Marine and Tropical Sciences Research Facility

Modelling factors affecting landholders' adoption of recommended natural resource management practices in the Wet Tropics region

N. Emtage, C. Smith and J. Herbohn

With complementary report:

Development of Bayesian Belief Network models linking the characteristics and circumstances of North Queensland landholders to their adoption of recommended land management practices

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Australian Government
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Reef & Rainforest
RESEARCH CENTRE

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Modelling factors affecting landholders' adoption of recommended natural resource management practices in the Wet Tropics region

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Acronyms Used In This Report

ABS.....Australian Bureau of Statistics
ANOVA .....Analysis of variance
BBN.....Bayesian Belief Network
BRS.....Bureau of Rural Sciences
CRC.....Cooperative Research Centre
CRP.....Currently Recommended Practice
DPI .....Department of Primary Industries and Fisheries (Queensland)
DNRW .....Department of Natural Resources and Water (Queensland)
EPA.....Environmental Protection Agency (Queensland)
FNQ.....Far North Queensland
GIS .....Geographic Informaiton System
MTSRF.....Marine and Tropical Sciences Research Facility
NRM .....Natural Resource Management
NTFP.....Non-timber forest product
URL.....Uniform Resource Location
WTWHA .....Wet Tropics World Heritage Area

Abstract

This report presents the results from a series of analyses that examined the adoption of a number of currently recommended practices (CRPs) to improve natural resource management (NRM) in the Wet Tropics region of far northern Queensland. The practices examined include a number that could be adopted by any rural landholder, those that could be applied by crop growers, and those that could be applied by graziers.

Practices examined that could be applied by any landholder include the preparation of property or business plans, the encouragement of regrowth of native vegetation, attending short courses related to land management and participation in Government NRM programs. Practices examined that relate particularly to graziers include the fencing of native vegetation areas, fencing of waterways and the use of soil testing prior to fertiliser application. Practices examined that relate particularly to crop growers include the use of soil testing, minimum tillage, stubble retention, the use of legume rotations and the use of earthworks to control soil movement.

In general, compared to those that have not adopted CRPs relating to agriculture (e.g. soil testing and the adoption of minimum tillage), those that have adopted industry CRPs:

- are more motivated to build their business;
- support a greater number of people with income from the property;
- operate larger scaled enterprises;
- are more reliant on their property enterprises for income;
- tend to live in the 'lowland' (coastal plain) areas of the region;
- are more interested in information generally, particularly from 'enterprise' groups;
- have undertaken short courses on land management and have prepared a property or business plan;
- participate in more social groups (particularly 'industry' groups);
- have higher levels of trust for 'productivity' groups; and
- are more concerned about the future viability of agriculture.

The pattern of differences between landholders and their landholdings in regard to the adoption of the CRPs that relate to vegetation management differs to those related to agricultural industries, where the greatest adoption tends to be by those landholders with smaller landholding areas who are less reliant on agriculture for their income. In relation to the adoption of CRPs within the cropping industry there is some evidence of differences in the rates of adoption between differing parts of the region, particularly between the 'upland' and 'lowland' areas. While these general patterns of characteristics of those who have adopted recommended practices are evident, it is also apparent that there are a number of differences in the characteristics of landholders' attitudes, their landholdings and their behaviour that are unique to each CRP.

A series of Bayesian Belief Networks were constructed and assessed for a subset of the CRPs that were examined for this report. The construction, testing and manipulation of these networks revealed that there is strong potential to use this technique to identify and illustrate the many inter-relationships between factors affecting the adoption of recommended practices.

The analysis of the spatial relationships commenced with the assessment of variations in attitudes, characteristics of the landholdings and practices that differed between landholders and their holdings according to their proximity to the Wet Tropics World Heritage Area (WTWHA). Landholders' properties were classified into a number of classes according to the minimum distance they are to the boundary of the WTWHA. Of all the analyses undertaken, the only significant result was that landholders whose properties are within one hundred metres of the boundary of the WTWHA are more concerned about the impacts of 'pests and weeds' than those whose properties are more than two kilometres from the boundary. A variety of additional research questions that could be addressed and datasets that could be used are described in this report.

Introduction

One broad objective of the research undertaken by the project team for MTSRF Project 4.9.4 is to improve understanding of the socio-economic character and attitudes of rural landholders and the relationships of these with land and water (natural resource) management practices. To provide data for the project, a survey of rural landholders (with greater than 2 ha land) was undertaken in late 2007/early 2008 by researchers from the University of Queensland in partnership with personnel from Terrain NRM Ltd, the regional Natural Resource Management (NRM) board for the Wet Tropics region of far northern Queensland (Figure 1).

