

native vegetation public conservation on private land

cost of forgone rangelands development in southern and western Queensland



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alister davidson, stephen beare, peter gooday,
phil kokic, kenton lawson and lisa elliston

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Australian Bureau of Agricultural and Resource Economics
GPO Box 1563 Canberra 2601

Telephone +61 2 6272 2000 Facsimile +61 2 6272 2001
Internet www.abareconomics.com

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foreword

Native vegetation can generate a diverse range of environmental benefits to society. In a free market, however, these benefits tend to be underprovided. As a way of maintaining or increasing the size of these benefits, all Australian governments have recently strengthened regulatory controls intended to protect large areas of native vegetation on private farms.

Although the broader community obtains the benefits from the environmental services generated by native vegetation conservation it does not directly determine the level or bear the cost of the provision of those services. This has raised questions about whether or not the level of environmental services derived from native vegetation both now and in the future can be achieved more efficiently.

In 2004 the Australian Government resolved to conduct regular and independent reviews of the costs and benefits associated with native vegetation and biodiversity policies. The research reported here was conducted to assess the economic impact that mandatory native vegetation conservation is having on broadacre agriculture in Queensland.

Based on face to face surveys conducted with broadacre farmers in southern and western Queensland in 2005, this report quantifies the extent to which native vegetation is having an impact on farm returns.



Karen Schneider
Acting Executive Director

September 2006

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This report draws heavily on data collected in ABARE's surveys of broadacre
industries. The success of these surveys depends on the voluntary cooperation
of farmers, their accountants and marketing organisations in providing data.
The dedication of ABARE's survey staff in collecting these data is also gratefully
acknowledged. Without this assistance, the analysis presented in this report would
not have been possible.

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summary

- > In recent years, the Queensland Government has strengthened regulatory controls over native vegetation in an effort to improve environmental outcomes. However, enforced conservation of native vegetation by society typically involves a tradeoff in many farming areas – farmers, and society more generally, forgo potential increases in agricultural income in order to realise potential improvements in environmental outcomes. Understanding the nature of this tradeoff is important when assessing whether conservation of native vegetation generates net benefits to society.
- > To investigate the opportunity cost of public vegetation conservation in broad-acre agricultural areas, data were collected in face to face interviews with farmers. The survey was undertaken in the rangeland and cropping areas of southern and western Queensland, a region of around 540 000 square kilometres. In all, 351 farmers were interviewed. Approximately half of the farmers had aspirations to improve their farm’s performance by undertaking further development of rangeland areas but were unable to do so because they are constrained by a number of factors.
- > Regulations intended to conserve native vegetation were identified by farmers as by far the most important constraint to development. Of the potential development areas identified in the survey, most were earmarked for improving livestock carrying capacity (95 per cent). The balance involved projects aimed at changing land use from grazing to cropping. Up to 7.5 million hectares, or 14 per cent of the survey region, were identified by farmers as likely to be affected by existing native vegetation regulations (and other factors as well in some areas).
- > Public policies designed to increase the stock of native vegetation above privately optimal levels can impose negative impacts on some farmers. These impacts include constraints on farm productivity growth as well as curtailed access to finance and increased personal stress (Productivity Commission 2004). Although some landholders may benefit from enforced conservation (for example, through the reduction of negative environmental impacts arising on other properties), on balance, native vegetation regulations are likely to have a net negative effect on farmers (Productivity Commission 2004).
- > It is estimated that the cost of forgone agricultural development opportunities in the survey region is around \$520 million in net present value terms. The

impacts are, however, likely to be highly variable across the region. For 90 per cent of farmers in the survey region, the opportunity cost of forgone development across a farm's operating area ranged between \$26 a hectare and \$838 a hectare.

- > The median cost of forgone rangelands development was \$217 000 a farm over the survey region, but for 90 per cent of the farmers affected by the vegetation regulations the cost ranged from \$3000 a farm to more than \$1 million a farm. The highly skewed distribution of cost estimates on both a per hectare and a whole farm basis indicates that while the impacts of the native vegetation regulations are widespread and frequently small to moderate, it is likely that the impact in some areas could be severe.
- > The significant regional variation in the costs imposed by the existing native vegetation regulations means that it is unlikely that the expected public benefits from enforced conservation will exceed the costs in all regions, unless production and conservation values are closely aligned. The costs of conserving a given level of native vegetation could be lowered if tradeoffs between agricultural development in one area and increased native vegetation conservation in another area were possible. To allow tradeoffs of this type, it is necessary to understand how environmental benefits vary across the landscape. It is also necessary to have a clear understanding of the environmental objectives being pursued, particularly at the paddock scale.
- > It is important to recognise that the costs and benefits of native vegetation conservation are likely to change over time as market conditions and societal preferences change. For example, land prices in some parts of the survey region have more than doubled in recent years (partly in response to increased cattle prices), implying that the opportunity cost of forgone development has also increased substantially. To ensure that native vegetation is allocated to its highest valued use (agriculture or conservation) over time, policies that allow adaptation to changes in the costs and benefits of conservation are required.
- > This study adds further weight to the Productivity Commission (2004) finding 9.8 that command and control regulation for addressing biodiversity conservation may be limited in its effectiveness and efficiency because 'the problem is too complex, dynamic and geographically heterogeneous for jurisdiction-wide rules that necessarily focus on achievement of proxy targets'.

- > While this study highlights the diversity in the opportunity costs of forgone development, it still needs to be established that identical or greater environmental benefits can be generated at a lower cost. Creating markets for agricultural and environmental tradeoffs to realise efficiency gains will result in transaction costs. Furthermore, additional efficiency losses may arise where information on the benefits and opportunity costs associated with environmental conservation is distributed asymmetrically between governments and landholders. The solution to the asymmetric information problem lies in designing markets that maximise competitive behavior in order to reduce undue market influences.
- > On its own, command and control regulation to manage native vegetation conservation is unlikely to allow the net benefits to society from using native vegetation (for agriculture or conservation) to be maximised either across regions or through time. Adopting a more flexible approach may improve environmental outcomes that are of benefit to society in ways that minimise the costs incurred by private landholders. However, such a policy will impose costs and risks, as the information required is extensive and subject to a high degree of uncertainty. In the presence of potential thresholds, the risks of having too much or too little native vegetation relative to the optimum will be minimised with a combined policy of price based and quantity based instruments (Hartwick and Olewiler 1998 p. 215).
- > Central to investigating many of the alternative approaches to native vegetation management is a reduction in the uncertainty about the provision of ecosystem services. A clear understanding of the final objectives – that is, the desired level of ecosystem services – and the link between native vegetation and meeting these objectives are essential to enable agricultural and environmental tradeoffs that are likely to generate net benefits to society.

introduction

Native vegetation is generally considered to be a scarce and hence valued resource in Queensland. In recent years, strengthened regulatory controls over native vegetation stocks have been introduced in an attempt to improve environmental outcomes. The Queensland Government passed the *Vegetation Management Act 1999* and consequential amendments in order to phase out broadscale clearing of remnant vegetation by December 2006. According to the Queensland Government Department of Natural Resources, Mines and Water, the new laws will: conserve remnant 'endangered' and 'of concern' regional ecosystems; prevent land degradation and the loss of biodiversity; manage the environmental effects of clearing; and reduce greenhouse emissions (NRM 2005).

The 1999 act and consequential amendments state the definition of vegetation as a native tree or plant other than the following: grass or nonwoody herbage; a plant within a grassland regional ecosystem prescribed under a regulation (that may include grass or nonwoody herbage species); and a mangrove (s. 8). Remnant vegetation is considered to be areas mapped as remnant native vegetation and, in other areas, to be native vegetation 'covering more than 50 per cent of the undisturbed predominant canopy; averaging more than 70 per cent of the vegetation's undisturbed height; and composed of species characteristic of the vegetation's undisturbed predominant canopy' (*Schedule Dictionary*).

The public conservation of native vegetation is being facilitated largely on privately managed rangeland areas. In many rangeland areas, conservation of native vegetation by society involves a tradeoff – farmers, and society more generally, may forgo potential agricultural production and broader economic benefits with an expectation of realising the benefits of improved environmental outcomes. However, ensuring that the net benefits to society from native vegetation conservation are positive is a complex task.

Recent changes to rights over native vegetation have imposed costs on society – in particular, the costs are borne by farmers with aspirations to develop their properties further. While they were compensated, these costs in terms of forgone development opportunities vary across landscapes and can change over time with the innovation and adoption of new technologies and practices.

According to the Productivity Commission (2004, finding 6.1), controls over the clearing of native vegetation can have a negative impact on farmers' management strategies by:

- > limiting the opportunities to expand or reconfigure the area of productive land
- > restricting the ability to maintain the amount of productive land on a property
- > inhibiting the introduction of new technologies
- > restricting or preventing changes in land use and
- > inhibiting a range of normal farm practices such as thinning vegetation, rotating (fallowing) parts of the property, clearing around fencelines and managing pest animals and weeds.

The Productivity Commission's 2004 inquiry into native vegetation and biodiversity concluded that the current regulatory approaches to native vegetation management were having a negative impact on some private landholders by imposing significant costs, preventing property development, preventing land use change to more profitable activities, preventing the introduction of cost saving innovations and restricting the clearing of regrowth vegetation and woodland thickening that results in reduced livestock production. Their report also highlighted the need to develop native vegetation policies that provide landholders with positive incentives to retain and manage native vegetation and to deliver specified environmental outcomes in flexible, innovative and cost effective ways.

