both productivity and persistence. Third, in any case, it is clear that in all States the clearing of indigenous plant species, subsidized and encouraged as it was by the public until recent changes in public attitudes, almost always and inevitably went beyond the margins of the economically sensible areas.

3/ Information

Markets in which decision-makers are not well informed and make poorly informed decisions are inefficient. In the context of decisions affecting native vegetation, farmers acting on poor information, say, the results of flawed methods of decision analysis or inadequate understanding of the present state and potential role of native vegetation, will result in a poorer native vegetation outcome from the public viewpoint than would otherwise be the case.

It may be that market based measures to promote the achievement of conservation goals might achieve public goals more effectively if the analyses of decisions were better informed and enabled markets to work better. Even though farming is often said to most nearly approximate the conditions of the competitive model, the information conditions for good market outcomes means that the argument can still be mounted for looking closely at how well farm analysis is conducted and whether the information content and method of that decision analysis could be improved or decisions brought forward and public outcomes improved.

Most of modern neo-classical economic theory was well-established by the first half of last century. Growing wealth and growing concerns about the state of natural resources in the second half of the last century led to a focus on means of getting the private managers, and often owners, of natural resources to manage these resources in ways that were consistent with public objectives. Predictably this search led to a suite of policy measures covering the spectrum from regulation to markets. The neo-classical paradigm and the absence or failure of markets naturally led to experimentation with and development of market-based instruments (MBI's) to facilitate private owners of natural resources acting self-interestedly and yet contribute to public goals (Stoneham *et al* 2003, Latacz-Lohmann and Van der Hamsvoort 1997). The strength of MBI's is in enabling owners and managers of natural resources to judge best the costs and benefits to themselves of alternative uses of the natural resources they control – including providing environmental services – and in certain circumstances being led by the many invisible hands of the public via public policy to use natural resources in ways the public desires. Good conservation outcomes are expected to result, as long as the decision-makers are sufficiently informed about the production situation when making their decisions. In the past thirty years Information Economics Theory has evolved to help fill some gaps in traditional theory. Stiglitz (2004) identified the functionalist fallacy that holds that as long as an institution is formed to fulfil a function, as long as it serves that function, efficient equilibrium outcomes will result. This may or may not be so. Efficient outcomes cannot simply be assumed to occur.

The focus of this section is on implications for private decisions, and for private and public 'negotiation' about natural resource management once we move from the abstract 'firm' and 'resources' of 'fully informed perfect competition' to real family farm businesses where the mastery of information ranges from a lot to a little and there is much that decision-makers cannot ever know well or even at all. There is an information argument that stems from theory about the conditions for perfect competition that holds that markets work best when participants are well informed. However, the 'well-informed' (sometimes expressed as 'fully informed') part of this theory has two main interpretations. In one interpretation, fully informed refers to buyers and sellers being fully informed about the qualities and prices of similar goods and services in the market in transactions currently being negotiated. This perfect information criterion of neo-classical economic theory criterion developed from Adam Smith's criterion that participants in markets needed to have 'tolerable' knowledge of the market opportunities (Stigler 1957). In

another interpretation, the term perfect information is also used by Knight (1921) in the context of there being no uncertainty about the future dimensions of the transactions taking place in the competitive markets. As Tisdell (1972) put it: one of the assumptions of perfect competition is that all traders are informed about relevant market prices and all are familiar with technological production possibilities and characteristics of goods. Tisdell also says that firms or production units are assumed to act in a way which maximizes their anticipated profits, and inadequate knowledge can cause violations of the conditions of perfect markets and competition. For example, he says, in the case of over-optimistic expectations, that if pursued will lead to social losses, government interference to reduce the range of price expectations can be justified and this could lead to an improvement (Tisdell 1972). A case can also be made for government subsidization of some market knowledge since externalities generally stem from providing such information. Tisdell notes the theory of second best, which comes into play when the first-best optimization conditions are violated. Then, government expenditure can be justified if it is necessary to reduce ignorance; or, to produce or subsidize the production of good which cannot be supplied in optimal quantities by the market; or to correct specific defects in the operation of markets; or to improve the working of markets by improving mobility and information.