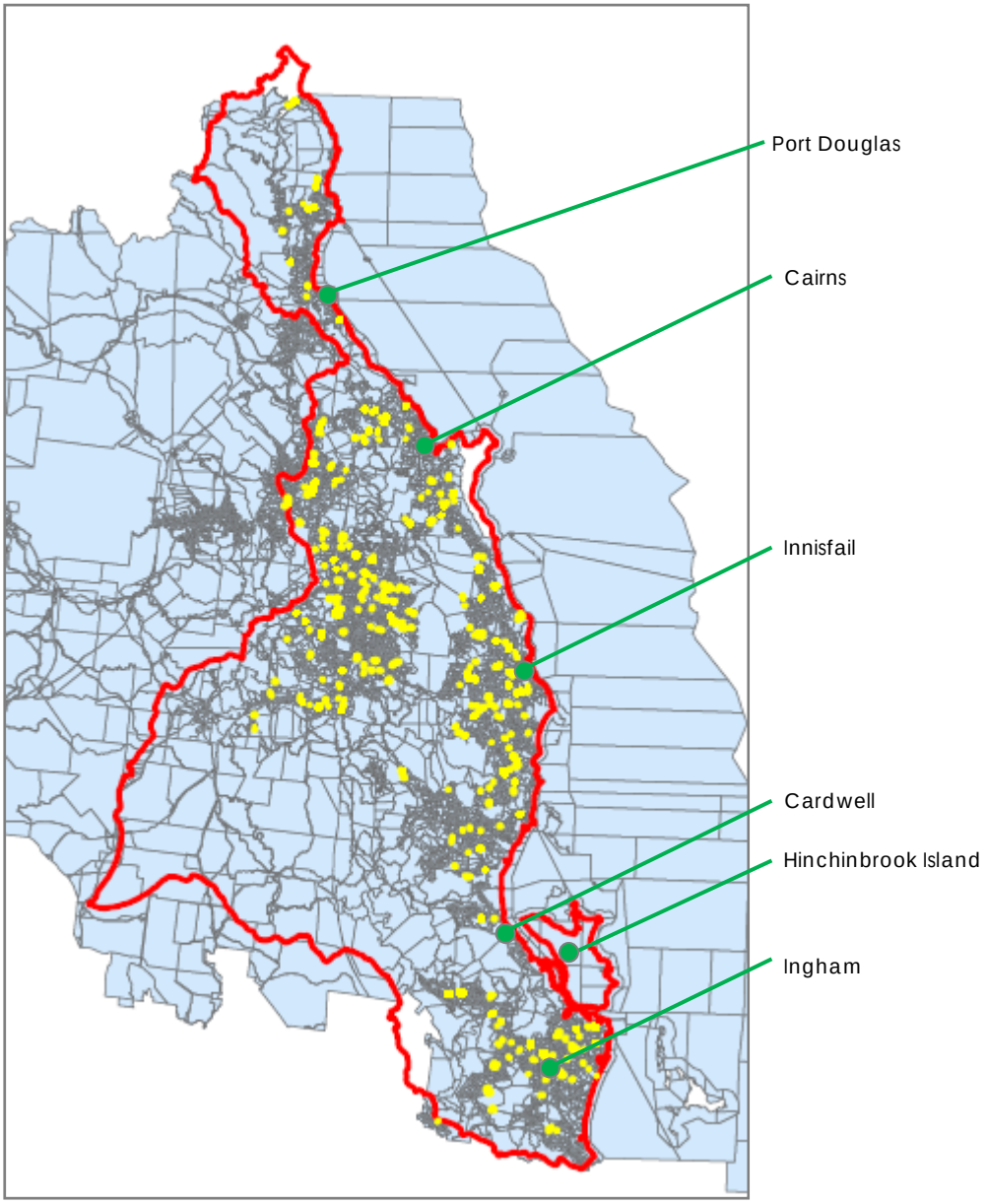

Figure 1: General location of survey respondents within the Wet Tropics NRM region.

To date, analyses of the responses to the landholder survey include descriptions of the survey responses (Emtage and Reghenzani, 2008), analyses of differences between respondents with different primary land use types, analysis of variations between respondents with differing scales of operation, principal component (factor) analysis of the attitudinal questions included in the survey (Emtage and Herbohn, 2008) and an assessment of the 'market' for NRM programs in the region (Emtage, 2009). These reports are freely available for download from the Marine and Tropical Sciences Research Facility website (see References for URLs).

The adoption of currently recommended practices (CRPs) is a central part in the effort to improve natural resource management (NRM) in the Wet Tropics region[1]. One way that researchers can assist those promoting adoption of CRPs is to help them better understand landholders' present activities as well as what motivates landholders in respect to their property management and the barriers they perceive to be preventing them from achieving their objectives. This report describes a series of analyses that have been undertaken to address these questions.

Structure of the report

The report is organised into three main sections. The first section describes the objectives for the research and the methods used to undertake the analyses that are presented. The second section provides summaries of the relationships between the socio-economic characteristics and attitudes of respondents, and the adoption of recommended practices including the development of Bayesian Belief Networks to assist in the interpretation of the analyses. Details of the results of the statistical tests used are provided in Appendix A. The third section describes the development of GIS analyses of the survey responses and methods to aid the assessment of revegetation programs in the landscape.

Research objectives

The objective of the research described in this report is to explore the relationships between the adoption of CRPs and other variables examined in the rural landholders' survey[2]. The ultimate objective is to build models of factors affecting the adoption of CRPs that can be used to help undertake cost-benefit analyses of policies and programs designed to improve water quality and other dimensions of natural resource management.

The research questions addressed in this report include the following:

- What are the key social, economic and psychological factors affecting the adoption of currently recommended practices by rural landholders?
- Can Bayesian Belief Networks assist the assessment and interpretation of the influence of these factors?
- What are the principles and existing data sets that can be used to develop a GIS-based tool to assess the costs and benefits of revegetation programs?

[1] See for example the Wet Tropics Regional NRM Plan (FNQ NRM Ltd and Rainforest CRC, 2004) and the Reef Plan (The State of Queensland and Commonwealth of Australia, 2003).

[2] A description of the basic survey design and responses are described in Emtage and Reghenzani (2008). Further description of subsequent analyses of the responses is provided in Emtage and Herbohn (2009).

Methods

The first stage of the analyses examined the relationships between the adoption of several key CRPs and biophysical and socio-economic characteristics using data collected in the survey of rural landholders reported by Emtage and Reghenzani (2008). The tests were undertaken using the SPSS software program (versions 14 and 17). Initial tests included:

- An examination of the correlations between the adoption of CRPs and other (continuous) variables examined in the survey; and
- An examination of the chi-square (Pearson's statistic) of the relationships between categorical variables and the adoption of CRPs.

A series of discriminant and multiple regression analyses were also undertaken to identify the relative influence of variables although the results of these tests are not reported in this report. Following the above analyses, Bayesian Belief Networks were constructed for a number of CRPs to assess their potential in aiding the construction of models of adoption. These models can be used to build understanding of the key factors affecting adoption including the relative influence and inter-relationships between them.