The aim in this report is to quantify many of these impacts, including the cost of forgone rangelands development, that have arisen as a consequence of the mandatory conservation of native vegetation on broadacre farms in southern and western Queensland. The report thereby contributes to the Australian Government's response to recommendations in the Productivity Commission (2004) inquiry into the impacts of native vegetation and biodiversity regulations released on 10 August 2004. This report complements an earlier study investigating the impacts of native vegetation conservation on productivity and returns to broadacre farms in New South Wales (Davidson et al. 2006b).

2

a brief economic framework

- > The environmental benefits generated by native vegetation conservation on private land that are of benefit to society more broadly are public in nature.
- > Farmers will generally conserve native vegetation on their property to the extent that it delivers private benefits but have little incentive to conserve beyond that level.
- > Government intervention in the management of native vegetation in order to increase the provision of public benefits from native vegetation conservation may be justified where net benefits are generated.

Native vegetation can generate a diverse range of goods and services that are of benefit to society. They include biodiversity benefits, improved wildlife habitat, improved water quality, reduced salinity, control of land degradation and other ecosystem services (Lockwood, Walpole and Miles 2000; Productivity Commission 2004; Sinden 2005). As our understanding of these benefits has improved, society's demand for environmental outcomes has also increased.

Farmers manage around two-thirds of Australia's land, much of it supporting native vegetation. However, tension can arise because the environmental benefits generated by native vegetation are 'public goods' – that is, society or some segment of society benefits from them but does not directly determine the level or bear the cost of their provision. Public goods tend to be underprovided in a free market.

Farmers will generally conserve native vegetation on their property to the extent that it delivers private benefits – for example, in the form of shelter for livestock and windbreaks – but have little incentive to conserve vegetation beyond that level. Once native vegetation exceeds some threshold level, it may start to compete with agricultural production. Government involvement in the management of native vegetation may be justified where the increased provision of native vegetation conservation benefits outweigh the costs. In such cases, the purpose of government intervention should be to ensure that the net benefits (public and private) of land use are increased where agriculture and conservation are competing activities in rangeland areas.

In the presence of severe information deficiencies, governments often gravitate toward the use of command and control regulation, in an attempt to address the underprovision of public goods. In such cases, governments are more likely to

pursue environmental policies that provide a greater degree of immunity against ecosystem failure, the more averse they are to the risk of an unfavorable environmental outcome (Ben-Haim 2001, p. 140). There is a tendency to invoke decisions that increase the probability of the desired environmental performance criteria being met – in the case of native vegetation, more vegetation is always seen as better. In doing so, governments trade off robustness in ecosystem services against potentially higher net benefits to society (Ben-Haim 2001, p. 42) and the opportunity to improve economic efficiency. However, in adopting command and control regulation, governments can unwittingly introduce perverse incentives that may reduce the certainty of achieving desired environmental outcomes in some areas.

An improvement in economic efficiency requires that a reallocation between agricultural and environmental outcomes increases society's net return. This will be achieved if the net return to a parcel of land is at least as high as it could be under any alternative use. Facilitation of this generally requires that the benefits associated with conserving native vegetation be considered against the opportunity cost of forgone agricultural development as well as the costs associated with government involvement to ensure that the net benefits are positive. Government transaction costs include the costs associated with the information required to set an appropriate policy instrument monitoring intended environmental outcomes, extensive surveillance and enforcing regulatory compliance.

A benefit-cost framework for prioritising and focusing conservation efforts in areas where the expected benefits from government intervention exceed the expected costs may assist in achieving a more economically efficient outcome. For example, the environmental benefits of conserving native vegetation in some cases could be sufficiently large to outweigh the costs to farmers of not being able to undertake agricultural activities. However, in other cases, the environmental benefits could be low – or the opportunity cost to farmers very high – such that restricting the agricultural activity could result in a net loss to society.

The implementation of a full benefit-cost framework requires an assessment of all benefits and costs, including the costs of forgone agricultural production, the benefits of native vegetation conservation and the transaction costs of government intervention. The environmental benefits of retaining native vegetation remain largely unquantified. Nevertheless, a partial or threshold analysis can still be used to establish how large these environmental benefits need to be in order to warrant public investment or other forms of government intervention. Understanding the nature of costs, not only their magnitude, but also the factors that determine them, can also help in designing more cost effective policies.

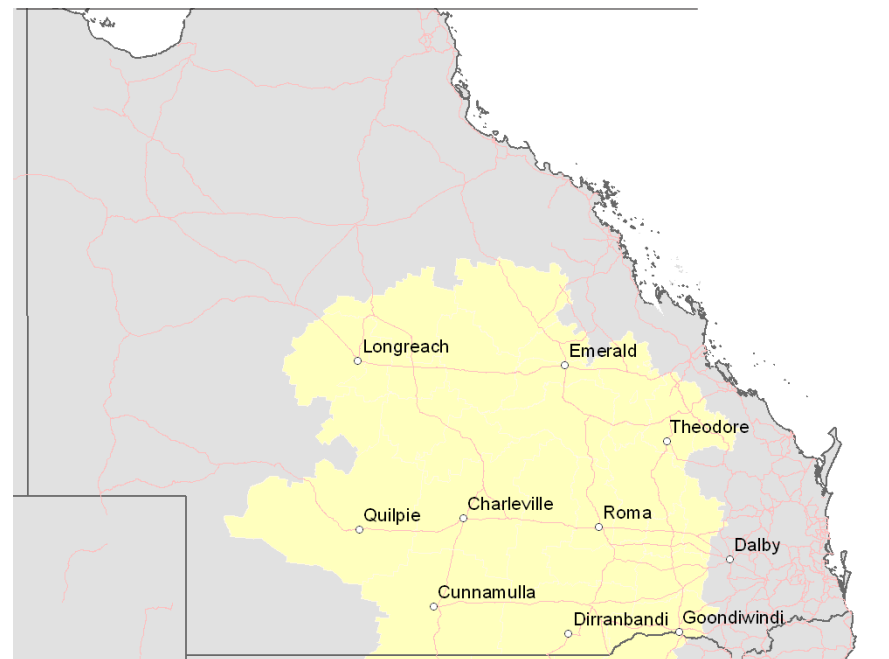
3

survey methodology

- > In total, 351 farmers operating properties within an area of around 540 000 square kilometres of southern and western Queensland were surveyed.
- > Farm financial, physical and spatial data for 2004-05, together with the nature, extent and perceived constraints of potential rangelands development projects were collected.

To collect the data necessary to investigate the opportunity cost of public vegetation conservation in broadacre agricultural areas, face to face interviews were conducted with 351 farmers situated in rangeland and cropping areas of southern and western Queensland. Survey farms were drawn from the ABS population list to ensure that statistically reliable estimates could be made. The survey region (map 1) covered parts of the Darling Downs, Fitzroy, Central West and South West ABS statistical divisions – an area of approximately 540 000 square kilometres at the interface of the wheat-sheep and the pastoral zones.

map 1 **survey region in southern and western Queensland**



The survey region was chosen because it was considered to be an area dominated by broadacre agricultural industries, realising growth that typically follows land development requiring vegetation clearing (ABARE and BRS 2003). The area is characterised by cattle, wool, prime lamb and extensive dryland cropping operations on farms with diverse levels of vegetation. It contains farms with significant development potential and properties affected by increasing vegetation density. Farms in the survey region that derive a significant proportion of their income from irrigated agriculture were not considered in this analysis.

Farm financial and production data were collected using ABARE’s existing Australian agricultural and grazing industries survey (AAGIS) methodology for the 2004-05 financial year (see also, map 2). The AAGIS data are extensive, covering all agricultural and non-agricultural production, costs and receipts, inputs and outputs, for the area operated by the farmer, with adjustments made for areas leased or share farmed.

The performance of broad-acre agricultural farms is largely dependent on their natural resource base, including climate, soil, vegetation cover and access to water sources (Boero Rodriguez, Kokic and Davidson 2006). Such natural resource inputs are spatially distributed – that is they vary in both quantity and quality across landscapes. In order to understand how environmental policies affect farm performance, it is necessary to measure the level of natural resource inputs used in generating agricultural outputs. This is examined through geospatial analysis using farm location, farm management areas and potential agricultural development areas that are spatially referenced, together with natural resource data sets in a geographic information system.

In order to generate spatial data for each survey farm, primary management units were digitally mapped, including rangeland areas, crop rotation areas and

map 2 **survey region overlaid with ABARE subregions**



areas unused for agricultural production. Farmers were also asked what areas they would like to develop for cropping or increased livestock carrying capacity, if there were no physical, financial or regulatory constraints. These potential development areas were mapped, together with supporting information on the nature and importance of any constraints to such development opportunities. A full explanation of the spatial data generation is contained in appendix A.

