Policies aimed at overcoming impediments to the implementation of on-farm conservation activities

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Abstract

In Australia, off-reserve (on-farm) biodiversity conservation is an important component of ecological sustainable management and development. Policies for biodiversity conservation must consider that sub-optimal levels of on-farm conservation may occur if the net private benefits of on-farm conservation are less than the net social benefits. Research into factors affecting the private costs and benefits of on-farm biodiversity conservation, and into the capacity of policy to influence those factors may thus has much to offer to influence design of effective and efficient policy for biodiversity conservation. This paper makes an empirical contribution to these issues, using data from a survey of landholders in the Burdekin Dry Tropics region in north-east Queensland, Australia. After providing some background information about conservation policy in Australia and in the Burdekin Dry Tropics, it explores the empirical links between (a) on-farm conservation practices and the socio-economic characteristics of landholders; (b) on-farm conservation practices and perceived impediments to adoption; and (c) landholder attitudes to policy instruments and perceived impediments to adoption. It then considers the policy implications of the analysis.

Keywords biodiversity conservation, landholders, adoption, impediments, policy, empirical analysis, econometric models

JEL codes Q21, Q28, Q12, C81, C25

1 Introduction

Traditionally, policy makers have sought to enhance biodiversity conservation by establishing nature conservation areas, such as national parks. For the most part, these conservation areas are in regions where the natural environment is relatively unaffected by human activity – but options for further reservation are rapidly diminishing. Not only are 'unaffected' locations becoming scarcer, but the location and design of many protected areas has been limited by economic and political constraints. This has limited the effectiveness of the conservation strategy and resulted in sub-optimal levels of biodiversity conservation (e.g. Pressey et al., 1996). Conservation planners are now recognizing the inherent limitations of strict reservation as an approach to biodiversity protection and are emphasizing a need for managing whole landscapes in order to reach conservation goals (Margules and Pressey, 2000). In this context, off-reserve biodiversity conservation policy – on which this paper focuses – is receiving greater emphasis and examination (Binning, 1997).

The challenges for off-reserve (on-farm) biodiversity conservation policy are multiple, including:

(1) the preservation (and improvement) of biodiversity where it still exists;

(2) the re-introduction of ecosystem function, connectivity and biodiversity where it has been lost; and

(3) the strategic connection of conservation activities across landscapes.

Where on-farm conservation practices are deemed 'insufficient', policies need to help bridge gaps between the net private and net social benefits of conservation activities.

On-farm conservation requires that landholders and other land-users adopt environmental management practices on a landscape that is designed, primarily, to support commercial activity. This is not to say that landholders have nothing to gain from such practices - utilitarian views of biodiversity stress the direct and indirect welfare gains of biodiversity (Nunes and Van den Berg, 2001)[1] – but private landholders may adopt fewer conservation practices than is socially 'optimal'.

More specifically, the economically 'efficient' (or socially 'optimal') number of on-farm conservation activities is that which sets the marginal social benefits (MSB) of those activities equal to the marginal social costs (MSC). In contrast, the profit maximising number of practices is that which equates marginal private costs (MPC) with marginal

[1] In agro-ecosystems, for example, biodiversity performs many ecological services beyond producing food, fiber, fuel and income, such as the recycling of nutrients, control of local macroclimate, regulation of local hydrological processes, regulation of the abundance of undesirable organisms, and detoxification of noxious chemicals (Altieri, 1999).

private benefits (MPB). Generally, it is assumed that: (a) most marginal costs are internal to the firm, but that some (if not many) marginal benefits are external; (b) the MSC of practices which improve the environment are an increasing function of the number of practices currently in place; and (c) the MSB of practices which improve the environment are a decreasing function of the number of practices currently in place. Hence, MPC=MSC, MPB<MSB, and profit maximisers will adopt sub-optimal levels of sustainable resource management practices (Figure 1).

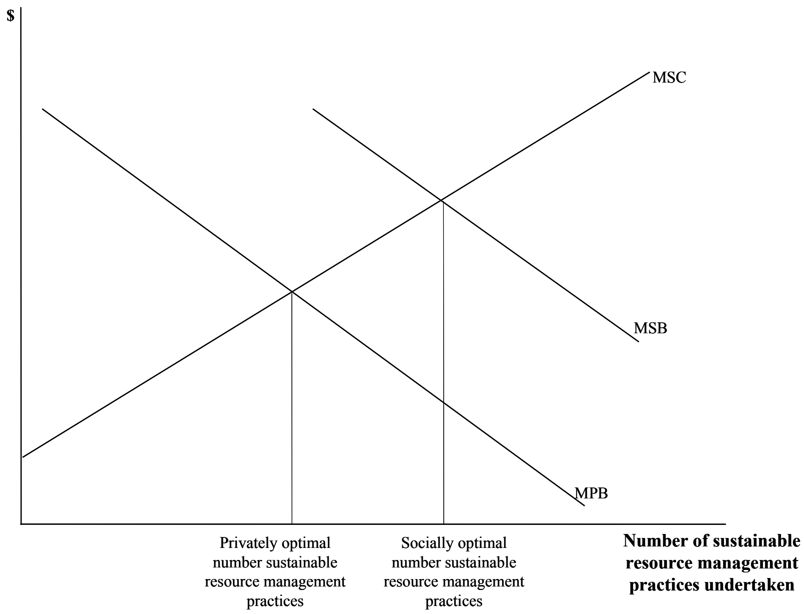

Figure 1: The "basic" economics of on-farm sustainable resource management

In other words, economic theory predicts that (*ceteris paribus)*

(1) Private adoption levels will, generally, be less than socially optimal levels;

(2) The higher (lower) are the marginal private benefits of sustainable resource management practices relative to the marginal private costs, the more (less) likely are landholders to adopt the practice.

(3) Even those whose sole aim is to maximise profits, will adopt some sustainable resource management practices – providing that the marginal private benefits of doing so are greater than the marginal private costs.

(4) Some sustainable resource management practices are undesirable – because the marginal social benefits of adoption are less than the marginal social costs.

Research into factors affecting the private costs and benefits of on-farm biodiversity conservation, and on the capacity of policy to influence those factors may thus have much to offer those in the pursuit of more effective and efficient conservation policy.