The potential of Bayesian Belief Networks (BBNs) were assessed through constructing models of a subset of the practices assessed in this report. The *Netica* program (version 3.25) was used to undertake these analyses. BBNs were used to examine the proportions of respondents that have adopted particular CRPs. The results of the one-way ANOVA, chi-square and multiple regression tests were used to identify the variables with the strongest relationships with adoption of the practices. The relative influence of the variables and the efficacy and interpretation of the model were assessed using a sensitivity analysis and examination of the effects of combinations of these variables on the adoption rates. Variables that were identified as potentially relevant in the ANOVA and chi-square tests were recoded to reduce the number of categories and thereby reduce the potential for combinations of categories across variables that have no or few respondents. In the majority of cases the number of categories used to represent a variable was two. The cut-off value to differentiate between 'high' and 'low' states of these variables was set at the median level for the variables. For example, the median proportion of income earned on the property was 33%, and this value was used to construct a nominal (categorical) variable to use in the BBNs so that those earning more than 33% of their income from the property were classed as 'high' and those earning less than 33% as 'low'.

The CRPs assessed for this report include some that are applicable to all respondents and others that relate specifically to either grazing or cropping industries:

- **All respondents:**
  - participation in NRM programs;
  - property planning;
  - encouragement of regrowth of native vegetation; and
  - short course attendance.
- **Graziers:**
  - fencing of native vegetation;
  - fencing of waterways; and
  - use of soil testing prior to fertilising.
- **Crop growers:**
  - use of soil testing;

- use of minimum tillage practices;
- stubble retention following harvest;
- use of legume rotations; and
- use of earthworks to control soil movement.

Adoption of currently recommended practices by all respondents

The following section presents summaries of the results of tests for differences in the characteristics of those who have and have not adopted several CRPs that could be used by all respondents.

Property and business planning

Overall, approximately 35% of surveyed respondents have completed or commenced a property or business plan. Those who have undertaken property planning tend to have larger properties, a greater reliance on their properties to provide household income, and are more likely to have made a profit in the 2006/2007 financial year. Property planning is more prevalent in the lowland (coastal plains) of the Wet Tropics NRM region compared to the highland areas. Half of all landholders who use their properties primarily for agriculture have completed a property or business plan.

Compared to those who have not completed or started a property or business plan, those who have commenced or completed such a plan also reported:

- greater interest in building their business and improving the environment;
- more concern about the continued viability of agricultural enterprises;
- greater interest in information from 'enterprise', 'media' and 'finance and family' sources;
- greater confidence in their capacity to manage native vegetation, sustainably produce timber on their property and more interest in clearing some vegetation;
- greater trust of 'productivity groups';
- more involvement in social groups, including civic groups, emergency services organisations, *Landcare* and catchment management groups, industry organisations and lobby groups; and
- are more likely to have participated in short courses (training regarding land and/or water management) and greater involvement in publicly funded NRM programs in the past.

Construction and assessment of a series of BBNs to assess the factors influencing adoption of property and business plans revealed that landholders attendance of short courses related to land management and motivation to 'build their business' have the strongest influence, followed by the proportion of income earned from the property enterprises and whether the enterprises were profitable (Figure 2, Table 1). Inclusion of the other variables listed above in earlier versions of the model revealed these variables had a negligible influence on the adoption of property planning.

A test of the property planning BBN is illustrated in Figure 3. In this example, for landholders with a 'high' proportion of their income from their property who have attended a short course, made a profit in the 2004/2005 financial year, and have a property area of between twenty and 200 ha, approximately 75% have completed a property plan else have one in progress. Note also that approximately eighty percent of these landholders have cropping or mixed farming enterprises and are located in the 'lowland' (coastal floodplain) areas of the region.

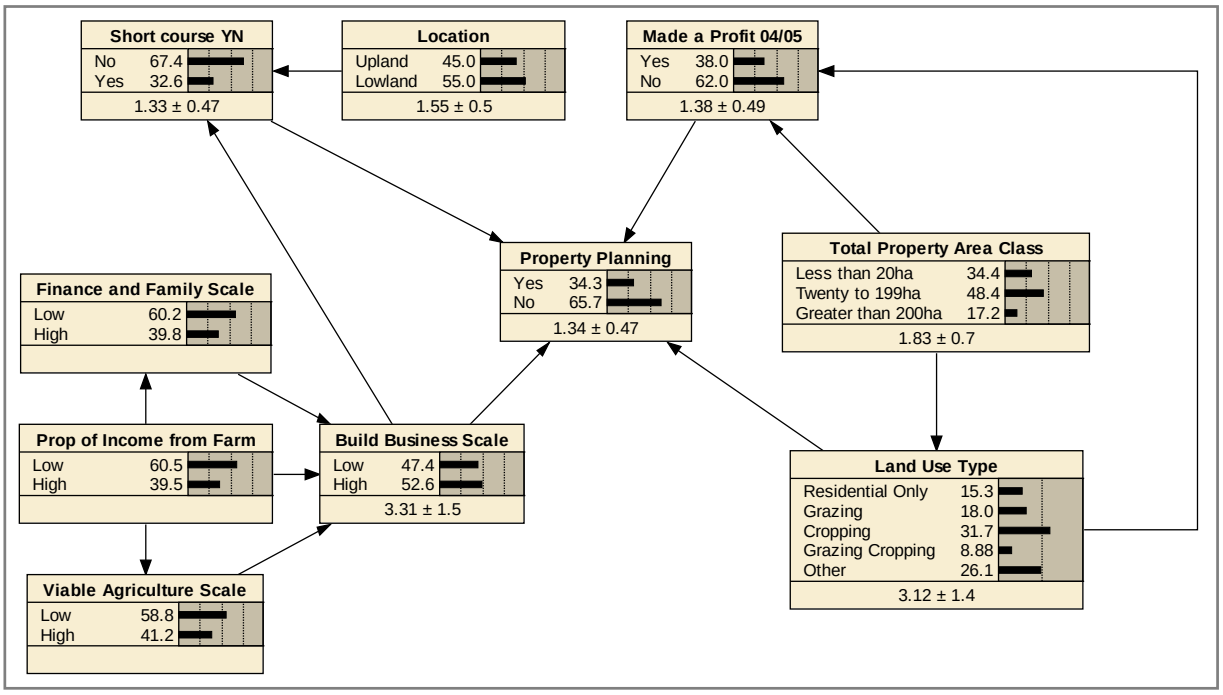

Figure 2: Bayesian Belief Network of factors influencing the adoption of property or business planning by surveyed landholders.