4

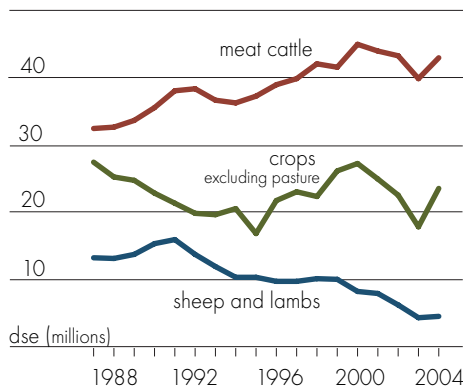
trends in broadacre agriculture

- > Productivity growth of broadacre agricultural industries has trended upwards over the long run. However, many of the approaches used to maintain productivity growth have involved changes to native vegetation stocks.
- > Increasing levels of native vegetation are leading to a decline in grazing productivity in some rangeland areas. The intrusion of native and non-native species has led to an estimated median 10 per cent reduction in carrying capacity since 1995 across the survey region, with the worst affected farmers (the top 5 per cent of those reporting a decline in carrying capacity) reporting declines in carrying capacity in excess of 50 per cent over the same period.

The negative impacts on the performance of broadacre farms from enforced native vegetation conservation can be broadly categorised as either restrictions on changes in land use or restrictions on productivity growth on existing enterprises – both of which are likely to have an impact on farm profitability in the long run.

The mix of agricultural activities undertaken on broadacre farms in the survey region has changed since the early 1990s in response to changes in their relative profitability (figure A). The decline in the demand for wool led to the demise of the wool reserve price scheme in 1991 and contributed to an immediate decrease in sheep numbers and an increase in cattle numbers and crop area, but the decline in wool demand has continued. Some of the shifts in the relative importance of agricultural industries illustrated in figure A, particularly the increases in cropping activity, may have involved a reduction in the native vegetation stock.

fig A **broadacre agricultural trends in southern and western Queensland**



Note: Using ABS data for the four statistical divisions most relevant to this study – Central West, Darling Downs, Fitzroy and South West. A dry sheep equivalent (dse) is the energy requirement of a 50 kilogram wether sheep maintaining constant weight (Davies 2005): 1 cattle \approx 8 dse, 1 hectare crop \approx 12 dse.

Productivity growth in broadacre agricultural industries has trended upwards over the long run and has provided an important means for maintaining farm viability (Davidson et al. 2005). Continued productivity growth can be achieved by adopting more efficient management practices, technologies, input mixes and output mixes. However, many of the approaches used to maintain productivity growth in the livestock industries have involved changes to native vegetation stocks. These have included thinning of native vegetation to increase livestock carrying capacity and construction of laneways to improve mustering efficiency. Now some livestock producers are operating against a backdrop of both invasive scrub and native vegetation thickening and a potential loss in productivity.

invasive scrub impacts on grazing productivity

Increasing levels of native vegetation can lead to a decline in grazing productivity in some rangeland areas. Invasive scrub (as this phenomenon will be referred to in this report) is the progressive establishment of vegetation, in terms of density and species mix, that is not part of the natural or developed landscape. Farmers' options to manage invasive scrub can be restricted under the *Vegetation Management Act 1999* (Queensland) and its amendments through either direct protection or limits over the types of clearing technologies permitted.

Invasive scrub reduces grazing production output, thereby affecting the efficiency and effectiveness of farm management practices. Declining livestock carrying capacity resulting from increasing levels of vegetation was reported by 42 per cent of farmers in the survey region. However, there was considerable regional variation, ranging from 37 per cent of farmers on the Darling Downs to 82 per cent of farmers in the west and south west areas (table 1).

Invasive species led to an estimated median 10 per cent reduction in carrying capacity since 1995 across the respondent survey region, with the worst affected farmers (the top 5 per cent of those reporting a decline in carrying capacity) reporting declines in carrying capacity of 50 per cent (table 1). Landholders can be further affected, as invasive scrub can also lead to stock management problems, land degradation and the increased prevalence of native and introduced pests.

The rangeland areas reported by graziers as being affected by invasive scrub species over the past ten years are shown in map 3. On the basis of graziers' opinions, an area to the east of Charleville has experienced a relatively sharp decline in livestock carrying capacity since 1995. Although thickening of species such as mulga has been recorded in the Charleville area since at least the 1940s (Beale

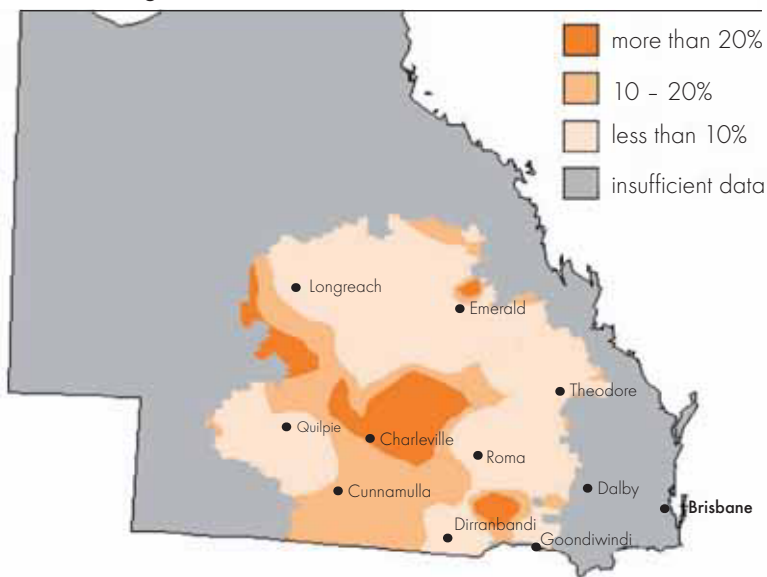
table 1 impact of invasive scrub on livestock carrying capacity

	survey region %	West and South West %	Charleville–Longreach %	Darling Downs %
Farmers reporting declines in grazing capacity because of increasing vegetation.	42	82	53	37
decline in carrying capacity ^a				
- lower 5 per cent	5	5	5	5
- median	10	15	12	10
- mean	17	16	23	16
- upper 5 per cent	50	30	50	50

^a Since 1995, reported by affected farmers only.

2004), areas that had already been ‘invaded’ prior to 1995 were not captured, as respondents were asked to consider only the past ten years. Both ‘scrub invasion’ and ‘tree thickening’ can lead to declines in carrying capacity; however, there has been no attempt to differentiate between these two phenomena.

map 3 decline in livestock carrying capacity due to increasing vegetation since 1995



5

opportunities for farm development

- > Rangeland areas have been developed in the past and some farmers have aspirations to undertake development activities in the future – to improve farm productivity.
- > Vegetation regulations were reported most often as a factor limiting the development of rangelands across the survey region and by 100 per cent of farmers in the Charleville–Longreach area.
- > An estimated 46 per cent of farmers in the survey region reported that they would develop parts of their rangeland areas if clearing constraints under the vegetation regulations, together with any other limiting physical, financial or regulatory constraints, were relaxed.
- > A median increase of 14 per cent in overall farm carrying capacity was expected by farmers wanting to undertake rangelands developments that were limited by the vegetation regulations and other constraints.

Farmers continue to seek opportunities to improve their productivity. Development of rangeland areas generally requires changes to the natural resource base. However, farmers' access to these natural resources, such as native vegetation stocks, can be affected by a range of natural, social and institutional factors (Ellis 2000).

factors constraining farm development

As part of the survey, farmers were asked about the importance of selected constraints that were limiting their ability to undertake rangelands development activities intended to improve broadacre agricultural productivity. In the survey region, vegetation regulations were reported most often as limiting the development of rangelands for both increased grazing productivity (figure B) and cropping (figure C). Of the farmers that wanted to undertake rangelands developments, 81 per cent on the Darling Downs, 88 per cent in the West and South West areas and 100 per cent in the Charleville–Longreach region reported that vegetation regulations were a constraint of at least some importance (table 2).

table 2 **perceived importance of vegetation regulations in constraining farm development**

	survey region	West and South West	Charleville–Longreach	Darling Downs
	%	%	%	%
Very important	64	75	92	56
Of some importance	21	13	8	25
Neither important or unimportant	2	12	0	2
Of little importance	9	0	0	12
Not important at all	4	0	0	5

fig B **constraints to rangelands development for increased livestock carrying capacity**

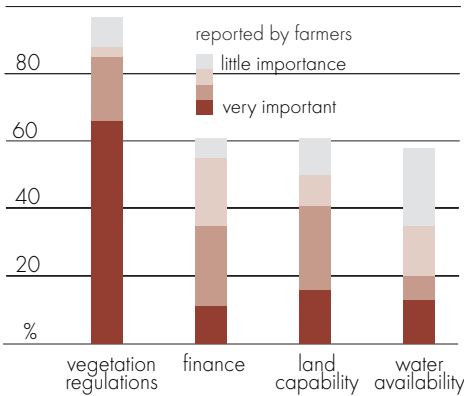
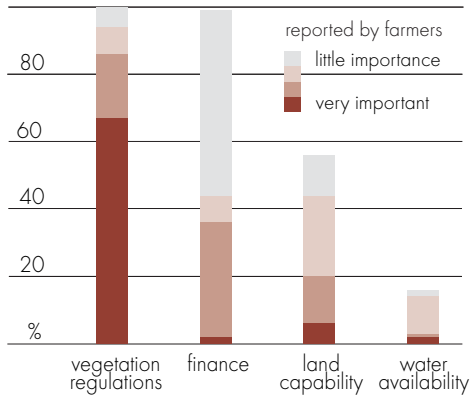


fig C **constraints to rangelands development for land use change to cropping**



In some instances, farmers reported more than one constraint to further development, including vegetation regulations. While it is not possible to separate these joint effects, it is useful to identify the areas for which potential rangelands development opportunities are constrained by the vegetation regulations only. As can be seen in map 4, the area to the east of Charleville is particularly affected – 50 per cent of the surveyed farms indicated that their development opportunities would likely be constrained by the vegetation regulations alone.

development opportunities constrained by vegetation regulations

An estimated 46 per cent of farmers in the survey region reported that they wish to develop parts of their rangeland areas for higher livestock carrying capacity or for cropping, if clearing constraints under the vegetation regulations, together with any

other limiting physical, financial or regulatory constraints, could be relaxed (table 3). For the purposes of this report, rangelands is a broad category of land characterised by native plant communities that are often associated with grazing.