Another relevant and related notion that helps explain how farmers and markets operate in reality is that of 'X-Efficiency' losses developed by Leibenstein. He argues that neither individuals nor firms work as hard, nor do they search for information as hard, as they could (p.231 in Mansfield 1979). So-called X-Efficiency losses, or inefficiencies or sub-optimal utilization of labour and capital - operating on sub-optimal production functions - can come about through not knowing enough to do it better, or through not using knowledge that is already known within the firm. Leibenstein argued such inefficiencies can be caused by lack of motivation or incentive, from both external and internal sources of both management and labour, to push some firms onto the higher production functions that are achievable by other firms in the same industry. Leibenstein argued that costs from inefficient use of resources arising from factors within the firm such as poor incentives or motivations (so called X-Inefficiencies), that leave some firms operating on lower production functions when technical knowledge exists that enables other firms to operate more efficiently, are likely to be greater than the costs arising from misallocation of resources caused by market imperfections such as non-competitive market structure.

It is observable that there exists in farming a wide range of performance of firms, and of partial productivity indicators of activity performance. Some of the difference performance is attributable to different capacities to command resources such as capital and management skill, and different attitudes to the risks involved. At the same time, some of the difference in firm performance is attributable to differences in the command of knowledge and information resulting in poorer decisions than would be the case with greater knowledge. It is this source of X-efficiency loss – sub-optimally informed decision-makers operating on lower production functions than they could be (p.237 in Mansfield 1979) – that may have implications for conservation management.

Implications of better informed decisions about managing native grasslands could be: (i) well run and eventually wealthier farm businesses can afford to undertake conservation management investments and activities, (ii) development of part of farm systems can reduce environmental pressure on sites of conservation significance, and (iii) if information problems are a cause of poor farm management decisions, the analysis of options offered for conservation purposes may not be as good as they could be and the public outcomes that result from a conservation viewpoint may not be as good as they could be.

4/ Nature of Farming

In the following section, we emphasise the importance of risk and uncertainty to the farm business, and also how information about these is communicated to the farmer to inform significant strategic decisions.

- A number of elements of the nature of farming as a business determine the context in which decisions affecting native vegetation are made. A list follows:
- Farming involves both working with and against nature.
- Every farm system is a unique combination of the human, physical and financial resources, mixed together in a unique risk-situation with a unique attitude to risk, with unique history – all subject to changes, some of which can be a steady progression and others are sudden.
- Farm decision-makers face massive uncertainty; about production functions, and about future prices, costs, yields and environmental conditions. And, farmers know they do not and cannot know much about these things.

- Farm family objectives are a mix of short term liquidity and medium term growth in wealth, sometimes accompanied by some interest in return to total capital over a run of years – always conditioned by aims of achieving significant non-pecuniary goals that derive from love of farming and other family aims.
- Moving onto a new production function has historically always done more for achieving farm family goals than refining allocative efficiency with an existing production function. Hence technical expertise and ability to adopt, implement and manage new technology has long been one of the defining features of successful farm management.
- Farm businesses cannot be highly geared for long in Australian farming as the debt will be unable to be serviced in some years.
- When considering possible change to a farm system, the proper comparison is between alternative futures; not between alternative futures and the status quo. Farmers, their systems, and the world around them, change constantly. Understanding the implications of change to a farm system involves looking at the whole system with and without the change, with particular emphasis on ‘hidden’ effects such as risk – both business and financial – and non-pecuniary benefits and costs.
- Farmers operate in an environment that most closely approximates the neo-classical economic model, in terms of many similar-sized firms producing homogenous products and facing keen competition to sell outputs and buy inputs. In this situation, farm resources are not especially mobile, and not all farmers are well-informed about their markets or their production systems.

Managing risks and uncertainty are the essence of the management challenge of farm businesses. There is a continuum from risk, which involves probabilities that can be estimated and risk analysed, to uncertainty where no probability estimates are possible, and cannot be analysed. Little can be done in an analytical sense about uncertainty. Farmers face many different types of risk, and most farmers manage risk adequately enough to stay in business for quite a long time. Risk is a term given various meanings, but they always relate to the volatility of potential outcomes. In business management the core of the management problem is dealing with uncertainty. In decision making, how do we cope with knowing that we don't know what is going

to happen in the future? One consequence of uncertainty that makes some decision analyses problematical is that the decision maker's goals are modified in response to the existence of this uncertainty. Included in the decision process about alternative uses of resources associated with differing degrees of uncertainty and risk is the reality that the goals themselves are modified by the existence of uncertainty. The nature and extent of this modification is determined by the decision maker's perception of where the decision lies on the continuum from risk to uncertainty, and their attitude to these circumstances (Malcolm, Makeham and Wright 2005).