This paper makes an empirical contribution to these issues, using data from a survey of landholders in the Burdekin Dry Tropics region in north-east Queensland, Australia. It assumes that environmental and conservation management practices applied in extensive grazing environments are beneficial to all four aspects of biodiversity[2], and uses the term 'adoption' to indicate that a landholder is applying environmental and conservation management practices. It analyses determinants of 'adoption' and landholder perceptions of the effectiveness of a range of different conservation policies aimed at encouraging 'adoption'. It is organized as follows:

Section 2 provides the context of biodiversity conservation in Australia in general and the Burdekin Dry Tropics region in specific. Section 3 explores the empirical links between self-reported rates of adoption and (a) socio-economic characteristics of landholders; and (b) perceived impediments to adoption. Section 4 looks at the empirical relationship between landholder attitudes to policy instruments and perceived impediments to adoption. Section 5 considers the policy implications of the analysis.

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[2] Biodiversity refers to 'the variability among living organisms from all sources, including terrestrial, marine and the ecological complexes of which they are part' (UNEP, 1992: art. 2, p.5). Turner et al. (1999) distinguish four levels of biodiversity, namely genetic diversity, species diversity, ecosystem diversity and functional diversity.

2 Context of biodiversity conservation in Australia

More than two-thirds of Australia's land area – some 500 million hectares – is currently managed by agricultural landholders, while less than 40 million acres (6%) is within the terrestrial reserves system (Environment Australia, 2003). As shown in Figure 2, some types of environments (defined as bioregions) are more abundant in Australian parks and reserves than others.

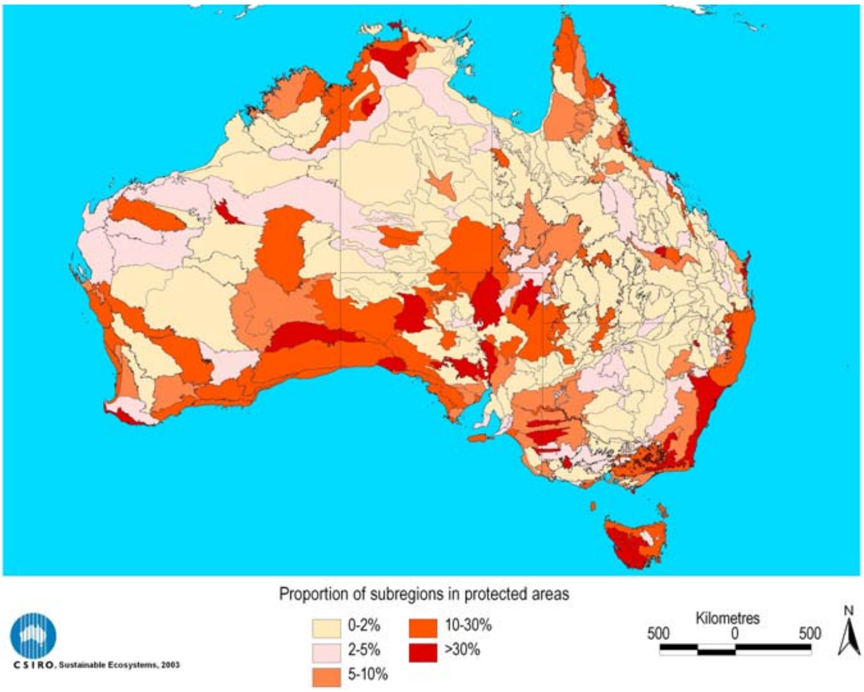

Figure 2: Representation of bioregions (subregions) in the national parks and reserve system

Source: map generated from data provided by National Land and Water Resources Audit, 2002 (Morgan, 2001)

The representation of dry tropical savanna bioregions – across the mid north of the continent – in parks and reserves is particularly low (<2%). It has become increasingly clear that National parks and reserves, alone, cannot be relied upon to conserve native plants and animals despite ongoing increases in the national parks estate (Table 1). The problem is further exacerbated by the fact that biodiversity outside reserves has been affected by vegetation clearance and modification and only scattered remnants of the original natural vegetation exist in large parts of Australia

That there is an increasing recognition that biodiversity conservation relies substantially on off-reserve conservation is evidenced by the recent emergence of Government programs, such as Bushcare and the National Vegetation Initiative. These offer incentives to landholders to (1) conserve, enhance and manage remnant native vegetation to maintain ecosystem function; (2) engage in revegetation activity to improve ecosystem function; and (3) integrate the management of native vegetation into conventional farming systems. However significant the initiation of these programs is, the incentives attached are rather small. In the financial year 2000/2001 the Federal Government spent about $250 million[3] for programs related to off-reserve conservation (Environment Australia, 2003) – less than 50 – 60 cents (AUD) per hectare of agricultural land. Regulatory frameworks in relation to clearing of native vegetation are in place in four of the six Australian States (Slee, 1998).

Table 1: Area of land in Australia under each conservation land tenure type between 1955 and 1999 (km^2)

(Source: National Land and Water Resources Audit, 2002: http://audit.ea.gov.au/ANRA/rangelands/docs/tracking_changes)

Class of tenure / Year	1955	1965	1975	1985	1995	1999
National parks (proclaimed and gazetted)	1,399	10,529	27,909	80,174	143,413	156,982
Conservation lands (not gazetted)	22,341	91,995	100,138	184,136	225,268	244,905
Forested areas (State forest, forest reserve)	4,075	5,409	10,511	19,349	32,787	32,787
Other reserves (hunting, historical, heritage)	759	786	835	877	2,454	2,473

The Burdekin Dry Tropics Region comprises an area of approximately 140 thousand square kilometers in Australia's north-east – an area larger than some of the countries within Europe (Figure 3).

The resident population (2001) is 188,000, of which 70% live in the coastal urban center of Townsville. 99% of land in the region is classified as rural. The region cross-sects three bioregions of the dry tropics (Figure 4). In their original state, these bioregions are characterized by open eucalyptus forests. Of these bioregions, very little is represented in the protected area estate. The area representation is 1.77% for the Einasleigh Uplands, 2.08% for the Briglow Belt and 2.23% for Desert Uplands. The comparative value for the state of Queensland is 3.98% (Sattler, 1999).