Table 1: Results of sensitivity analysis of factors affecting the adoption of property or business planning by surveyed landholders.

Variable	Variance reduction	Variance reduction (%)
Property planning	0.2253	100.00
Short course	0.0255	11.30
Management goal scale – build business	0.02397	10.60
If profitable in 2004/2005 financial year	0.00746	3.31
Proportion of income earned on-property	0.006891	3.06
Regional issue scale – concern about future viability of agriculture	0.004286	1.90
Land use type	0.003702	1.64
Information scale – usefulness of 'finance and family' sources	0.00364	1.62
Area of property owned	0.002282	1.01
Location class	0.001563	0.69

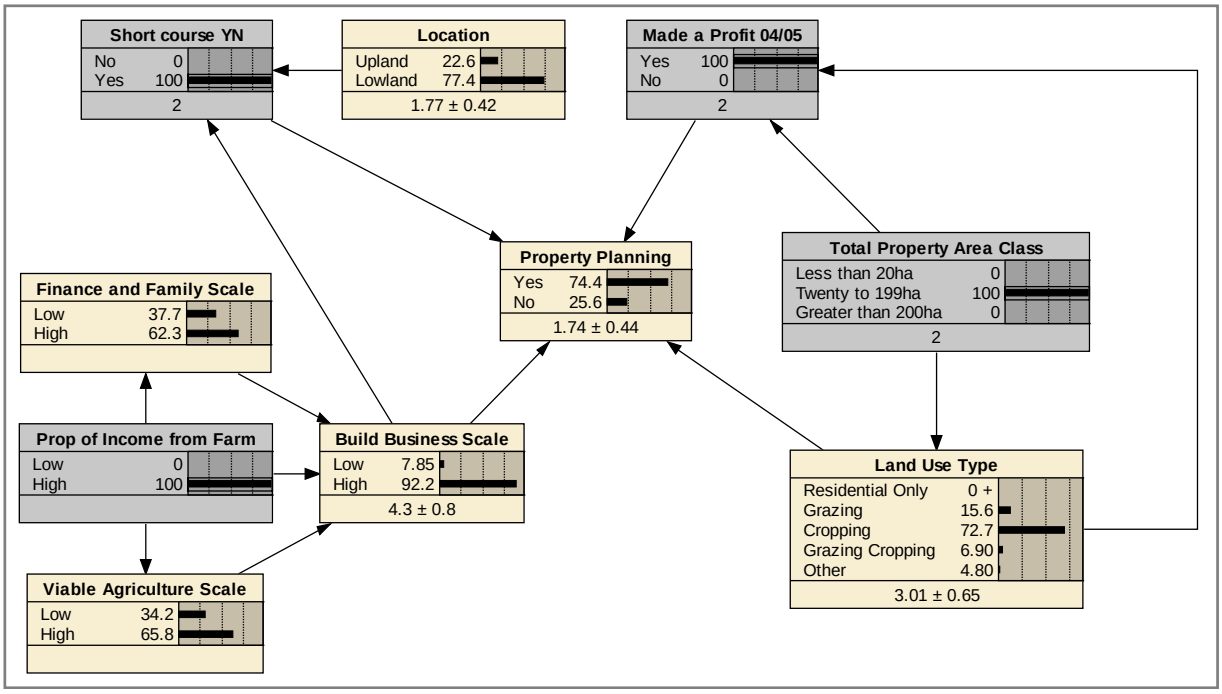

Figure 3: Bayesian Belief Network of factors influencing the adoption of property or business planning illustrating the influence of short courses, high reliance on property enterprises for income, profitability and property size.

Encouraging regrowth of native vegetation

Approximately 55% of survey respondents indicated they have encouraged regrowth of native vegetation on their landholding, and on average they have encouraged regrowth of 6.5 ha (standard error 2.18 ha) with a median value of 7.5 ha.

The characteristics of those who have encouraged the regrowth of native vegetation differ from those who have not in a number of ways. Those who have encouraged regrowth:

- own smaller areas of land;
- are less likely to be running an agricultural enterprise;
- are more likely to have a business or property plan;
- are more likely to have been involved in NRM programs in the past;
- are more concerned about the health of the environment on their property and in the region;
- are more concerned about the decline in services in rural areas;
- are less likely to intend on expanding their business activities on-property;
- are less likely to want to clear their vegetation;
- are more trusting of information from 'environment' groups; and
- are more likely to have higher levels of formal education.

Furthermore, landholders who have encouraged the regrowth of native vegetation are more likely to use their forest areas for recreational purposes, including the gathering of non-timber forest products (NTFPs) such as flowers and seeds.

Participation in NRM programs

Approximately twenty percent of survey respondents have been involved in Government NRM programs in the past five years. When compared to landholders who have not been involved in NRM programs, those who have:

- are more dependent on their property for income;
- work longer hours on their properties;
- are more likely to be male;
- are more likely to have a business or property plan;
- are more likely to make a profit from their property enterprises;
- are more likely to regularly attend meetings of either *Landcare* groups, catchment management groups or industry groups;
- have a greater number of people who live on the property and are supported by the property (employ more people to work on their properties);
- use a higher proportion of their property for cropping and have a lower proportion under native vegetation;
- have lived in their local district for a longer period of time, on rural properties and on their current property;
- are more concerned about the health of their soil;
- are more motivated to build their property business and improve the environment; and
- find information from 'enterprise' and environment' groups more useful, as well as information from 'finance' and 'family' (e.g. banks, accountants and other family members).

Landholder participation in NRM programs has been more concentrated in parts of the Wet Tropics region, particularly in the 'lowland' areas, with the exceptions of higher rates in the former Eacham Shire and lower rates of participation in the former Douglas Shire.

The construction and assessment of a BBN of the factors influencing participation in NRM programs revealed that landholders' land use type and the proportion of income they earn from property enterprises have the strongest relationship with program participation (Table 2, Figure 4).

An assessment of a variety of scenarios with the BBN model revealed that the highest level of participation was by landholders with 'mixed' enterprise types in the 20-199 ha property size class (Figure 5). The lowest level of participation was by landholders with 'grazing' enterprises on properties larger than 200 ha.