The important business-related risks and uncertainties are those that have potential for having a major impact on the owner's goals that matter most, such as wealth and business survival. Strategic decisions that play themselves out over a run of years are the most critical in achieving goals such as wealth, business survival, consumption and leisure. It is sometimes argued that the medium- and long-term outcomes are merely the coalescence of numerous day-to-day and tactical decisions. While the effects of day-to-day and tactical decisions add to whatever cumulative outcomes eventuate, the strategic periodic big decisions affecting intensification, extensification, specialisation, diversification, land development, enterprise type, gearing, land and machinery acquisition are the main determinants of ultimate wealth and business survival. Yet much risk research in agricultural economics has focused on the short-term risks of farming. This is misguided. It is often a run of related risk events that has the biggest impact.

From a practical decision-making point of view it is important, therefore, to monitor relevant changes affecting production efficiency and variability; and changes occurring in the wider, longer-term environment that might indicate a need to consider strategic change. A failure to watch shifting fortunes at a strategic level can allow a farmer to slide into a situation of focusing effort on the more and more efficient production of the wrong output mix for the farm.

Increasingly in the future, for some farms, part of that output mix might be environmental services.

The rational thing for farmers in Australia to do is to recognise that financial performance cannot be under tight, close control, due to uncertainty, and to accept that (a) there will be considerable variability in financial performance; (b) long-run survival is the core objective; and (c) the focus of strategic attention should be to meet medium term aims to do with production and profits. This will involve placing most farm management emphasis on controlling what can be controlled: farm

physical productivity and choices about investments (that is, the investment portfolio). This will ensure market relevance and that the farm is well positioned to take advantage of opportunities that arise from time to time. This approach involves identifying enterprises that are ‘physically rational’ for the farm and farmer, as well as ‘economically and financially rational’. Economically and financially rational enterprises will be those that seem to offer a level of volatility, and risk shifting opportunities, and range of financial outcomes over time, that are most consistent with the farmer’s attitude to risk.

Appreciation of risk and uncertainty and its management is aided in all manner of ways by more information and by greater clarity of communication about the risk and uncertainty. The framing of questions is the key to answering them, especially in gaining understanding of risk and uncertainty. The simple arithmetic of probability can bring clear perspective to risky events.

The question follows: How best to assimilate the essential elements of the foregoing discussion about information and the nature of farming and risk and uncertainty into improved decisions about native vegetation in farm systems?

5 / Farm Benefit Cost Analysis and decisions about the productive use and conservation of native vegetation

Crosthwaite (1997, 2001) and Crosthwaite and Malcolm (2000) looked at questions of farm management and of farm management analysis in the context of the conservation and utilization of native grasslands. In this work, a series of case study investigations were conducted. All farms had grazing activities and a proportion of total land under native pasture. The aim was to identify opportunities for farmers to manage at least part of their farm primarily for conservation outcomes, and be confident that this would not jeopardise their goals associated with income-earning. This was encapsulated by forming a vision of what the farm might be like in 20 years time – the question was then how to possibly get there.

Farm benefit cost analysis was conducted to identify the net benefits from the plausible range of farm futures. The process of deciding whether, or to what extent, the managers of these farms ought to contemplate changing the way they managed their system and the native pasture component of it, involves the following steps.

1/ Identifying the goals of the family and the owners and managers is the first step in analysing how a farm, is currently being run. The annual *status quo* with respect to the human, technical, financial, economic and risk state of affairs for the way the system currently operates is established. Complementary, supplementary and competitive relationships and quantities were assessed. The current balance sheet is established. Most likely annual operating profit and net cash flow before and after debt servicing is estimated for the system, based on most likely activity yields, prices and gross margins, and most likely opportunity discount rates and for financial analysis, interest rates. Expected balance sheet at end is estimated and expected growth in equity. The sensitivity of key indicators such as efficiency (return on capital), liquidity (net cash flow) and growth (change in equity) to scenarios reflecting volatility of prices, yields and interest rates is tested. The implications of volatility for the achievement of short and medium term goals is assessed using scenario and sensitivity testing.