With the exception of confined coastal areas and small pockets of land in the south, the region is being extensively grazed for cattle production – on mostly leasehold land. Gross value of livestock production is $198 million (year 1998-99; OESR 2002), or an average $15 per hectare of grazing land. Grazing land productivity may be as low as $5.63 per hectare for the northern areas of the region and average stocking rates varying between 8

[3] Currency is in Australian Dollars (AUD). Exchange rate at time of submission of this paper (30 April 2003): 1 AUD is approximately 0.60 USD.

and 12 head of cattle per square kilometer over the past 30 years (Greiner et al., 2003). Mean farm size is about 280 km^2.

Figure 3: Size of the Burdekin Dry Tropics (lined) compared to Europe

Source: Bachmeier (2002, unpublished)

Native vegetation covers approximately 30% of the land in the south-eastern parts of the catchment where there are high levels of fragmentation. In the northern parts, there are areas with more than 90% cover – areas where connectivity is classified as 'intact'. Despite a generally low rating of landscape stress in the latter areas, 30-50% of ecosystems there are classified as being at risk by the National Land and Water Resources Audit in 2001.

A survey of landholders in the Burdekin Dry Tropics region was conducted as part of a study into social and economic issues of natural resource management (NRM) (Greiner et al. 2003). The survey aimed to profile socio-economic characteristics and 'scope' a broad range of NRM issues over a geographically stratified area for adequate representation across the catchment. In total, 170 landholders were asked to participate in the survey and 82 questionnaires were completed. Amongst other things, the survey collected data on

(1) which types of sustainable resource management practices were being used in the region and which were not;

(2) socio-economic characteristics of respondents;

(3) respondent perceptions of constraints on the adoption of more sustainable resource management practices; and

(4) respondent perceptions of the effectiveness of different policies (in their ability to encourage adoption).

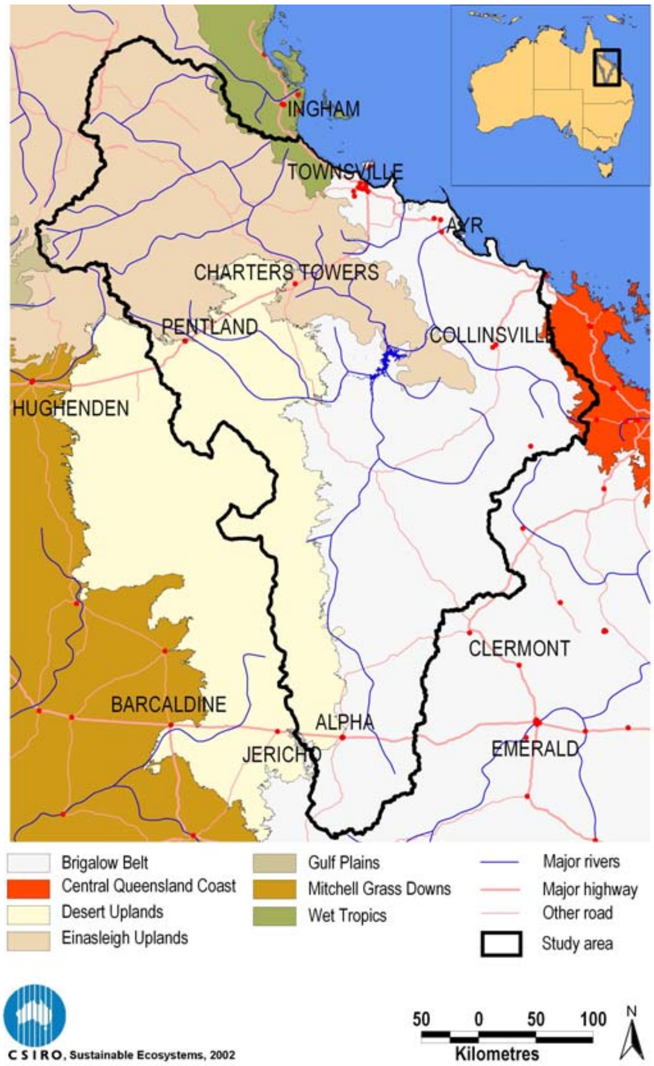

Figure 4: Bioregions of the Burdekin Dry Tropics region.

The analyses performed in this paper focus exclusively on the 57 responses from grazing properties in the dryland part of the catchment, which coincides with the three bioregions shown in Figure 4.

3 Adoption of conservation measures by landholders in the Burdekin Dry Tropics region

The survey scoped the degree of implementation of a series of activities related to NRM. The listing included specific practices under the following groupings: grazing management, crop management, pest and weed control, soil and water management, and environmental management. Figure 5 provides an overview of the average level of implementation of those activities. There is very little implementation of measures associated with active management and conservation of native vegetation and re-vegetation compared to activities related to grazing, weed and pasture management. This could be interpreted through the theoretical framework of Figure 1 as indicating that some activities are perceived as generating net private benefits (ie. MPB > MPC), while others are not.

3.1 The empirical link between 'adoption' and socio-economic characteristics of landholders

Past research has shown that the capacity and willingness of land users to adopt more sustainable management practices, including biodiversity conservation measures, varies with socioeconomic characteristics, such as their income, debt, education, and participation in a community environmental groups (eg. Cary et al., 2001; Fenton et al., 2000; CIE, 2001). If conservation policy ignores such characteristics then it is more likely to fail (Productivity Commission, 2003). Hence, the survey sought information on these characteristics.

Consistent with tenure conditions across the catchment, most (70%) surveyed grazing properties were leasehold. A large majority (85 %) were owner-operated with two-thirds of respondents indicating that management decisions were being made by the owner/manager in consultation with other family members. On average, each property had four (3.9) people working on it – both full-time and part-time – more than half of which (2.6) were family members. 52% of respondents were younger than 50 years old and almost 30% were under the age of 40. About 20% of managers were over the age of 60. The average length of time that the current manager had been running the property was 24 years. In terms of membership in community groups, 94% of respondents were members of the rural fire brigade, 85% were members in the producer association Agforce, and 78% were members of Landcare groups.