Farmers wanting to undertake rangelands development were mostly interested in achieving higher livestock carrying capacities compared with land use change to cropping, although some farmers wanted to undertake both grazing and cropping developments (table 3).

Not only were most farmers interested in grazing development, but the scale of potential grazing developments was considerably larger than that of potential cropping developments. On average, potential grazing development areas covered around 20 per cent of a farm's operating area compared with 9 per cent for potential cropping developments (table 4). However, there was considerable variation across the survey region. The median potential grazing development area was approximately 900 hectares but was over 29 000 hectares for the larger developments (top 5 per cent) in the West and South West area (table 4).

The improvements in grazing productivity that were expected by farmers following development of selected rangeland areas were significant over large parts of the survey region. A median increase of 14 per cent in overall farm carrying capacity

map 4 **proportion of farmers with potential rangelands development opportunities constrained by vegetation regulations only**

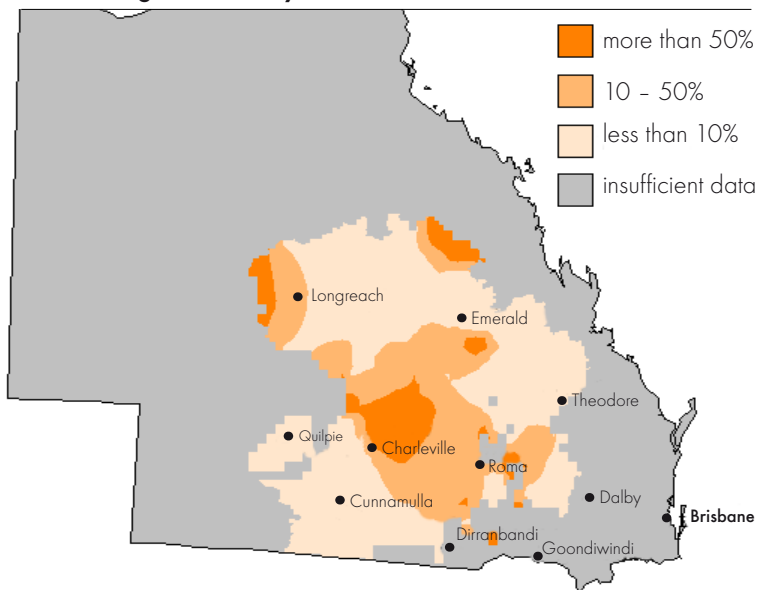


table 3 potential rangelands development opportunities in survey region

	survey region	West and South West	Charleville–Longreach	Darling Downs	
Farmers wanting to undertake rangelands development:	%	46	70	47	45
- for cropping	%	16	–	11	18
- for grazing	%	42	70	42	40
Total potential development area:	'000 ha	7 533	1 785	1 732	4 016
- for cropping	'000 ha	406	–	79	327
- for grazing	'000 ha	7 127	1 785	1 653	3 689

Note: Data from farms where developments were identified as being constrained by the vegetation regulations (either alone or in combination with other factors).

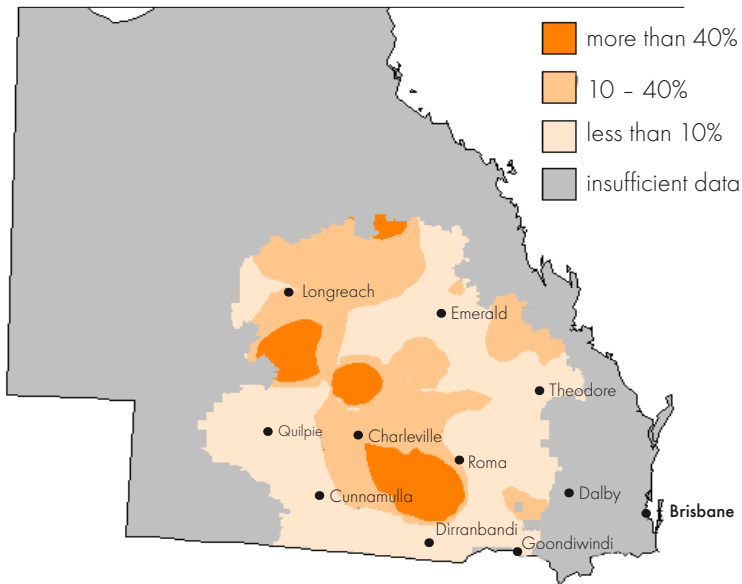
was expected by farmers wanting to develop rangeland areas but limited by the vegetation regulations and other constraints (table 5). The estimated increase is reported as an average for the entire property. This issue is discussed more thoroughly later. Considerable variability was again observed over the survey region, with some farmers south east of Charleville and north west toward Longreach reporting expected increases in livestock carrying capacities in excess of 40 per cent following rangelands development, as illustrated in map 5. If achievable,

table 4 rangelands development opportunities on farms with potential development areas

	survey region	West and South West	Charleville–Longreach	Darling Downs	
Potential crop development					
Proportion of operating area	%	9	–	6	9
Potential development area:					
- lower 5 per cent	ha	31	–	267	31
- median	ha	267	–	426	127
- mean	ha	502	–	834	468
- upper 5 per cent	ha	1 851	–	1 862	1 851
Potential grazing development					
Proportion of operating area	%	20	28	19	20
Potential development area:					
- lower 5 per cent	ha	42	1 661	216	42
- median	ha	915	5 668	1 619	514
- mean	ha	3 088	8 368	4 518	2 134
- upper 5 per cent	ha	14 526	29 203	13 275	12 553

Note: Data from farms where developments were identified as being constrained by the vegetation regulations (either alone or in combination with other factors).

map 5 **expected increase in average livestock carrying capacity from potential rangelands development**



these gains could contribute significantly to total farm productivity and the long term viability of grazing in the survey region.

Current vegetation stocks are potentially limiting substantial improvements in live-stock carrying capacity, particularly in areas around Cunnamulla, Charleville and Longreach. The survey data indicate that regulations that limit vegetation clearing or limit the adoption of clearing technologies are likely to curtail opportunities for productivity growth in the survey region.

table 5 **expected increase in carrying capacity from grazing development**

	survey region %	West and South West %	Charleville – Longreach %	Darling Downs %
Lower 5 per cent	1	3	0	1
Median	14	9	30	10
Mean	32	29	48	28
Upper 5 per cent	116	116	73	82

Note: Data from farms where developments were identified as being constrained by the vegetation regulations (either alone or in combination with other factors).

6

cost of public vegetation conservation on private farms

- > The estimated median cost of forgone development opportunities across the survey region is \$150 a hectare for farmers wanting to improve the productivity of rangeland areas but are being constrained by the vegetation regulations (and other factors as well in some areas).
- > Opportunity cost estimates varied considerably across the survey region. Of the farmers who wanted to undertake developments, 90 per cent of the costs ranged between \$26 a hectare and \$838 a hectare of potential development land.
- > The costs of regulation can change with changes in commodity markets and economic conditions more generally.

Broadacre farmers generally invest in land development activities with an expectation of improved financial returns. The private returns to land clearing are generated from the increased carrying capacity (or crop yields) and the associated increase in operating profits. This can be expressed mathematically as outlined in box 1.

The cost of clearing vegetation varies depending on its type and thickness. The average per hectare costs for clearing remnant vegetation to native pasture assumed in the analysis are presented in table 6. For the purposes of this analysis, contractor clearing costs for potential crop development areas were assumed to be double the clearing costs for pastoral use in order to reflect the more extensive land preparation necessary for crop establishment. Clearing costs were applied to potential development areas on the basis of their average projected foliage cover (PFC) according to the National Forest Inventory classification (with no allowance for height): woodlands (10–30 per cent PFC); open forest (30–70 per cent PFC) and closed forest (greater than 70 per cent PFC).