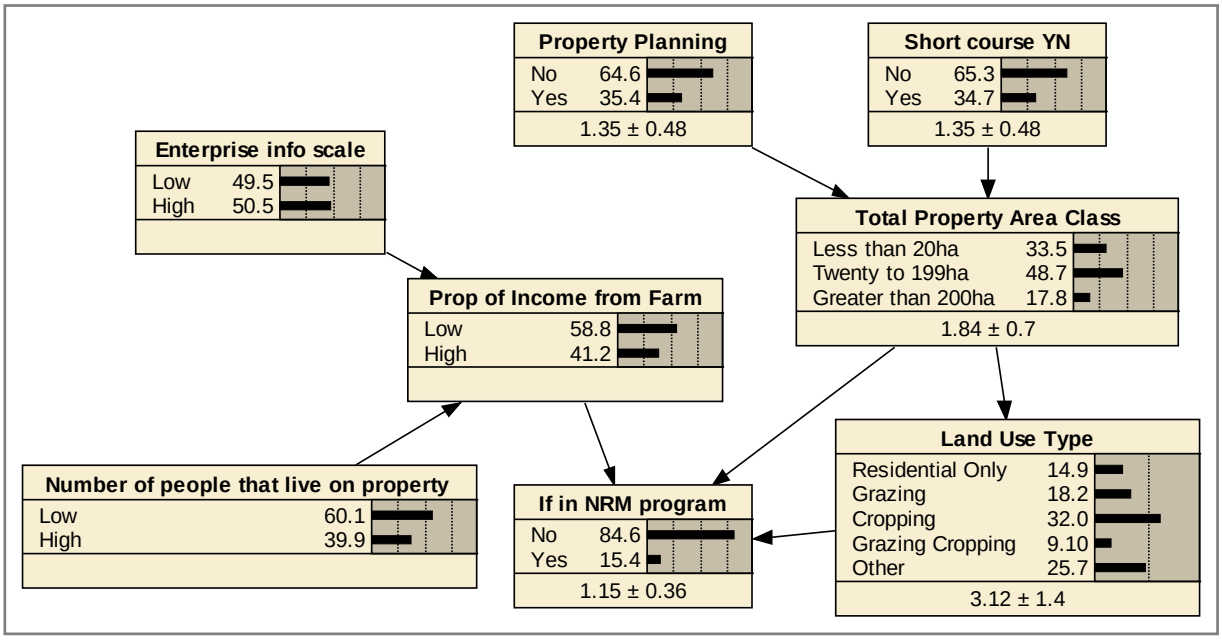

Figure 4: Bayesian Belief Network of factors influencing landholders' participation in Government NRM programs.

Table 2: Results of sensitivity analysis of factors affecting landholders' participation in Government NRM programs.

Variable	Variance reduction	Variance reduction (%)
If participate in Government NRM program	0.1303	100.00
Land use type	0.009487	7.28
Proportion of income earned on-property	0.005629	4.32
Area of property owned	0.001257	0.97
Information scale – usefulness of 'enterprise' sources	0.001043	0.80
Number of people who live on the farm	0.0001855	0.14
Short course	0.0001556	0.12
Property planning	4.201e-005	0.03

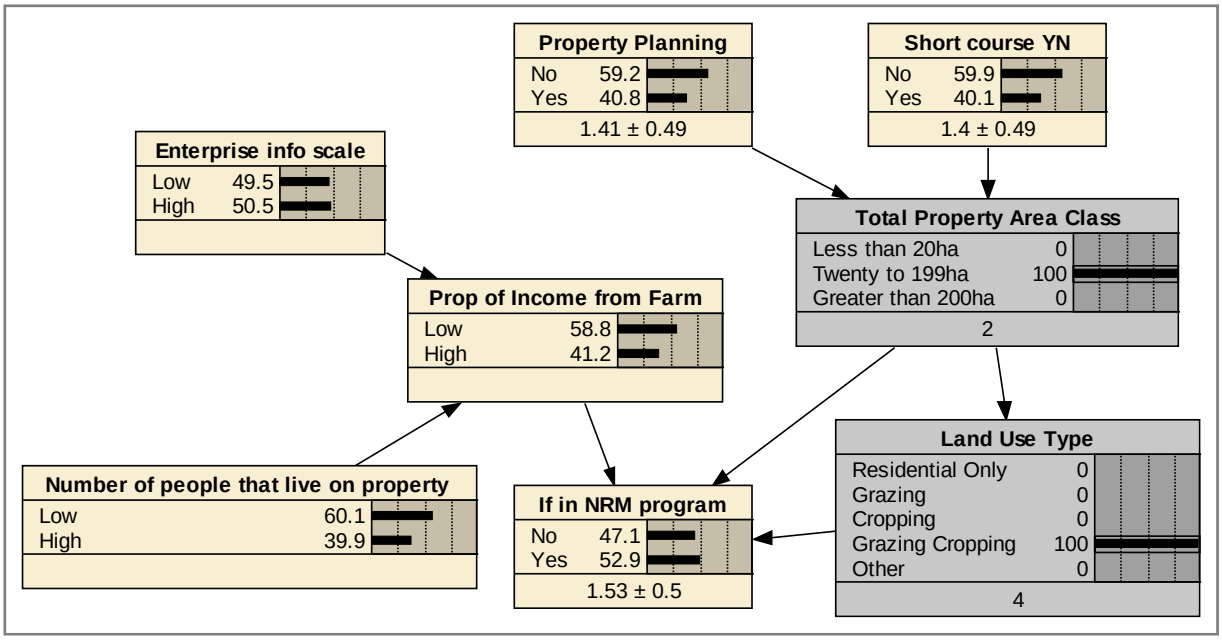

Figure 5: Bayesian Belief Network of the influence of land use type and property size on landholders' partricpation in Government NRM programs.