Interpreted through the theoretical framework of Figure 1, the MPB curve measures private 'demand' for on-farm biodiversity conservation practices. It therefore reflects both the willingness (or perceived private benefits) and the ability to pay for these practices. Hence, socioeconomic factors affecting either attitudes or financial status will also affect the position of the MPB curve (and possibly, the MPC curve[4]). A statistical analysis of the

[4] If socioeconomic factors influence the cost of adoption (eg. education about cost-effective land management practices), then they will also influence the position of the MPC curve.

empirical relationship between the degree of implementation of selected environmental management practices, or EMPs (the response variates), and the socio-economic characteristics of landholders and farms (explanatory variables) was performed. Details of this analysis are reported in Herr et al. (2003); a summary of which is provided below.

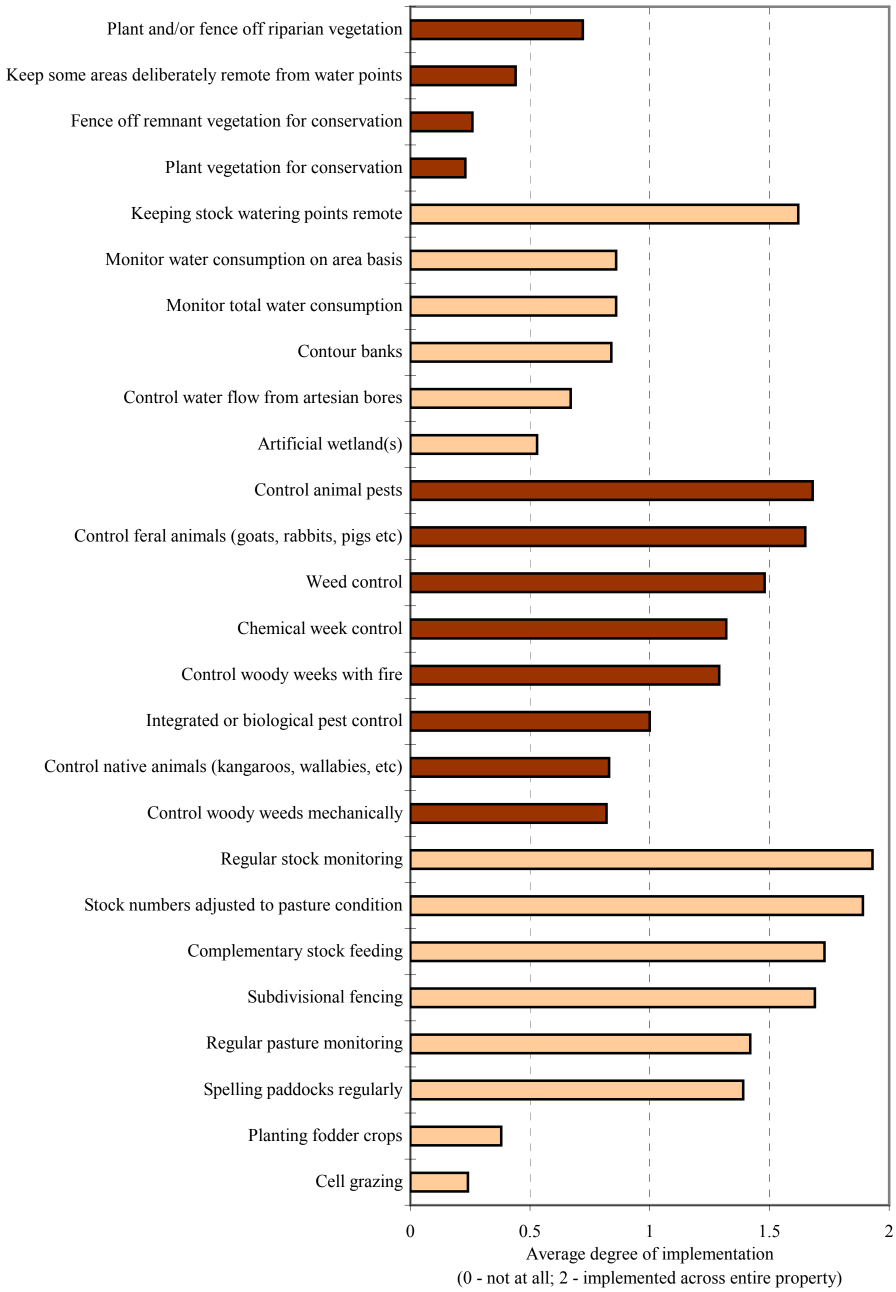

Figure 5: Degree of implementation of NRM practices

The small sample size and the relatively large number of 'missing values' meant that there were few degrees of freedom for analysis, which restricted the number of explanatory variables that could be used for modelling. Each EMP was analysed using three different models: a multinomial with AIC forward and backward selection (Model 1); a binary with AIC forward and backward selection (Model 2); and either a binomial or a quasibinomial (depending on dispersion) using a deviance ratio test for – forward – variable selection (Final model). The results of the analysis are summarized in Table 2.

Table 2: Summary of environmental adoption practices modelling. Variables in grey indicate the focus of subsequent discussions.

(Source: Herr et al., 2003)

	MODEL 1: Multinomial (AIC criteria)	**MODEL 2: Binomial (AIC criteria)**	**FINAL MODEL (based on more stringend deviance test and using quasibinomial if under/over dispersion)**
Response Variable	**Discrimination ability**	**Discrimination ability & dispersion**	**Variables selected (direction)**
Pasture monitoring	63%	84% Under-dispersed	Quasibinomial None
Paddock spelling	72%	96% Under-dispersed	Quasibinomial Equity (-) Freehold (-) Income (+) Family Successor (-) Owner (-)
Fodder crops	71.5%%	84% Under-dispersed	None based on quasibinomial
Cell grazing	87%	82% Under-dispersed	Quasibinomial None
Biological pest control	64%	83% Under-dispersed	Quasibinomial Higher education (+)
Improving riparian vegetation	74.8%	71.8%	Binomial Equity (-) Management Plan (+) Higher education (+)
Fencing off remnant vegetation	77.2%	72%	Binomial Number of family members working on farm (-)
Keeping stock water points remote	64.5%	65% Over-dispersed	Quasibinomial None

The results are consistent with the findings of Cary et al. (2002) and BRS (2001) in that they confirm that different factors and socio-economic variables are associated with adoption. The results reinforce that financial capacity and education are key drivers for implementation of NRM activities. In addition, the analysis raises important questions about the role of title (freehold versus leasehold), family characteristics and operating mode (owner versus manager) in the adoption behaviour of landholders.