The opportunity costs arising from forgone rangelands development opportunities for which the vegetation regulations are at least partly limiting are reported in table 7. For the following analysis it was assumed that potential development opportunities in the absence of constraints would occur progressively over fifteen years, with annual amounts being discounted at a rate of 5 per cent. The median cost across

box 1: estimating the opportunity cost of forgone development

Private returns to land clearing are generated from the increased carrying capacity (or crop yields) and the associated increase in operating profits and can be expressed as:

$$\text{return to land clearing} = \text{expected increase in agricultural output from clearing} \\ \text{times net returns per additional unit of agricultural output} \\ \text{less cost of clearing and development}$$

Increased returns to land clearing are capitalised into farm land values. The opportunity cost of forgone development may be estimated as follows:

$$\text{opportunity cost} = \text{farm value}_{\text{dvlp}} - \text{farm value}_{\text{pre}} - \text{clearing cost}$$

where $\text{farm value}_{\text{dvlp}}$ is the expected value of the farm operating area following development, $\text{farm value}_{\text{pre}}$ is the predevelopment value of the farm operating area and clearing cost is the cost of clearing and development of selected areas for either improved livestock carrying capacity or cropping.

Accordingly, the opportunity cost arising from development opportunities forgone as a result of native vegetation conservation policies can be estimated by comparing land values with and without such development (Middleton et al. 1999; Davidson et al. 2006b) if the farm operating area does not change, as follows:

$$\text{opportunity cost} = \text{operating area} \times (\text{land value}_{\text{dvlp}} - \text{land value}_{\text{pre}}) - \text{clearing cost}$$

where operating area (hectares) is the farm area including leased area but excluding areas leased out and land value (\$/ha) is the average per hectare land value net of the operator's residence and other capital improvements.

In order to predict the expected change in average land value if a potential development opportunity was undertaken on survey farms, it was necessary to construct a hedonic model that included, among other characteristics, land use intensity – a variable sensitive to changes in livestock carrying capacity and crop development, as follows:

$$\log(\text{land value}) = \alpha + \beta \times \log(\text{land use intensity; other characteristics})$$

The individual importance of a broad range of characteristics that could potentially influence broadacre agricultural land values were investigated, as listed in Davidson et al. (2006b). Factors found to be important determinants of broadacre land values in the survey region were land use intensity (dry sheep equivalents per hectare), pasture growth index (relative climate index of long run plant productivity) and stream frontage, as shown in the table. Other potential factors were tested, including vegetation density, average land slope and distance to nearest town with a population greater than 2500 or 5000, but these did not significantly explain differences in farm land values.

hedonic land value model

variable	coefficient	standard error
<i>constant</i>	8.73	0.38
<i>log(land use intensity)</i>	0.71	0.04
<i>log(pasture growth index)</i>	2.47	0.27
<i>stream frontage</i>	0.07	0.02

Note: Dependent variable is log(land value). All coefficients are highly significant at the 1 per cent level ($n = 203$, $R^2 = 0.82$).

The predicted change in average land value for each farm (Δ land value) was calculated according to its expected increase in average land use intensity (that is, over the entire farm operating area) likely to be realised following development activities, as follows:

$$\Delta \text{land value} = \text{land value}_{pre} \times \left[e^{\beta_1 \{ \log(LUI_{dvlp}) - \log(LUI_{pre}) \}} - 1 \right]$$

where LUI_{dvlp} is the developed land use intensity, LUI_{pre} is the predevelopment land use intensity and β_1 is the regression coefficient for $\log(\text{land use intensity})$ obtained from the hedonic land value model above. According to the land value model in the table, land use intensity is the only factor that can be potentially influenced by farm management decisions to improve farm performance. Land use intensity is the amount of metabolisable dry matter produced per unit area and is measured in dry sheep equivalents per hectare. Each farm's land use intensity following development was determined from survey data of expected increase in carrying capacity in dry sheep equivalents.

table 6 **assumed contractor costs for clearing native vegetation to native pasture**

	West and South West	Charleville- Longreach	Darling Downs
	\$/ha	\$/ha	\$/ha
Closed forest	94	94	119
Open forest	94	94	119
Woodlands	68	68	89

Source: ABARE and BRS (2003) inflated to 2004-05 in consultation with contractor. Cost includes stick raking, burning and pasture establishment.

the survey region was \$150 a hectare; however, considerable variability was observed across the survey region. For 90 per cent of the farmers that wanted to undertake developments, opportunity costs ranged between \$26 a hectare and \$838 a hectare of potential development land. The variability in cost estimates is likely to reflect differences in intended land use, land capability, climate and access to surface water between potential development areas.

A spatial distribution of these opportunity cost estimates on a per hectare basis is shown in map 6. The variability shown in map 6 indicates that the cost impacts of the vegetation regulations are likely to be widespread. Furthermore, it is likely that enforced conservation of native vegetation could have a severe impact on potential farm performance in particular areas.

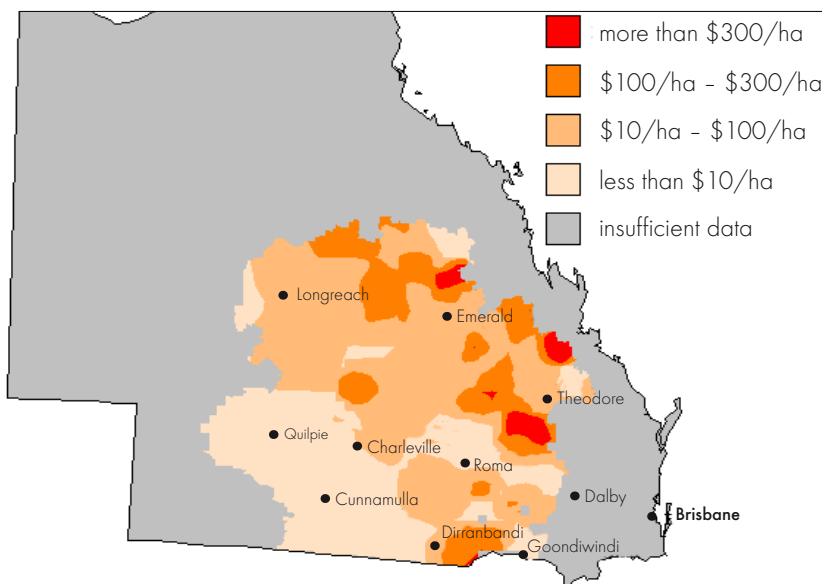
table 7 **opportunity cost of forgone broadacre agricultural development attributable to vegetation regulations**

		lower 5 per cent	median	mean	upper 5 per cent
Cost per hectare of development area	\$	26	150	268	838
Cost per farm	\$'000	3	217	346	1 004

Note: Opportunity costs reflect progressive development over a 15 year period at a real discount rate of 5 per cent. Data from farms whose developments are constrained either jointly or severally by the vegetation regulations.

The median opportunity cost of forgone rangelands development was \$217 000 a farm over the survey region, but for 90 per cent of affected farms, the cost ranged from \$3000 a farm to over \$1 million a farm. Again, the highly skewed distribution of cost estimates on a whole farm basis adds to the evidence that, while the impacts of native vegetation regulations could be relatively small and widespread, it is likely that there could be individual properties that are bearing a disproportion-

map 6 opportunity cost of forgone rangelands development over which vegetation regulation is a contributing factor



ately high share of the cost of public conservation of native vegetation on privately managed land.

Regional opportunity costs were obtained using survey weights based on ABS industry characteristics (Davidson et al. 2006b). The total cost of forgone rangelands development on agricultural land in the survey region was estimated to be \$520 million in net present value terms as a consequence of the vegetation regulations constraining development, either alone or in combination with other factors.

generality of the estimates

The estimated costs of forgone rangelands development reported in table 7 are likely to be sensitive to a number of key assumptions underpinning the analysis. The estimated costs are dependent on the extent to which constraints other than vegetation regulations are likely to limit rangelands development. Where instances of multiple constraints occurred, it was not possible to conclude that the development opportunity was forgone on account of the vegetation regulations alone, even though they were typically the most important restriction. Where this occurs the opportunity cost estimates will be overstated.

The opportunity cost estimates are sensitive to assumed development projections and assumed clearing costs. Farmers' development intentions are likely to be strongly influenced by prevailing commodity market conditions and projected developments are highly uncertain. The clearing cost estimates used in this study are based on contractor rates with full cost recovery. However, it is likely that on some farms, the opportunity cost of resources applied to land development may be valued lower than those appropriate to a contractor. At the assumed contractor clearing rates, many of the potential development opportunities in the far western areas become unviable and thus understate the opportunity cost where clearing costs are less than those assumed.

The opportunity cost estimates are based on stated preferences collected from farm surveys. The veracity of the development aspirations of the survey farmers has not been examined or corroborated against land use capability, financial viability or the native vegetation regulations themselves. The data therefore represent the impact on agricultural development as perceived by surveyed farmers. It was not possible to speculate on the impact of potential response bias on the cost estimates.

comparison of results with ABARE BRS 2003 study

ABARE and BRS (2003) undertook for the Australian Government a socio-economic assessment of a proposal to immediately halt clearing of 'of concern' vegetation and phase out clearing of remnant vegetation in Queensland.