2/ Having established 'what is', the next step is to investigate 'what could be'? Plausible alternative futures involving a small number of development options are defined and analysed for the medium term. The return on marginal capital in the steady state, net present value and IRR of investment in a range of pasture development options is estimated. Comparisons are made between annual measures of performance of the farm system in the respective steady states of the alternative futures, and between cumulative medium term outcomes – NPV for economic efficiency and wealth, nominal net cash flow for liquidity. These key measures are subject to risk investigation too. One potential future is continuation of the current system with minimal changes, mainly to do with expected future prices and costs. The implications of these analyses for decisions about management of natural resources – in this case native vegetation - depend on the detail of each system and each future analysed.

In the case of native pasture there are usually a number of possible alternative futures that emerge that were common to the farm systems studied:

- Native vegetation might be a minor remnant, remaining only because the land was unsuitable for development using introduced grasses and legumes. The majority of the farm is comprised of introduced grass and legume species, based on high fertilizer input and high dry matter production per hectare.

- The whole farm might be a low input-low output per hectare operation comprising mostly native pasture.
- The farm system might be mostly pastures that were once sown to introduced grasses and legumes, but which is now primarily a mix of naturalised annual grasses, broad-leafed weeds and possibly some perennial native grasses that are re-establishing.

Regardless of the situation, the steps in farm benefit cost analysis as outlined above remained the same. The particular focus, when emphasis is on preservation of significant native vegetation from a public perspective, is on investigating an alternative future among others for the farm business in which public objectives have a chance of being achieved to some extent. The key measures associated with this future, when compared to other alternative futures, indicate the magnitude of private net benefits or opportunity costs of pursuing a change to the system that also contributes to meeting public objectives. One of the key aims when carrying out these analyses is to identify where within the system native pastures are competitive or complementary or supplementary to the activities. Importantly, it is useful to investigate farm development options that do not involve native pasture and that make conservation management options feasible too. It might be the case that the best return to marginal capital is to invest in improving the productivity of the existing non-native grassland areas, and run the native grassland in a way that is compatible with conservation values. The superiority of this plan might be clear-cut.

In another case the superiority of the conservation compatible plan might not be marked but could be made more so by contributions from the public, or by values farmers might place on these goals themselves.

Another case: all native pasture on the farm is managed along the lines advocated by Langford *et al* (2004). This might promise the best future in terms of important measures and be compatible with conservation management aims.

Another case: it might make no business sense to run the farm in a way that is compatible with conservation values. More likely, there will be some degree of compatibility, but also a point above which devoting more resources to managing part of the farm primarily for conservation begins to carry significant risks for the business. Crosthwaite (2001) explored this question, while it has been a focus also for research by MacLeod & McIvor (2003) and Sinden (2004). All farms are different.

Moll *et al* (2003, 2005) have found an average of 6% of the area of 17 farms across central and north-east Victoria are currently managed for biodiversity, or in a way that is very consistent with it – along stream-banks etc. The proportion is significantly higher in Queensland (MacLeod & McIvor 2003).

Crosthwaite (1997, 2001) assessed re-organization of some case study farms to accommodate twin sets of goals: the traditional profitability, liquidity and wealth affects over the planning period and (ii) the innovation goal of maintaining or increasing native pasture in the farm system. He used standard farm management benefit cost analysis techniques. Risk was dealt with using discrete scenarios and sensitivity testing – which captures only part of the risk story as these methods do not incorporate probabilistic elements.

Ideally, farm management analysis of any questions, including those to do with native vegetation, would marry the most powerful elements of the discrete scenario and sensitivity methods that allow for farmers to adjust how they run their systems when conditions change, with probability-based methods that recognize that it is not the lifetime expected value of distributions that matter but that it is runs of events that matter².

The potential value of applying probability analysis is now explored using a hypothetical decision about managing native grassland.

6 /A Hypothetical Example Analysis of a Decision about an Area of High Conservation Value on a Grazing Farm.

The hypothetical grazing business consists of 2000 hectares of mostly introduced annual and perennial pastures. The property also has an area of 200 hectares of hill country that consists mainly of native grassland of high conservation value, but which also has the potential to contribute more to the farm business.

The farmland is worth on average \$2000/ha, and carries an average of 20,000 DSE per year as sheep and cattle worth \$1m, that generate an annual most likely gross margin/DSE of \$23. Most likely Total Gross Margin is \$460,000, Overheads are \$250,000, expected Operating Profit is \$210,000. Total assets are land \$4m, livestock \$1m and plant and machinery \$500,000, equals \$5.5m. Most likely return on total capital before tax is 4% p.a. Debt is \$1m, 10 year term loan at

8% interest p.a. Debt servicing requirement in year one is \$80,000 interest and \$80,000 principle. Most likely net profit is \$130,000. Most likely net cash flow before debt servicing is \$230,000 and \$70,000 after debt servicing. Tax payable is \$34,000. Most likely growth in equity is \$96,000 or 2% p.a.