This has important policy implications for biodiversity conservation and management of grazing land in that region and elsewhere. It emphasizes that 'capacity' in the form of (a) knowledge and therefore motivation, and (b) financial ability is a necessary condition for adoption. However, there are additional conditions that influence the likelihood of adoption, which have so far not been adequately addressed in adoption research. One of those conditions, namely the role of (perceived) impediments, is explored in the following section.

3.2 The empirical link between 'adoption' and perceived 'Impediments'

Attitudinal dispositions of farmers may be more important than socio-economic characteristics in influencing decision making on farms (Battershill and Gilg, 1997). This is because landholder perceptions of barriers or impediments to the adoption of conservation practices affects the positions of both the MPC and the MPB curves (real or imagined). The landholder survey, therefore asked respondents to rate the importance of numerous potential impediments to adoption on their property (Figure 6).

"Variable climatic conditions and drought" is the single most highly rated impediment, closely followed by a series of impediments that relate to direct expenses and/or opportunity costs of the implementation of conservation activities (and a lack of government incentives).

Next, a statistical analysis of the empirical relationship between the degree of implementation of selected environmental management practices, or EMPs (the response variables), and 'importance' of impediments (explanatory variables) was performed. The small sample size and the relatively large number of 'missing values', meant that there were relatively few degrees of freedom for analysis. To minimize this problem, missing values and invalid responses of the explanatory variables were replaced with medians.

In the first instance, the relationship between overall adoption rates and impediments was examined using a binomial regression. The response variable was defined as: *x* out of *total* – where *x* reflects the number of EMPs adopted by each individual landholder, and *total* reflects the number of EMP practices potentially applicable[5] on the property. Model selection identified important impediment variables by the lowest AIC change and included an assessment of residual deviance against degrees of freedom (df) to identify over or under dispersion. In case of dispersion issues the quasibinomial or quasipoisson model identified relevant variables (Venables & Ripley 2002). When fitting problems (of the computing algorithm) occurred the final model included only variables identified prior to this occurance. "Insufficient labour resources" and "Variable climate conditions" were both identified as significant impediments for the adoption of conservation activities in general (Table 3).

[5] Eg. Landholders without watercourses on their land are not able to affect changes to riparian vegetation.

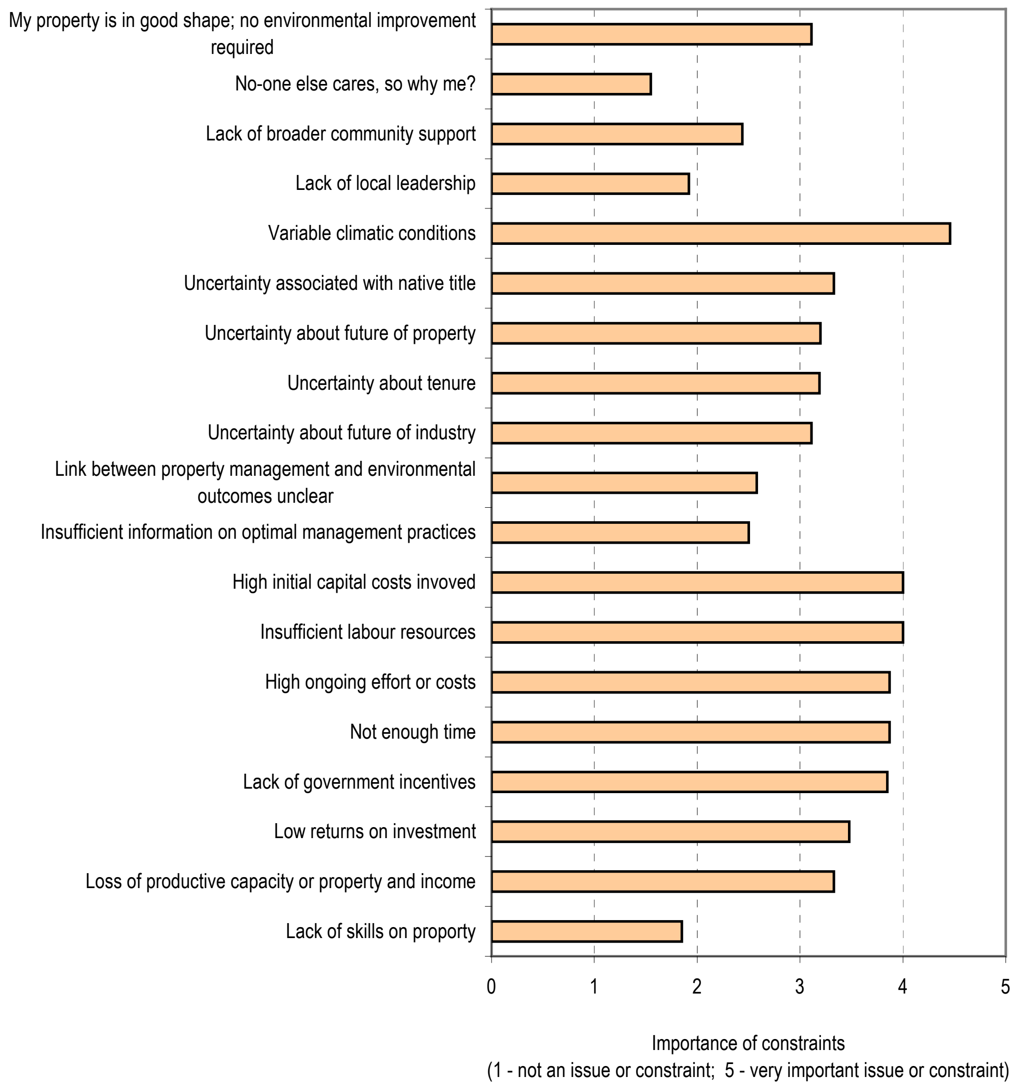

Figure 6: Perceived impediments to implementation of NRM activities

Table 3: Analysis of deviance results for impediments to overall adoption 'rates' (dispersion = 1.15)