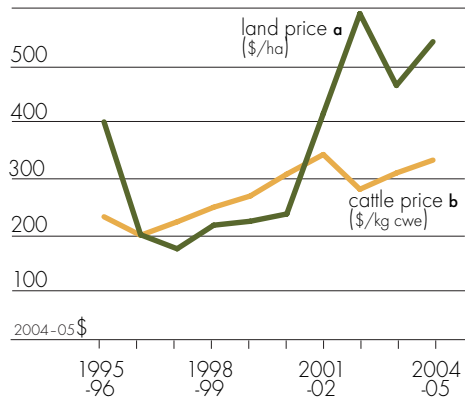
Two of the key findings in that study are of direct relevance to this report, namely:

- > The net area of remnant vegetation in rural Queensland that is forgone under the proposal that was investigated, but would otherwise be subject to economic clearing over the next 25 years is around 4.8 million hectares (compared with 7.5 million hectares in this study).
- > The estimated opportunity cost of forgone clearing under the proposal if 2 per cent of future clearing was for cropping is likely to be around \$190 million (compared with \$520 million in this study).

While the opportunity cost estimates of the two studies are quite different, there are some valid reasons for this. Indeed, understanding the main reason for the difference in the estimates provides an important insight into the characteristics of efficient native vegetation management policy. There are many methodological differences between the two studies. For example, the difference between the estimates of total forgone potential development area may simply reflect differences in the estimation techniques – expert opinion in the 2003 study versus farmers' stated preferences in the 2006 study.

However, the bulk of the difference in the opportunity cost estimates can be explained by the continued increase in real (inflation adjusted) broadacre land values on which the estimates have been based – largely driven by the upward trend in beef prices (figure D). Median prices for all farms in the survey region (net of homestead and other improvements) have increased over the past three years, for both grazing and cropping properties. However, examination of land price movements according to farm operating area (by area quartile) indicates that the larger properties (and thus more likely to be grazing properties) are more likely to have experienced the larger increases in land value (table 8). Around half of the properties have experienced a doubling in land values and for the largest 25 per cent of the properties, land values have more than trebled.

fig D land and cattle prices



a Land price is the median land price for the survey region net of homestead and other improvements. b Cattle price is the Australian weighted average saleyard price for cattle in carcass weight equivalents.

It is likely that the development aspirations of farmers are closely linked to price movements on commodity markets. There has been a long upward trend in the size of the cattle industry (figure A). For many beef producers who wish to improve their grazing productivity, the cost of their forgone rangelands development opportunities is likely to increase in tandem with the current upward movement in cattle prices, general economic conditions and property markets in general. This is an important point. The costs of regulation can change with changes in commodity markets, economic conditions in general or changes in societal preferences. Vegetation management policies should be designed to allow some flexibility in how vegetation conservation goals are reached and determined.

table 8 median land values in the survey region, 2001-02 and 2004-05

		area quartile				
		all farms	0-25%	26-50%	51-75%	76-100%
2001-02	\$/ha	373	690	646	206	81
2004-05	\$/ha	531	951	728	439	278
% difference		42	38	13	113	243

implications for natural resource management policy

- > A clear understanding of the desired level of ecosystem services and the dependence of ecosystems on native vegetation conservation across landscapes is essential to enable agricultural and environmental tradeoffs that are of net benefit to society to be realised.
- > Opportunities may exist to target efforts to maintain or increase levels of native vegetation where benefit–cost ratios are highest.
- > If such opportunities exist, command and control approaches to managing native vegetation conservation are unlikely to allow the net benefits to society from using native vegetation (for agriculture or conservation) to be maximised.
- > Market based instruments can potentially provide policy makers with more flexible approaches to enable natural resource assets to be allocated more efficiently.
- > Creating markets for agricultural and environmental tradeoffs to realise efficiency gains will result in transaction costs.
- > There are likely to be net gains to society from reducing the incidence of invasive scrub in areas where mutually beneficial outcomes to key stakeholders can be negotiated.

It has been argued that, in general, a reliance on command and control regulation to enforce native vegetation conservation on private land, in order to increase ecosystem services that benefit society more broadly, is unlikely to be fully effective (Davidson et al. 2005). It is also unlikely to lead to an outcome where environmental services are delivered at least cost (Davidson et al. 2006b). Government involvement in the provision of ecosystem services is necessary because of its public good nature. Where private land management dominates, ecosystem services that are of benefit to the broader community are likely to be underprovided in the absence of government involvement.

The information requirements needed for governments to apply command and control regulation as a means of generating agricultural and environmental outcomes that are of maximum benefit to society are likely to be high. Govern-

ments must know both the marginal benefits and marginal costs arising from the enforced inclusion of additional areas of native vegetation in the national estate. Faced with severe information uncertainties, it is not surprising that governments invoke decisions, such as attempting to maximise native vegetation conservation, in order to minimise the probability of an adverse environmental outcome.

Regulations requiring the conservation of native vegetation on privately managed agricultural land above privately optimal levels impose a cost on some farmers. In the absence of government intervention, farmers will generally conserve native vegetation on their property to the extent that it delivers private benefits such as shade, erosion control, shelter belts and wind breaks. However, farmers have little incentive to conserve vegetation beyond levels that maximise private benefits. The magnitude of the costs of enforced native vegetation conservation imposed on some farmers that have been estimated in this study appear to provide a justification for the exploration of alternative policy instruments. However, improving the efficiency of native vegetation regulation is likely to require multiple approaches.

Central to investigating many of the alternative approaches to native vegetation management is a reduction in the uncertainty about the provision of ecosystem services. A clear understanding of the final objectives – that is, the desired level of ecosystem services – and the link between native vegetation and meeting these objectives is essential to enable agricultural and environmental tradeoffs that are likely to generate net benefits to society. The reliance on proxy measures of ecosystem services, such as native vegetation targets are likely to preclude the attainment of more efficient land use allocations and of more valued environmental outcomes.

A key disadvantage of command and control regulation as the dominant policy instrument is that it often reflects an assumption that there will be standard benefits arising from policy action across all those regulated (Chaudhri 2003). Native vegetation conservation benefits vary across landscapes and society can benefit from environmental policies that make use of more flexible instruments that improve environmental outcomes in a way that generates lower costs to landholders.

This study highlights the considerable variability in the costs of forgone development opportunities across broadacre agricultural landscapes. Accordingly, the total costs to society of conserving native vegetation, which include costs associated with administering policies intended to conserve native vegetation, are also likely to vary considerably across large areas of Queensland. Heterogeneous landscapes, in terms of both agricultural and environmental productivity, create

potential opportunities for society to gain from targeting opportunities to preserve native vegetation where benefit–cost ratios are highest. These opportunities are likely to be larger where there is a divergence in the values of land for agricultural and environmental purposes.

The scope for trading potential environmental or agricultural development opportunities will not be as great where land that is more productive for agricultural activities is also more productive in delivering environmental outcomes. An important objective of future research is likely to be establishing how often environmental and agricultural values coincide and require tradeoffs compared with how often they are clearly opposite.

The costs of conserving a given level of native vegetation could be lowered if tradeoffs between agricultural development in one area and increased native vegetation conservation in another area were possible. In order to allow tradeoffs of this type, it is necessary to have a clear understanding of the environmental objectives being pursued, particularly at the paddock scale and understand how environmental benefits vary across the landscape. For this to occur, native vegetation policy would need to refocus from being based largely around regulation of inputs (for example, the types of activities that are allowed) to being based around the provision of vegetation conservation outcomes.

While this study highlights the diversity in the opportunity costs of forgone development, it still needs to be established that identical or greater environmental benefits can be generated at a lower cost to society. Creating markets for agricultural and environmental tradeoffs to realise efficiency gains will result in transaction costs. These transaction costs include the costs associated with acquiring additional information on the likely increase in environmental benefits, assigning conservation or development rights, monitoring environmental outcomes and enforcing contractual compliance. In particular, the information requirements necessary to effectively implement market based approaches to buying improved environmental outcomes, including offset trading schemes, are likely to be substantial (Grafton 2005, p. 2). Where information gaps exist, governments need to balance the additional costs with the expected additional benefits associated with acquiring more information.

To reduce the costs of acquiring the information necessary to make informed choices in competitive markets, governments are increasingly reliant on models intended to predict both environmental values and opportunity costs arising from vegetation conservation. However, the underlying assumptions may be more relevant to some ecosystems or agricultural production systems than to others. Accord-

ingly, the cost savings realised by the adoption of a model based approach in some areas may be offset by the increased risk of generating spurious outcomes in other areas. A more robust approach may involve multimodel based decision support tools that are founded on complementary paradigms.

An additional efficiency loss may exist when the available information is distributed asymmetrically among market players. This problem is likely to be acute when considering markets for trading environmental outcomes where governments are often the only buyer of environmental benefits (and seller of development rights) but there may be many landholders willing to sell environmental offsets (and buy development rights). For example, landholders may know more about the opportunity cost of their land as well as its native vegetation cover than the government (Stoneham et al. 2000, p. 1).

Although governments have knowledge of their biodiversity aims, neither landholders nor governments have a good grasp of the other's knowledge (Stoneham et al. 2000, p. 15). In the presence of information asymmetries, one stakeholder group may be able to influence the market to extract higher payoffs at the expense of the other. The solution to the asymmetric information problem, at least in part, lies in designing markets that are likely to maximise competitive behavior (see Stoneham et al. 2000 for a detailed discussion on the asymmetric information problem).

Over the past couple of years there has been growing interest in the use of market based instruments to more efficiently allocate natural resource assets between competing stakeholders. For example, the creation of a market known as Bush-Broker to enable the registration and trading of native vegetation credits between landholders who are potential suppliers of native vegetation and those seeking development opportunities is currently being developed by the state of Victoria.