Participation in short courses

Approximately 35% of respondents reported attending a short course relevant to land management during the past five years. These respondents differ from those who have not attended from such courses in a number of ways, including:

- being managers of larger areas of land used for agricultural activities and a lower proportion under native vegetation;
- having more reliance on the property for income, employing more people and working longer hours on their properties per week;
- residing for longer periods of time on rural properties, in the local district and on their current property;
- being more likely to be male;
- being more likely to be making a profit;
- being more likely to regularly attend either *Landcare*, industry, catchment, emergency services or church groups;
- being less likely to maintain tracks through their native forest areas or gather NTFPs from these areas;
- having more concern about the soil health and pests and weeds on their property;
- being more likely to use legume rotations in their cropping activities;
- being more concerned about the future viability of agriculture;
- being more motivated to build their business and improve the environment;
- having greater motivation to clear native vegetation, more concern about the difficulties associated with vegetation management and more confidence they can sustainably produce timber from their property;

- being more likely to find information from all sources as useful; and,
- being more trusting of 'productivity' groups.

Adoption of currently recommended cropping practices

A total of 147 (40%) respondents reported having some cropping land[3]. Respondents were asked to indicate their level of agreement or disagreement with a series of statements concerning potential issues relating to CRPs (Table 3). The majority of survey respondents agreed that there are benefits for soil health and susceptibility to erosion from minimum tillage. Many also thought, however, that this practice resulted in an increased need for herbicide application. Approximately 42% of respondents thought that, on balance, using herbicides was better than mechanical cultivation, while ~23% disagreed and ~35% remained neutral. The question of whether conventional tillage practices more effectively maintained soil fertility and increased yields split survey respondents, with almost 38% indicating they were neutral and ~28% agreeing. One third of respondents were also undecided regarding the benefits of stubble retention while just over 58% thought it was advantageous.

Table 3: Frequency and proportion of survey respondents' attitudes to various aspects of recommended cropping practices. The proportion of respondents with cropping land is provided in brackets.

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Reduced tillage improves soil health and reduces erosion	- (-)	11 (7)	16 (10)	73 (44)	66 (40)	166
The cost of new machinery constrains practice change	5 (3)	13 (8)	18 (11)	69 (42)	58 (36)	163
Conventional tillage more effectively maintains soil fertility and increases yields	10 (6)	46 (29)	60 (38)	36 (23)	8 (5)	160
Benefits of stubble retention outweigh problems with pests and diseases	3 (2)	11 (7)	53 (33)	65 (40)	29 (18)	161
Reduced tillage increases the need for herbicides	9 (6)	32 (20)	39 (24)	56 (34)	27 (17)	163
Overall, using herbicides is better than using mechanical cultivation	12 (7)	25 (15)	57 (35)	55 (34)	14 (9)	163

The following section summarises the results of testing for differences in the characteristics of those who have and have not adopted various currently recommended cropping practices.

[3] See Emtage and Reghenzani (2008) for an overview of the types of cropping practiced and other description of respondents.

Adoption of mínimum tillage practices

Of the surveyed landholders with some cropping land, ~54% reported using minimum tillage on all their cropping land, while ~25% reporting use of minimum tillage on parts of their land. Testing of the socio-economic and attitudinal characteristics of those who had adopted at least some use of minimum tillage practice and those who had not revealed several differences. There are significant differences in the level of adoption of minimum tillage practices between the highland and lowland (coastal plain) parts of the region, with croppers in the lowlands significantly more likely to have already adopted the use of minimum tillage practices.

Furthermore, those who have adopted minimum tillage practices are more likely to:

- have larger areas of land use for cropping;
- obtain a greater share of their household income from agriculture;
- have lived on rural properties, in their local district and on their current properties for a longer period of time;
- be profitable;
- have a property or business plan;
- not work full-time off-farm;
- have attended a short course about land and/or water management;
- be motivated to build their business;
- be more concerned about the future viability of agriculture; and
- be more trusting of ‘productivity’ and ‘enterprise’ groups.

Landholders who have not adopted the use of minimum tillage practices are more concerned that the practice does not fit with their resources rather than their management goals; possibly because of the specialist equipment this practice requires (Tables 4 and 5). Approximately 45% of landholders not using the practice reported that they may adopt the practice in the future (Table 6).

Table 4: Landholders' views about the compatibility of mínimum tillage practices with their property management goals according to whether they have adopted the practice (proportion).

If currently use minimum tillage	If minimum tillage fits with goals				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	41.2	11.8	17.6	29.4	**100.0**
Partly	2.9	54.2	40.0	2.9	**100.0**
Yes	1.3	22.3	71.1	5.3	**100.0**
Total	7.0	29.7	55.5	7.8	**100.0**

Table 5: Landholders' views about the compatibility of mínimum tillage practices with their property management resources according to whether they have adopted the practice (proportion).

If currently use minimum tillage	If minimum tillage fits with resources				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	56.2	12.5	12.5	18.8	**100.0**
Partly	5.7	57.2	31.4	5.7	**100.0**
Yes	2.7	18.7	77.3	1.3	**100.0**
Total	10.3	28.6	56.3	4.8	**100.0**

Table 6: Landholders' views on the likelihood of adopting or continuing mínimum tillage practices according to whether they have adopted the practice (proportion).

If currently use minimum tillage	If will adopt or continue minimum tillage			Total
	No (%)	Maybe (%)	Yes (%)	
No	55.6	27.7	16.7	**100.0**
Partly	-	48.6	51.4	**100.0**
Yes	1.3	10.4	88.3	**100.0**
Total	8.5	23.1	68.4	**100.0**

Adoption of soil testing by landholders with cropping enterprises

Of the respondents with some cropping land approximately 56% reported using soil testing prior to applying fertiliser on all their cropping land with approximately twenty percent reporting use of soil testing on parts of their cropping land. Eighty-seven percent of those who stated the primary purpose for land ownership as ‘agriculture’ reported using some soil testing on their cropping land.

Testing of the socio-economic and attitudinal characteristics of those who had adopted at least some use of soil testing, and those who had not, revealed a number of differences. There are significant differences in the level of adoption of soil testing between the highland and lowland (coastal plain) parts of the region, with croppers in the lowlands significantly more likely to have already adopted soil testing.