Impediment Variable	df	Deviance	Res.df	Res. Dev.	P
Insufficient labour resources	4	12.01	52	65.2	0.007
Variable climate conditions and drought	4	9.96	48	55.3	0.041

The problem of insufficient labour resources reinforces earlier comments re the financial constraint of landholders, while the problem of variable climatic conditions draws attention to issues of risk. Interpreted through the simplistic model of Figure 1, it is worth noting that the expected value of MPB may be relatively constant over time, but variable climatic conditions and drought will serve to alter its ‘actual’ position frequently – and unpredictably. Risk neutral land holders may consider the pros and cons of adoption using the expected value of MPB, but risk averse landholders will not. Instead, they will ‘discount’ the value of adoption – assessing MPBs at something less than the expected value. If climate also affects the MPCs of adoption, risk averse landholders will assess the net private benefits of adoption using estimates of costs which are higher than the expected values. Either way, variable climatic conditions will serve to exacerbate problems of sub-optimal adoption – a problem clearly noted by landholders in the Burdekin.

To investigate the issue further, a binomial modeling approach was used to examine the relationship between the adoption of individual EMPs (as binary coded variables) and perceived impediments to adoption (step 1). Where it was possible to identify individually significant ‘impediments’ to the adoption of an individual EMP, the relationship between adoption/non adoption and the strength of respondent reaction to that impediment was examined in detail (contingency table testing for statistically significant differences in the attitudes of adopters and non-adopters to each impediment). In cases where no impediment was identified as having a statistically significant relationship with an EMP, the relationship between adoption/non-adoption and the strength of respondent reaction to the impediments of Table was examined, instead.

Six response variates (pasture monitoring, cell grazing, fodder crops, fence-off remnant vegetation, plant native vegetation and install remote watering points) identify different important impediments, namely: "Insufficient labour resources"; "Variable climate condition"; "Uncertainty about tenure"; "Uncertainty about the industry"; "Loss of productive capacity on property"; "Lack of broader community support"; and "Insufficient information on optimal management practices". The attitude "No-one else cares, so why me?" is strongly rejected by farmers not planting native vegetation. Four response variates (paddock spelling, biological pest control and riparian vegetation improvement) do not relate to any impediment variables directly using binary modelling procedures. However, using contingency tables, paddock spelling is identified as being significantly related to "Variable climate condition", while biological pest control is significantly related to "Insufficient labour resources" as well as "Variable climate conditions”. Riparian vegetation improvements also relate significantly to “Variable climate conditions”.

These results (Table 4) show that the key barriers to the (increased) adoption of conservation activities are costs associated with risk – primarily climatic risk, but also risks associated with tenure, and the future of the industry. Other key barriers are those associated with expenses and/or opportunity costs of implementation – many landholders feel that they are unable to adopt more with existing budgets (in the face of current relative factor and output prices and with current assessments of the net private benefits of adoption).

The results also show that different impediments relate to different conservation practices, although there are no perceivable differences in impediments to vegetation-related NRM activities as compared to other NRM activities. They also highlight the role for community support in conservation and show that non-adopters strongly reject any notion that they might have a stewardship attitude problem. The results have important policy implications for biodiversity conservation and management of grazing land in that region and elsewhere – they re-emphasize the critical importance of financial 'capacity' as a necessary condition for adoption, while suggesting that risk mitigation may also be an important policy target.

Table 4: Summary of the relationship between 'adoption' of individual EMPs and individual 'impediments'.

Response variate	Impediment variables that were statistically significant (at 5%) when including all explanatory variables	Impediment variables that were statistically significant (at 5%) when doing contingency table tests using variables from the previous column if available, otherwise variables from Table
Pasture monitoring	*Quasi-binomial*	*Quasi-binomial*
	Insufficient Labour resources	Insufficient Labour resources
	Uncertainty about future of industry	
Paddock spelling		*Negative binomial*
	None, convergence problems	Variable climatic conditions
Cell grazing	*Quasi-binomial*	*Negative binomial*
	Variable climatic conditions	Variable climatic conditions; a strong impediment for non-adopters
Fodder crops	*Quasi-binomial*	*Negative binomial*
	Uncertainty about tenure	Uncertainty about tenure – this was a dichotomous distribution with slightly more landholders rating this as an important impediment than as an unimportant one.
	Productive capacity loss on property	
Biological pest control		*Poisson*
		Insufficient Labour resources; a stronger impediment for adopters than for non-adopters
	None	Variable climatic conditions; a stronger impediment for adopters than for non-adopters
Riparian vegetation improvement		*Negative binomial*
	None	Variable climate condition
Fence off remnant vegetation	*Quasi-binomial*	*Negative binomial*
	Insufficient labour resources	Insufficient labour resources; a stronger impediment for non-adopters than for adopters
	Lack of broader community support	
Plant native vegetation	*Quasi-binomial*	*Poisson*
	No-one else cares, so why me? strongly refuted as an impediment	No-one else cares, so why me?; strongly refuted as an impediment for non-adopters
	Insufficient information on optimal management practices	Insufficient information on optimal management practices; strong impediment for non-adopters
Installing remote watering points	*Quasi-binomial*	N/a
	Insufficient labour resources	

4 Landholder-preferred policies to support adoption of conservation activities

In relatively remote, sparsely populated regions such as the Burdekin, it is costly and resource intensive to monitor and enforce rules and regulations. The most efficient way to gain compliance, is to have the support of the landholders and the community. It is, therefore, important to consider landholder attitudes to policy instruments.

The survey asked respondents to rate the ‘effectiveness’ of a variety of policies and programs aimed at environmental improvements. Figure 7 shows the mean ratings of perceived effectiveness.

Landholders rated financial incentives – specifically income tax incentives – as the most effective mechanism, closely followed by cost sharing arrangements. On-farm demonstration sites were rated most highly out of the range of educational/training/ extension alternatives. Conversion from leasehold to freehold land was also rated ‘highly effective’ in achieving NRM implementation.

4.1 The empirical link between perceived impediments and individual policy instruments

Several statistical analyses were used to investigate the empirical link between the perceived ‘impediments’ to adoption (identified in the preceding section) and individual policy instruments.