With a better understanding of both the costs and benefits of public native vegetation conservation, it may be possible to improve environmental outcomes in a way that lowers the associated opportunity costs to private landholders. Market based instruments can potentially provide policy makers with more flexible approaches to enable natural resource assets to be allocated more efficiently.

The results of this study add further weight to the Productivity Commission (2004, finding 9.8) that command and control regulation for addressing biodiversity conservation may be limited in its effectiveness and efficiency because 'the problem is too complex, dynamic and geographically heterogeneous for jurisdic-

tion-wide rules that necessarily focus on achievement of proxy targets'. This assessment could also imply that the costs of establishing and monitoring a market based approach are also likely to be high and the benefits uncertain. Nevertheless, in the presence of potential thresholds, the risks of having far too much or far too little native vegetation relative to the optimum will be minimised with a combined policy of price based and quantity based instruments (Hartwick and Olewiler 1998, p. 215).

It is also important to recognise that the costs and benefits of native vegetation conservation are likely to change over time as market conditions and societal preferences change. For example, land prices in some parts of the survey region have more than doubled in recent years (partly in response to increased cattle prices), implying that the opportunity cost of forgone development has also increased substantially. To ensure that native vegetation is allocated to its highest valued use (agriculture or conservation) through time, policies that allow adaptation to changes in the costs and benefits of conservation are required.

Areas that are facing invasive scrub or woody weed incursions are likely to be areas where negotiation with a view to settlement between key stakeholders could provide an opportunity to improve the efficiency of the current regulations. As the areas affected by invasive scrub increase, the additional value to society from its conservation are likely to diminish and, in some cases, generate net costs to society. In addition, the additional cost to farmers is likely to continue to increase. There are likely to be net gains to society from reducing levels of invasive scrub in areas where mutually beneficial outcomes to key stakeholders can be negotiated.

However, a higher order question for government is establishing whether blanket preservation of all invasive scrub and timber thickening in some areas actually generates any environmental benefits or in fact delivers adverse environmental outcomes – for example, the potential loss of very rare graniferous birds because of conversion of grasslands to thickets of acacia species such as brigalow and mulga.

In addition to investigating the role of market based instruments to improve the efficiency of native vegetation management, there is another possible way of dealing with the relatively small number of exceptionally high cost 'victims' of regulation that involves an appeals process (Productivity Commission 2006). This process may have particular relevance in areas where it is accepted that the purpose of the legislation is not the conservation of vegetation as such, but rather the expected environmental outcomes that are underprovided and that the links between these

two remain uncertain. Such a policy would allow appeals against the application of the general prohibition on clearing or modifying remnant native vegetation, where owners can demonstrate to an independent tribunal that, for their specific property, the controls impose disproportionately or unreasonably high costs of conservation either because the public good benefits are very small (or zero or negative) or the opportunity costs and compliance costs are excessive or disproportional (Productivity Commission 2006, finding 9.2).

spatial data capture

about the spatial mapping tool

ABARE developed a spatial mapping tool known as SGP (survey georeferencing project) in order to collect spatial data during face to face surveys on farms (map 7).

ABARE has been collecting farm level financial and physical data for nearly sixty years as an input to assessing farm productivity and returns. In the past, these data have been sufficient, for example, for evaluating the impacts of regulations intended to improve the orderly marketing of farm commodity outputs, such as wool, wheat and milk. Such marketing schemes have since been disbanded. In recent times, there has been a growing trend toward the regulation of farm inputs, such as some chemicals and fertilisers, as well as land use and native vegetation.

map 7 **spatial mapping tool toolbars**

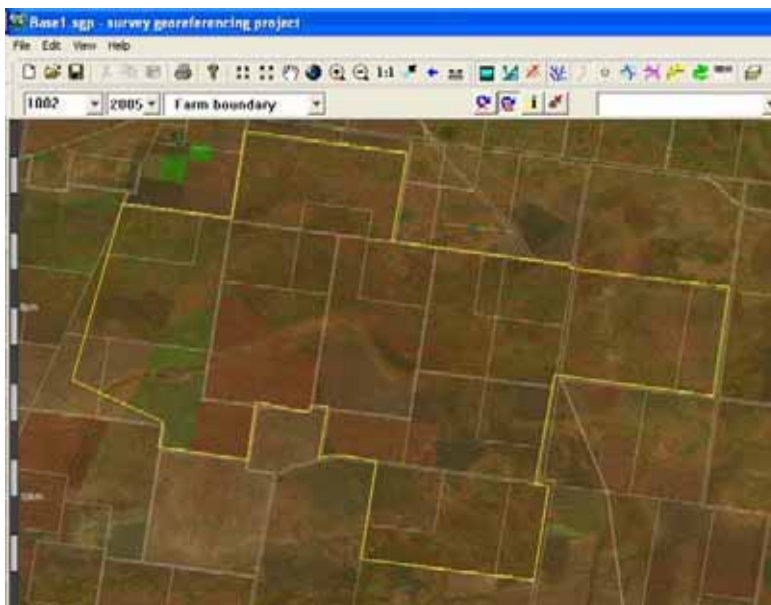


Analysis of regulations governing land use and native vegetation require the collection of spatial data at a subfarm level. The spatial data collected with SGP enable the integration of farm financial and physical data with subfarm spatial data, such as land capability and vegetation cover (see Davidson et al. 2006a for a complete discussion).

SGP was developed in Microsoft Visual C++ 6.0 using MFC, ADO, Shapelib C library v1.2 and Earth Resource Mapping's ECW JPEG2000 SDK v3.1. When working in geographic coordinates, the areas of digitised polygons are computed using an Albers equal area projection. Digitised polygons may be queried and edited; self intersections are not allowed. Polygon and point attributes are stored in a Microsoft Access database as well as in shapefiles. Printing and export to BMP are also supported. Standard GIS navigation tools are provided, as illustrated in the navigation toolbar in map 8. Digitised polygons can be edited in the field using purpose built tools.

The background image that has been adopted for farm mapping is a landsat satellite image of Australia overlaid with cadastral boundaries, as illustrated in map 8.

map 8 spatial mapping by point and click



A landsat image is selected that best captures seasonal activities during the survey year to facilitate farmers' identification of management and cropping areas.

Other feature layers that are used to assist in locating farms and identifying areas to be mapped are: roads, rivers, state boundaries, localities, river basins, ABS statistical local areas, ABARE broadacre survey regions and ABARE dairy survey regions, as depicted in the feature toolbar in map 7. Some feature labeling and search facilities are also supported.

The status toolbar shown in map 7 contains various summary statistics of the current mapping operation, including polygon areas, horizontal and vertical scales and the latitude and longitude of the cursor's position.

Farm mapping is undertaken using a point and click technique on vertices to create polygons. Polygons with holes can also be digitised. The polygon data is stored in a database along with a unique farm number and collection year to enable these spatial data to be merged with farm financial and physical data. Auxiliary nonspatial data, such as management area type, crop yield or type of vegetation cover, are also collected concurrently with the farm areas being mapped to enable further interpretation of the spatial data.

collecting spatial data on farms

mapping farm management areas

The majority of ABARE farm surveys are undertaken in person in a farm office or around a kitchen table. Farm spatial data capture begins by digitising the 'farm boundary' polygon to define the farm operating area (map 9). The farm operating area includes freehold land, areas of private and crown land leased and areas share farmed but excludes areas leased out.

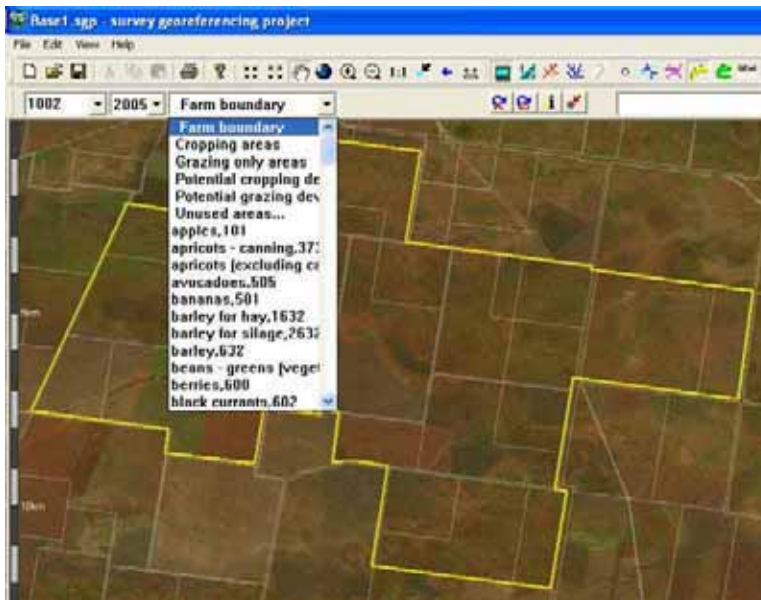
The farm boundary polygon is defined by repeatedly clicking to record all the places where the boundary line changes direction. The current polygon area is shown in the status bar. Mapping accuracy is increased after the data are cleaned up in the office, particularly where a farm boundary follows a water-course or other irregular features.