Furthermore, those who have adopted soil testing are likely to:

- have larger areas of land use for cropping;
- obtain a greater share of their household income from agriculture;
- have lived on rural properties, in their local district and on their current properties for a longer period of time;
- be profitable;
- have a greater number of people living on and supported by the property enterprises;
- have a property or business plan;
- have attended a short course about land and/or water management;
- be motivated to build their business;
- be more inclined to want to clear remnant vegetation;
- be more concerned about the future viability of agriculture; and
- be more trusting of ‘productivity’ groups and more interested in using information from ‘enterprise’ and ‘environment’ groups, and ‘finance and family’ sources.

Of those respondents who do not presently use soil testing, nearly half were unsure whether the practice fitted with their management goals, and thirty percent were not sure it fitted with their resources (Tables 7 and 8). Approximately three-quarters of those repsondents not currently using soil testing prior to fertiliser applications indicated they may adopt this practice in future (Table 9).

Table 7: Landholders' views of the compatibility of soil testing practices with their property management goals according to whether they have adopted the practice (proportion).

If currently use soil testing	If soil testing fits with goals				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	9.5	14.3	28.6	47.6	**100.0**
Partly	-	77.4	16.1	6.5	**100.0**
Yes	-	12.7	86.1	1.3	**100.0**
Total	1.5	28.2	60.3	9.9	**100.0**

Table 8: Landholders' views of the compatibility of soil testing practices with their property management resources according to whether they have adopted the practice (proportion).

If currently use soil testing	If soil testing fits with resources				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	18.2	13.6	36.4	31.8	**100.0**
Partly	3.3	63.3	23.3	10.1	**100.0**
Yes	-	3.8	93.6	2.6	**100.0**
Total	3.8	19.2	67.7	9.3	**100.0**

Table 9: Landholders' likelihood of adopting or continuing soil testing (proportion).

If currently use soil testing	If will adopt or continue soil testing			Total
	No (%)	Maybe (%)	Not sure (%)	
No	26.1	34.8	39.1	**100.0**
Partly	3.3	70.0	26.7	**100.0**
Yes	-	6.5	93.5	**100.0**
Total	5.3	26.2	68.5	**100.0**

The construction of a BBN model to examine the factors influencing the use of soil testing by those with cropping enterprises and subsequent sensitivity analysis revealed that the size of the area operated by the respondents had the greatest impact (Figure 6, Table 10). Again, the motivation to build the business together with the profitability of the business and preparation of property plans were also influential (Figure 7).

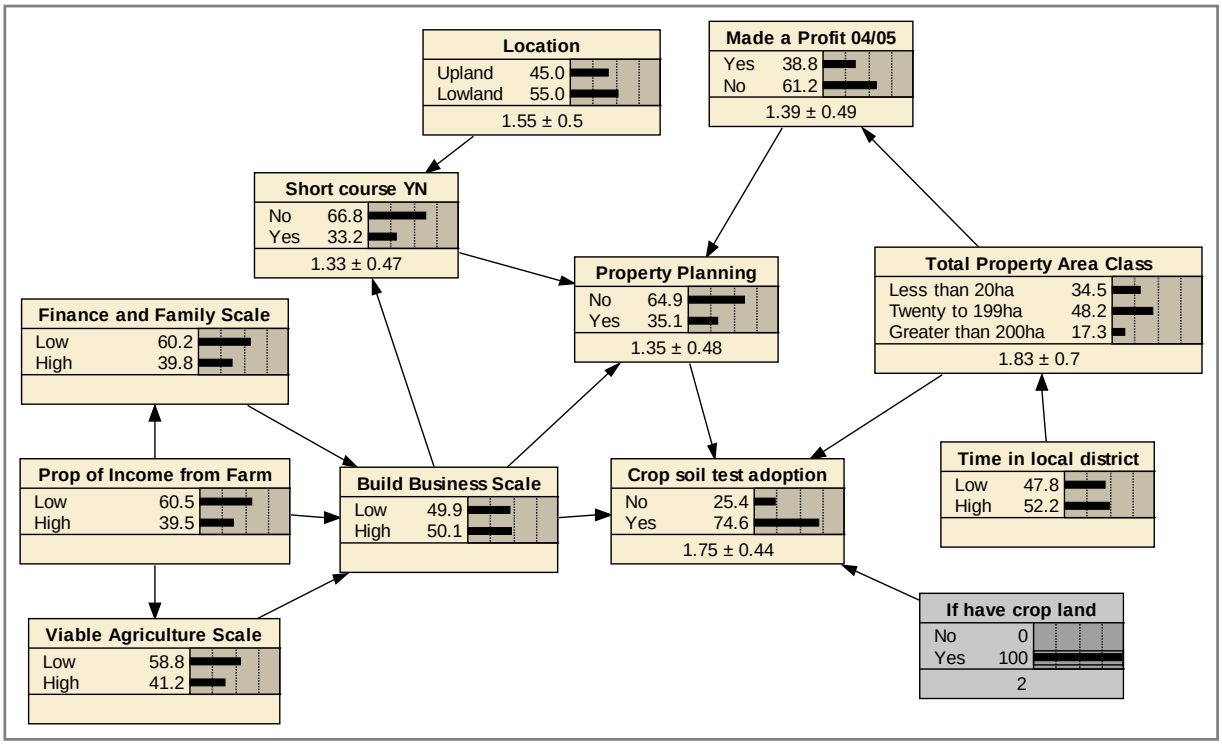

Figure 6: Bayesian Belief Network of the factors influencing the adoption of soil testing in cropping enterprises.

Table 10: Results of sensitivity analysis of factors affecting the adoption of soil testing in cropping enterprises.