Firstly, each impediment (the response variable) was regressed against the effectiveness of each policy (the explanatory variables) using a multinomial distribution. This regression (the results of which are reported under the column header ‘model 1’ in Table 5) used Akaike's Information Criterian (AIC) criterion to select polices deemed to be significantly related to impediments.

Secondly, a proportional odds model using AIC with forward/backward selection identified significant variables. Where computational convergence problems occurred, AIC forward selection (Venables and Ripley 2002) detected the most significant variables until convergence issues occured. These results are reported under the column header ‘model 2’ in Table 5.

Finally, a Poisson (if dispersion ~1), quasi-Poisson (if underdispersed) or a negative binomial (if overdispersed and the variance>mean) model was used in a contingency table analysis for those policy variables selected in Model 2. This final analysis supports the interpretation of the relationships previously identified – as reported in the final column of Table 5.

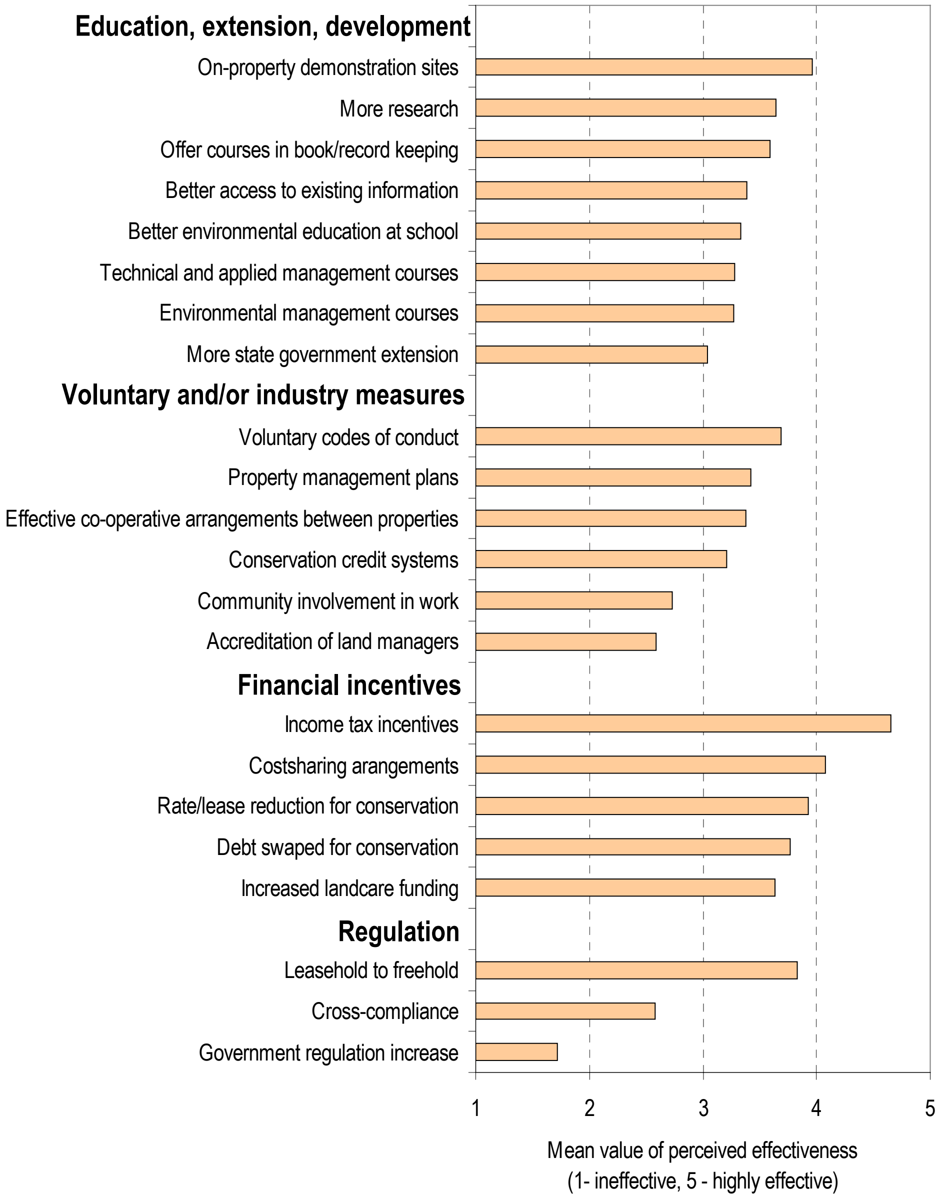

Figure 7: Perceived level of effectiveness of policies and programs to enhance adoption

Landholders who rated "insufficient labour resources" as a strong impediment to adoption also rated "increased government regulation " as ineffective while respondents who rated variable climate condition as strong impediment rated the conversion of leasehold land to freehold as an effective policy to support adoption of conservation measures. Respondents who see "Lack of community support" as an important constraint, think that income tax incentives are effective in raising adoption, while those who do NOT view “Lack of community support” as an impediment rated "Debt swaps for conservation" as highly effective.

Table 5: Significant relationships between perceived impediments and policies rated as 'effective'

Impediment	Policy Variables selected in Model 1	Policy Variables selected in Model 2	Interpretation of relationship – from Model 3
Insufficient labour resources	Government regulation increase	Government regulation increase	Those viewing insufficient labour resources as an impediment think that government regulation is not an effective means to raise adoption
	Rate/lease reduction for conservation		
	Cross-compliance	Cross-compliance	**Cross-compliance not significant in this model**
Productive capacity loss on property	Conservation credit systems	None	N/a
	Increased landcare funding		
	Government regulation increase		
	Cross-compliance		
	Leasehold to freehold		
Variable climate condition	None	Leasehold to freehold	Those viewing variable climatic conditions as an impediment think that conversion of land title from leasehold to freehold is an effective means of raising adoption
Uncertainty about the future of the industry	Conservation credit systems	None	N/a
	Increased landcare funding		
	Income tax incentives		
	Rate/lease reduction for conservation		
	Government regulation increase		
	Cross-compliance		
Uncertainty about tenure	Conservation credit systems	None	N/a
	Increased landcare funding		
	Rate/lease reduction for conservation		
	Government regulation increase		
	Cross-compliance		
Lack of broader community support	Conservation credit systems		
	Increased landcare funding	Increased landcare funding	Increased landcare funding not significant in this model
	Income tax incentives	Income tax incentives	Those viewing lack of broader community support as an impediment think that income tax incentives are a very effect means of raising adoption.
	Debt swaped for conservation	Debt swaped for conservation	Those who do NOT view lack of broader community support as an impediment think that Debt swapped for conservation is a very effect means of raising adoption
	Cross-compliance	Cross-compliance	

5 Conclusions

This analysis highlights several important issues in relation to the development of biodiversity policy in general, and specifically in vast and remote landscapes such as the Burdekin Dry Tropics in Australia, which are characterized by low productivity, low population and volatile biophysical and economic production environments.