The farmer faces the option of negotiating an agreement with a public agency that essentially removes grazing by farm livestock in perpetuity (or, equivalently, to sell the land to the agency).

The interesting question from the public viewpoint is how much will it cost to acquire the rights to conserve this area of native grassland? From the farmers viewpoint the question is how much is needed to compensate fully for giving up the rights to use this area of native grassland compared to its value as part of the farm system, properly analysed using the whole farm approach and taking cognizance of risk.

The crudest, but common, approach (a partial view and average thinking) is to say: average annual carrying capacity of the native pasture is 4 DSE per hectare, therefore the farmer is giving up 800 DSE at a most likely \$23/GM/DSE, a most likely cost of \$18,400 p.a. If it was valued according to the average return to total capital invested in the whole farm – 3% - it would be valued at \$613,333 using the productive value method, i.e. $\$18,400/0.03$. At the return on marginal capital of 10% it is worth \$184,400. This calculation assumes that the farmer will receive what grazing the land seems to contribute in most years, without accounting for the benefits to the farming system as a whole. Some farmers might accept this value as an indicator of the opportunity cost of giving up the rights to graze the land. However, for the purposes of this paper and given what farmers might reasonably expect, the estimate is not very useful as it is of the average annual production of the 200 hectares without accounting for the nature of its contribution to the whole system over time, nor of the potential for improving the productive capacity of the land sometime in the future.

The aim of a whole farm and marginal approach would be to recognize that at present the 200 hectares provides grazing over the year, predominantly in the autumn when feed is scarce and valued at a premium. That is, without the 200 hectares, total carrying capacity of the farm would be reduced by more than 800 DSE's. As well, the potential that the 200 hectares could be

² Expected value is all right as long as you are plan to live forever and don't care much what happens along the way.

developed in the future to increase profits and returns to capital would need to be taken into account. Potential to develop other parts of the farm, and the relative returns on capital from the development options, is also useful information. Time effects on the value of benefits and costs need accounting for, and there might also be a possibility that the opportunity cost of capital over the future planning period might change as years go by. The risks of the system with and without the change in the alternative futures that are relevant warrant consideration too.

First, let us account both for the current contribution of the 200 hectares of native pasture to feed supply across the whole farm over the full run of seasons, and for the potential to increase the carrying capacity by changing management (see earlier discussion). Without the 200 hectares native pasture, assume that potentially 1600 DSE less would be carried throughout the year, as the native pasture will provide a greater quantity of feed at a valuable time (time of feed shortage on the rest of the property, e.g. autumn) and will enable a greater year round stocking rate to be carried. At a most likely GM/DSE of \$23, the total gross margin foregone is \$36,800 in real terms any year. An implicit assumption is that this value will be maintained in real terms in the future by investment in and adoption of annual productivity gains that offset the negative effect of annual cost-price squeeze. If this loss of TGM of \$36,800 was capitalized as a perpetuity using the before tax real opportunity cost discount rate of 10% for marginal capital investment, the equivalent lump sum is \$368,000³. Put another way, this is the sum the farmer would be prepared to pay for the 200 hectares of native pasture land and livestock if 10 per cent real before tax could be earned from similarly risky investment elsewhere on the farm or off it.

Now let's move to whole farm benefit cost analysis, incorporating time and risk and future options into the analysis. This involves setting up a whole farm budget comparing development of the 200 hectares of native pasture with removal of all grazing rights. For each year the annual net benefit from the bundle of capital involved is calculated, using a randomly generated gross margin per DSE for each year, drawn from a distribution defined in this case as a triangular distribution with most likely \$23/DSE and minimum of \$10/DSE and maximum of \$30/DSE, e.g. by using

³ From the viewpoint of the private business person, the after tax benefits foregone is the cost of changing the land use from grazing to preservation. From the viewpoint of the public, the cost of giving up grazing is the before tax earnings. In this analysis, before tax net benefits foregone are estimated because this is the loss to society. Also, the assumption is that if the land were sold the farmer would invest the capital in another taxable activity.