Digitising other farm polygons is the same as for the farm boundary except that the appropriate description is selected from the list box. The primary management

areas are usually digitised next and these include crop rotation areas (areas that can be cropped or grazed, including fallow areas), grazing-only areas and areas that are not directly used or are unsuitable for agricultural production (including airstrips, dams, heavily timbered areas or steeply sloping country). In the demonstration property (map 10), the crop rotation and unused areas are in pink and blue respectively. In this case, the balance of the property is grazing only areas. It is generally more accurate to omit the major management type during surveys as it can be generated in the office by subtracting the other management areas from the farm boundary.

Survey year crop areas can also be digitised and where farmers keep individual paddock records, the production can also be recorded against the area (map 11). This facility has been included to enable the creation of paddock level productivity models.

map 9 defining farm areas to be mapped



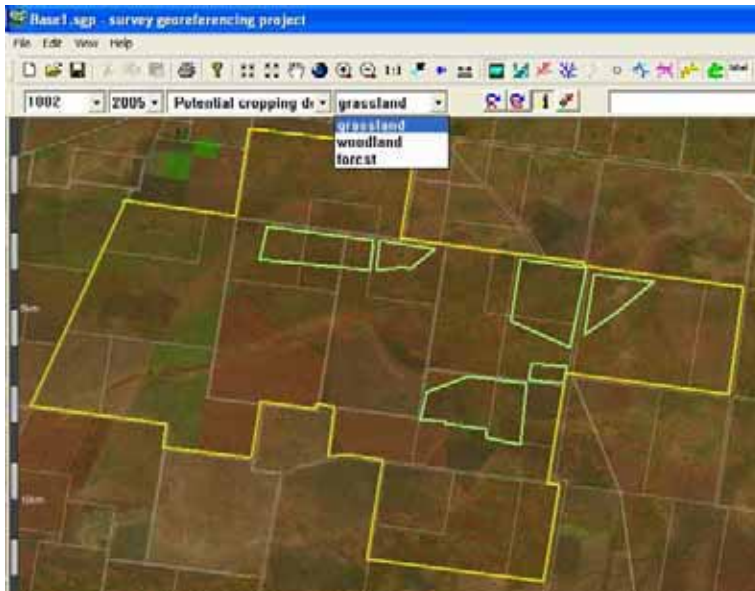
A broad description of the vegetation cover on potential grazing and crop development areas is collected to enable corroboration of data with other spatial data layers, as shown in map 12.

cleaning spatial survey data

Cleaning of the spatial farm survey data is undertaken in the office after collection to improve accuracy and maintain quality. It involves the use of a combination of manual and automated techniques.

The data shape files are edited in ESRI ArcMap™ 9.1. Farm boundary areas are snapped to geometric cadastral boundaries and traced along water courses and other irregular features. The two mapped primary management areas are visually edited against the background satellite image and then snapped to farm boundaries at given tolerances. The residual unmapped management area is clipped out of the total farm area to ensure that all primary management areas are mutually exclusive and all inclusive. Survey year crop areas are snapped to crop rotation areas and visually edited to match the underlying image where possible. Existing crop rotation areas are clipped out of potential grazing and crop development areas to ensure logical consistency of land development. The areas of survey

map 12 mapping potential development areas



polygons are also cross checked against farm management areas recorded in the financial and physical survey.

Area data are generated by intersecting farm survey polygons with other shapefile data layers such as vegetation density and land capability. Raster or grid-point data such as climate or moisture indexes are averaged over particular farm survey polygons. A description of the spatial covariates used in this study are summarised below.

pasture growth index

A moisture availability index obtained from the Queensland Department of Primary Industries was used to account for climate variations between farms. It measures at the shire scale the amount of moisture available for wheat production during the winter growing season, and is based on a soil water balance model that takes into account factors such as rainfall, soil type, sunlight and temperature (Potgieter, Hammer and Butler 2002).

vegetation density

Vegetation density data used in this study was *Statewide Landcover and Trees Study (SLATS) 2003 Foliage Projective Cover (FPC) 0.001 degree mosaic* provided by the state of Queensland (Department of Natural Resources, Mines and Water) in 2006. Foliage projective cover (FPC) is the percentage of ground area occupied by the vertical projection of foliage. It indicates the degree of density of wooded vegetation (foliage and branches).

The SLATS FPC mapping involves an automated decision tree classification technique. All dry season Landsat image dates were used in the classification. The field data used to calibrate the imagery / FPC relationship was mostly collected over the 1996–99 period.

There are several known limitations that affect the attribute accuracy – that is, the level of nonspatial data accuracy linked to location. The analysis has been completed on each of 87 satellite scenes. These have been joined together in the MGA (Map Grid of Australia) zone applying to the majority of each scene to give three mosaic products. This 0.001 degree ground resolution image (approximately 110 metres) represents the average value of the original 25 metre FPC image, exclusive of 0 values. Predicted FPC values greater than 100 per cent or less than 0 per cent FPC have been truncated. Zero value pixels include masked data. These data include deep shadow areas associated with mountains, water

bodies, cloud and cloud shadows. The averaging process was completed for three segments of Queensland corresponding to the three MGA zones – 54, 55 and 56. The result of this was projected into Geographic coordinates (Spheroid: GRS1980; Datum: GDA94) using nearest neighbor resampling. The three images were joined to create a single statewide image.

stream frontage

Stream frontage was included as a potential covariate to capture productivity benefits associated with access to surface water for stock (and domestic) purposes. Measuring effective stream frontages linearly is problematic where streams are heavily folded or in the presence of braided streams – streams that diverge into two or more anabranches. To overcome these complexities, buffers were drawn around streams and the ratio of these buffer areas to farm operating area was adopted as the appropriate stream frontage metric. Buffer widths were assigned according to the following Strahler's stream ordering: 1 (25 metres); 2 (50 metres); 3 or greater (100 metres). In western areas, minor and major streams were assigned buffers of 25 metres and 100 metres respectively. Stream data were obtained from Geoscience Australia.

survey systems for farm mapping

Collection of spatial data necessary to evaluate the impacts of natural resource policies is fully integrated with ABARE's annual Australian agricultural and grazing industries survey (AAGIS). This survey is ABARE's main farm survey platform and is used to collect detailed financial, physical and socioeconomic information from farm businesses across Australia.

The data collected in AAGIS are comprehensive, covering all agricultural and nonagricultural production; costs and receipts; and inputs and outputs. These data correspond to the area actually operated by the farmer, with adjustments made for areas leased or share farmed. In the case of the native vegetation study, not all of these data were necessary for the analysis. However, there are various data edit checks that can be performed if all the survey data are collected, which enables a high level of quality control over the survey data.

The main method of collection for the broadacre surveys is face to face interviews with farmers – often around kitchen tables or in farm offices – with the mapping and other data collected electronically on laptop computers. Although face to face interviews are resource intensive, this approach also assists in maintaining a high level of quality control over the data that are collected.

In the case of the native vegetation research, a supplementary survey was attached to the main survey. It included additional questions designed to investigate the key productivity impacts of vegetation related issues and the extent to which the native vegetation legislation was limiting farmers' management practices. The supplementary survey and spatial data collection process were developed, trialed and revised in conjunction with a regional agronomist – who had an in-depth understanding of the production systems and development options in the survey region – to ensure that the data collected were of high quality and met the project objectives.

sample selection

ABARE surveys are designed and samples selected on the basis of a framework drawn from the Business Register maintained by the Australian Bureau of Statistics to conduct its agricultural census. Permission for ABARE to gain access to the agricultural census framework is required from Parliament each year. This framework includes agricultural establishments in each statistical local area, classified by size and major industry. Sampling from the ABS framework ensures that statistically reliable estimates can be made.

The surveys cover agricultural establishments with an estimated value of agricultural operations of \$22 500 or more. Industry definitions are based on the Australian and New Zealand Standard Industry Classification (ANZSIC). This classification is in line with an international standard that is applied comprehensively across Australian industries, permitting comparisons between industries, both within Australia and internationally. Farms assigned to a particular ANZSIC class have a higher proportion of their total output characterised by that class. Further information on ANZSIC and on the farming activities included in each of these industries is provided in *Australian and New Zealand Standard Industrial Classification* (ABS 2006, cat. no. 1292.0).

sample weighting

The population of broadacre farms in a survey region is typically stratified and the sample selected in varying proportions from the strata to improve the precision of survey estimates – a technique known as stratified random sampling. Since the mix of enterprises varies from farm to farm, a consequence of this approach is that sample weights must differ from farm to farm. Typically, larger farms have smaller weights and smaller farms have larger weights, reflecting the strategy of sampling a higher fraction of the larger farms than of smaller farms (the former having a wider range of characteristics and accounting for a much larger proportion of total output).

Survey estimates are calculated by appropriately weighting the data collected from each sample farm and then using these weighted data to calculate population estimates.

Sample weights are calculated using a model based weighting procedure (Bardsley and Chambers 1984) so that population estimates of numbers of farms, areas of crops and numbers of livestock in various geographic regions and industries correspond as closely as possible to known totals supplied by the ABS. In the case of the native vegetation project, the weights were further adjusted so that estimates of total agricultural areas of different land capability types would conform to known totals.

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