First, there is very little implementation of measures associated with active management and conservation of ecosystems, specifically native vegetation and re-vegetation, in the Burdekin Dry Tropics Region – compared to activities related to grazing, weed and pasture management. Evidently, some on-farm conservation activities are more ‘popular’ with landholders than others – perhaps because they are deemed to generate the higher net private benefits. Public policy aimed at increasing the adoption of other, less ‘popular’ conservation measures (eg those associated with the conservation of native vegetation, re-vegetation, and/or flood control) may, therefore, need to consider ways of raising the net private benefit of such practices.

Second, there is an empirical link between socio-economic variables and adoption. Principally, higher adoption rates are associated with higher education levels, and with greater financial capacity. In addition, family characteristics, operating mode (owner versus manager) and title (freehold versus leasehold), are also correlated with propensity to adopt. Policies that strengthen the financial position of landholders and/or raise the education levels of property managers may, therefore, indirectly contribute to conservation.

Third, "insufficient labour resources" and "variable climate conditions" were both identified by landholders as significant impediments for the adoption of conservation activities. These factors were also identified as significant impediments for the adoption of specific conservation activities (pasture monitoring, cell grazing, and the fencing of riparian vegetation). Other impediments (‘uncertainty about the future of the industry’, ‘uncertainty about tenure’, ‘productive capacity loss’, ‘lack of broader community’ and ‘insufficient information on optimal management practices’) were also identified as potentially significant impediments to other, specific, conservation activities (pasture monitoring, fodder crops, fencing of remnant vegetation, and planting native vegetation, respectively). Here too, it is evident that policies which strengthen the financial position of landholders and raise general education levels (thereby providing information about optimal management practices) may contribute to conservation. It is also evident that policies which help landholders deal with risk may have much to offer.

From a policy perspective, this indicates that those wishing to raise the adoption rates of conservation activities (particularly poorly practiced ones associated with vegetation conservation) may need to target key ‘constraints’ – education, resources (financial and labour), and uncertainty. Landholder attitudes towards various policy instruments appear to largely support these observations. Landholders rated financial incentives – particularly income tax incentives – as the most effective policy instruments to support the adoption of conservation activities; closely followed by cost-sharing arrangements. Both of these policies can be viewed as helping alleviate financial and resource constraints. On-property demonstration sites also rated well; policies capable of raising education and awareness of conservation practices.

On the surface, however, these 'popular' policies do not appear to handle the issue of risk and uncertainty. Such an omission is important – primarily because variable climatic conditions were rated as the single most important impediment to 'adoption'. Such variable conditions impact upon the land (drought, flooding, etc) and, inevitably, upon landholder income. Greiner et al (2003) found that land productivity in the Burdekin region was highly variable over time with the per-hectare value of agricultural production rising (and falling) as much as 30% from one year to the next with farm incomes and profits fluctuated widely between years in response to production, price and climatic fluctuations. Over the past 25 years, the average profit – and therefore taxable income – generated by broadacre farms was negative, on average, in two out of every five years (Greiner et al, 2003). In this context, the positive attitude of landholders to 'income tax incentives' is somewhat puzzling, in so much as they would only be applicable in three out of every five years (depending upon the taxation system's rules regarding whether or not financial loses can be carried over from one year to the next).

Taxation law in Australia considers the effects of profit variability due to climatic and global economic conditions. Current taxation laws allow private business to carry over losses from one year into another (in some circumstances). The effectiveness of 'income tax incentives' as a conservation policy in a broader policy context can be increased if tax incentives are also transferable from bad years to good, then such policies allow for a degree of income smoothing – an attractive strategy for risk averse landholders. Further, landholders in the Burdekin ranked 'business advisers' (tax accountants) as a key source of information for land and water management decisions – second only to other family members (Greiner et al, 2003). Those who visit the tax accountant regarding 'income tax incentives' for conservation, may therefore achieve three important things: financial help; income smoothing; and education/advice.

This should not be taken to indicate that income tax incentives are the only answer to conservation problems, quite to the contrary. Conservation issues are a complex mix of landscape, climate, business, personal and policy factors. Impediments are multiple and there are a wide variety of potential policy approaches to supporting adoption of biodiversity conservation, many of which have broad levels of acceptance by landholders. To be effective and efficient, conservation policy needs to refine 'blanket-type approaches' such as environmental regulation and tax incentives for NRM, and develop a suite of supportive policies by:

(1) drawing on the full suite of potential policy instruments available;

(2) taking into consideration the likely acceptability by the community and landholders;

(3) tailoring policy to biophysical and ecological conditions in certain areas; and

(4) co-ordinating public investment from various conservation policies and programs in a strategic manner.

Providing consistent policy signals over time is another important consideration. Given the boom-and-bust cycles in agriculture, caused predominantly by climatic and market volatility, long-term perspectives of policy are essential. For example, tax incentives are only effective in years where landholders generate sufficient profit. Short-term policies (such as one-off funding of individual and small-scale projects) run the risk of being ineffective because they cannot be strategically applied in a highly volatile environment.

The research described here highlights three crucial 'targets' for conservation policy: financial constraints, education constraints, and risk/uncertainty. Economic theory generally indicates that separate policy targets require separate policy measures. *Ceteris paribus,* the three targets identified here, will – at the very least – require three different policies (ones which, ideally, compliment and reinforce each other like those in the tax incentives example above). There are, undoubtedly, many other separate policies (eg some of the risk management strategies developed in the merchant banking sector) and policy combinations that are capable of encouraging on-farm biodiversity conservation, and it is our hope that this research provides policy makers with valuable background information.

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