programs such as Crystal Ball or @Risk. A planning horizon of 60 years is used. Then set up the whole farm budget without the 200 hectares of developed native pasture contributing anything, and calculate annual net benefit from the same whole bundle of farm resources for the same distribution of GM/DSE. Then calculate the net difference between the ‘with’ and ‘without’ situations. Next, estimate the present value of the annual benefits using annual discount rates randomly generated and drawn from a distribution defined, in this case, as normal with mean of 10 per cent and ranging over 3 standard deviations from 1% to 19%. Then sum the annual PV of net benefits to give a total PV of the benefits foregone if the right to use the 200 hectares of native pasture land is relinquished. This gives one estimate of the possible total PV of the cost not grazing the native pasture over the 60 year planning horizon, i.e. one ‘run’ of 60 years with variable GMs and discount rates. One thousand runs of these 60 years can be done, almost instantaneously, and a distribution derived of estimates of the value of the native grassland to the farm business. As a further angle, the possibility can be considered that the decision-makers view of opportunity cost and rate of time preference might change over the planning horizon. For illustrative purposes, in this case, the effect of applying a 10 per cent real required return on marginal capital (with range from 1% to 19%, normally distributed) for the first 30 years (while the farmer is aged say 30-60 and the business is continually pursuing growth) to a more conservative opportunity cost of mean 4% real and variation of one standard deviation, from 1% to 7 % (as farmer aged from 60-90 and seeks greater security). Note: much is possible – rate of time preference considerations could see very high rates of time preference in the later years too.

What are the implications for the information the farm decision-maker now has about the risky aspects of estimates of net benefits and more information about the capitalization rate to use in valuing the stream of net benefits?

Results using probabilistic analysis (Crystal Ball tool) are now presented.

Risk adjusted estimate of value of native grassland to farm business with distributions of annual gross margin/DSE and discount rates used:

Mean value	\$320447
Median	\$325748
Coefficient of Variation	0.23932

Maximum value	\$525841
Minimum value	\$131007

These statistics describe the distribution of the possible values that the land could contribute over a sixty years planning horizon, based on a thousand possible futures, called 'runs'. The key points are that we now have a distribution of values instead of a single value, and also, that the distribution changes as more information is added about risk. By estimating distributions of values of the land, both the farmer and government are able to know more about the range of possible values and have a more informed bargaining position. The alternative is for each party to place a single value, and to negotiate around that. The proposed method results in more informed decisions, and, conceptually, better estimates of costs to society and more efficient resource allocation.

The information can be expressed in terms of the cumulative frequency of the probability of the value of native grassland to farm business being less than:

0%	\$128567
20%	\$245448
40%	\$302966
60%	\$338157
80%	\$379083
100%	\$519261

This tells us that there is no chance that the value of the land used for grazing is certain to be more than \$128,000 and certain to be less than \$519,000. There is 60% chance it will be less than \$338,000. In the negotiation between the farmer and government, the discussion shifts from a focus on a single value to the range of possible values of the land and probabilities of values within the distribution of values, making for more informed 'horse-trading'.

With more probabilistic information, a farmer might be prepared to sell the grazing rights to the government for a price at which there is 60% chance its value will turn out to be less than \$338,000 and only 40% chance its value will turn out to be more than this i.e. a 6/4 on (6 chances of it happening, 4 chances of it not happening) bet that the farmer will get a higher return by

selling the rights than by grazing the land and a 6/4 against (4 chances of it happening and 6 chances of it not happening) bet that the farmer would have been better off grazing the land. From the government perspective, the reverse odds apply – the government would be taking a 6/4 on chance that it may be paying more than the opportunity cost for the land and taking a 6/4 against chance that it may be getting the land cheaply, in light of all that is currently known. If the 80% less than cumulative probability value can be negotiated – that’s a 4/1 on chance that the price the farmer is selling at represents a better return than keeping the land and grazing it, i.e a very good bet. On the other hand, at this price, there is 4/1 on chance that the government has paid ‘too much’ for the grazing rights and put too high a price on the native grassland, i.e. a very bad bet. In practice there will be a number of competing punters trying to negotiate bets with the government. Risk information presented in useful form is potentially very valuable in the design and implementation and negotiation of market-based instruments.

Changing the distribution of discount rates as time passes.

When the distribution of the discount rate was changed to lower mean and lower high and low values in a triangular distribution for the latter half of the planning period, the results were:

Mean value	\$459884
Median value	\$469144
Co-efficient of Variation	0.23344
Maximum value	\$194972
Minimum value	\$698402

Comparing the estimates of the mean cost of giving up grazing the native grassland shows that different values result according to the extent risk is considered, and the way it is considered in the analysis:

- value based on average contribution of the native grassland: \$184,400 (\$922/ha)
- value based on marginal contribution, with fixed values for GM/DSE and Discount Rate: \$368,000 (\$1840/ha)
- value based on marginal contribution, with varying, random GM/DSE and Discount Rate (constant distribution over whole time): \$320,447 (\$1602/ha)

-value based on marginal contribution, with varying, random GM/DSE and Discount Rate (different for years 30-60 and years 60-90): \$459,884 (\$2299/ha)

The spread of the distribution of values was reduced slightly when discount rates were reduced from the mid-life of the investment.

The finding is that in this case the value placed on the native grassland is different once whole farm and marginal thinking are used, and importantly, once risk is formally incorporated into the analysis in the form of distributions of activity gross margins and discount rates. Also, quite a different value is placed on the native grassland once a changing distribution of discount rates over time is incorporated more fully into the analysis.

7/ Discussion

When considering future options for the use of farm resources that could include shifting capital that is currently in agriculture into publicly funded conservation management, the following needs consideration:

- the private and public decision-makers will have different costs of the capital that is currently producing the net benefit from agriculture
- the private and public decision-makers will have different attitudes to risk
- incorporation of risk by allowing for the reality that the GM/DSE and the opportunity discount rates will vary each year will produce different estimates to the case when fixed values for key variables are used.
- Giving weight to the possibility that the private decision maker's discount rates will change as they get older will also produce a different cost of giving up the use of the native grassland

More complete accounting for risk and uncertainty associated with investments changing the future shape of farm systems than hitherto has generally been the case will lead to different conclusions than would follow from less complete analysis. Depending on the case, there is no foretelling which change in the system will come out best. Nor does it matter – only that a more informed decision (bet) will have been made. This will be a decision that contributes more to the national well-being than otherwise would have been the case.

When considering questions about managing and conserving native grassland in the face of uncertainty it is necessary to ponder a potential qualification: to what extent marginal improvements in the information content and quality of the decision will result in an improved decision, and to what extent will the Great Uncertainties of Agriculture in Australia ‘swamp’ any attempts at fine-tuning the information content of farm decisions? Being better informed sounds like a good thing, but in agriculture uncertainty is so great it might not make much difference. That is, the goodness or badness of decisions may well be over-taken by uncertain events. The question is ‘Now that sophisticated risk analysis tools are available enabling convenient and quick probability sampling techniques to be used, how much more useful is the information provided and how far ought we sensibly go using probability analysis?’ It seems undeniable that more sophisticated incorporation of risk into valuation of private assets whose rights may be acquired by the public leads to different valuations from those that derive from analysis using less sophisticated risk analysis. This has implications for the amount the public may have to pay to acquire these rights.

This question of risk and information has been the point of the paper, rather than the economic results. The example is hypothetical and illustrative only. In many cases, native grassland of high conservation value will run much lower stocking rates than four DSE/ha used in the example, except possibly on the fertile areas of former grassland, like the basalt plains of western Victoria. In addition, in many situations some grazing is now regarded as consistent with maintaining conservation values.

While the questions of risk and information have motivated this paper, there are also questions about alternative directions for public policy. Should the development rights for areas of conservation significance on private land be purchased, with the areas then managed separately to the rest of the farm system, or should policy pursue the path of integrating conservation into the production system (Dorrrough *et al* submitted)? The relative merits of this choice will depend on the nature of the native grassland, the effect of potential farm management activities on its conservation values, and on the nature of the farming system. In the hypothetical example outlined above, the opportunity cost to the farmer and the cost to the public agency is likely to be considerably less if agreement can be reached to continue the current management of the hill country. The cost is likely to be further reduced if maintaining conservation values is consistent

with some changes to management, such as deferred grazing (Zollinger 2005, Moll *et al* 2005) that increase productivity, and better integrates native pasture into the farm system.

In any case, Stiglitz (2004) dictum remains true: establishing institutions that theory proves will enhance efficiency is a necessary condition to improving efficiency, but it is not always sufficient. Efficiency will only be improved if the institutions work properly.

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