Variable	Variance reduction	Variance reduction (%)
Adoption of soil testing	0.1895	100.00
Area of property owned	0.03357	17.7
Management goal scale – build business	0.009856	5.2
If have a property plan	0.008456	4.46
If profitable in 2004/2005	0.006925	3.65
Time lived in local district	0.003659	1.93
Proportion of income earned on-property	0.002768	1.46
Regional issue scale – concern about future viability of agriculture	0.001887	1.00
Short course	0.001401	0.74
Information scale – usefulness of ‘finance and family’ sources	0.001162	0.61

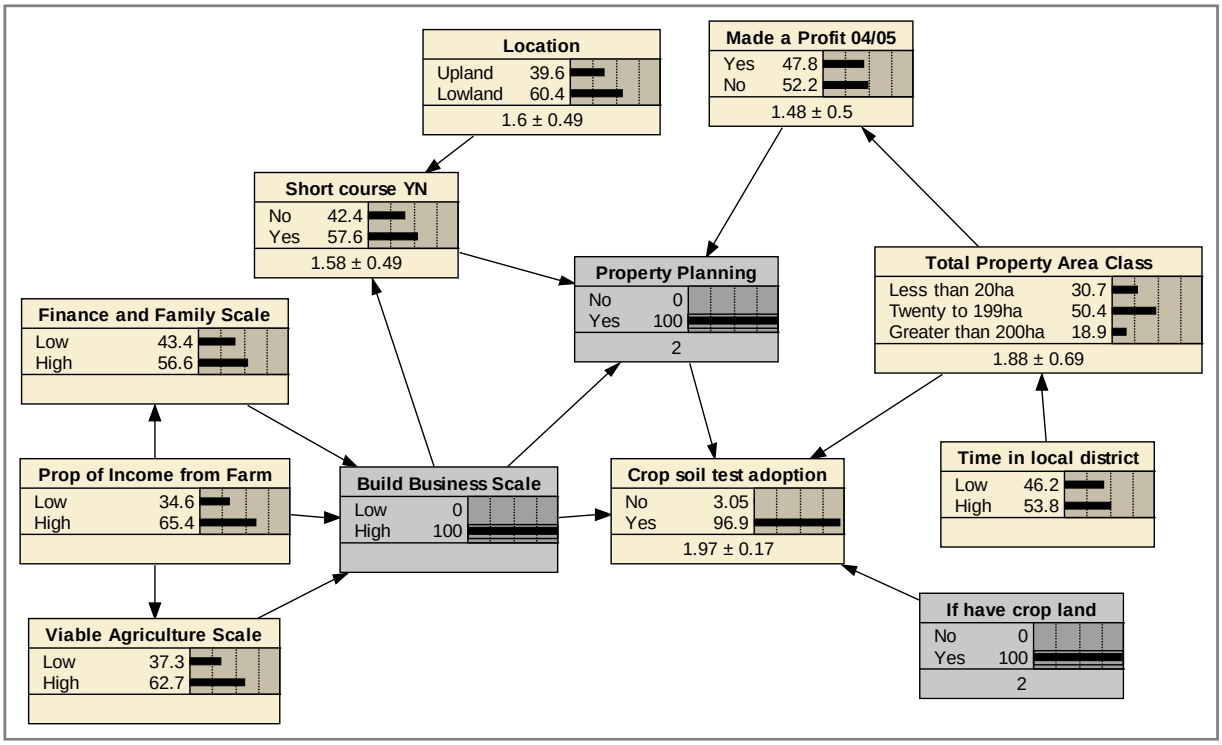

Figure 7: Bayesian Belief Network of the influence of property planning and motivation to build enterprises on the adoption of soil testing in cropping enterprises.

Adoption of legume rotations

Of the survey respondents who reported having some cropping land, approximately 68% reported using legume rotations on part or all of their cropping land. Compared to those who have not adopted the use of legume rotations, those that have adopted this practice:

- own larger properties and have greater areas of cropping land;
- have a higher proportion of land used for cropping activities and a lower proportion under native vegetation;
- work longer hours on their property, earn a higher proportion of their income from property enterprises and support a greater number of people from these enterprises;
- are more likely to have attended a short course related to property management, have a property plan and have participated in a Government NRM program;
- have lived on rural properties, in the local district and on their current farm for a longer period of time;
- are more concerned about the future viability of agriculture;
- are more motivated to build their property enterprises and protect the environment;
- find information from ‘enterprise’ and ‘finance and family’ sources more useful;
- have greater levels of trust for ‘productivity’ groups; and
- are more confident that timber can be sustainably produced from their areas of native vegetation.

Of the respondents who have not adopted the use of legume rotations, just over forty percent reported that this practice is partly or fully compatible with their property management **goals**, while almost 33% were uncertain (Table 11). On the other hand, approximately forty percent of the same respondents thought the use of legume rotations is not compatible with their property management **resources** and nearly 24% were unsure (Table 12). Nearly seventy percent of respondents who do not presently use legume rotations indicated they will or may take up this practice in the future (Table 13).

Table 11: Landholders' views of the compatibility of the use of legume rotations with their property management goals according to whether they have adopted the practice (proportion).

If currently use legume rotations	If legume rotations fit with goals				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	26.1	26.1	15.2	32.6	**100.0**
Partly	-	70.8	25.0	4.2	**100.0**
Yes	-	15.3	83.0	1.7	**100.0**
Total	9.3	29.5	48.0	13.2	**100.0**

Table 12: Landholders' views of the compatibility of the use of legume rotations with their property management resources according to whether they have adopted the practice (proportion).

If currently use legume rotations	If legume rotations fit with resources				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	39.1	8.7	28.3	23.9	**100.0**
Partly		66.7	25.0	8.3	**100.0**
Yes		12.1	84.5	3.4	**100.0**
Total	14.1	21.1	53.1	11.7	**100.0**

Table 13: Landholders' views of the likelihood of adopting or continuing to use legume rotations according to whether they have adopted the practice (proportion).

If currently use legume rotations	If will adopt or continue legume rotations			Total
	No (%)	Maybe (%)	Yes (%)	
No	31.9	51.1	17.0	**100.0**
Partly	-	76.0	24.0	**100.0**
Yes	-	6.8	93.2	**100.0**
Total	11.5	35.9	52.6	**100.0**

The construction of a BBN model examining the factors affecting the adoption of legume rotations and subsequent sensitivity analysis revealed that the most influential factors were landholders' motivation to 'build their business' and the total area of their property (Figure 8 and Table 14).

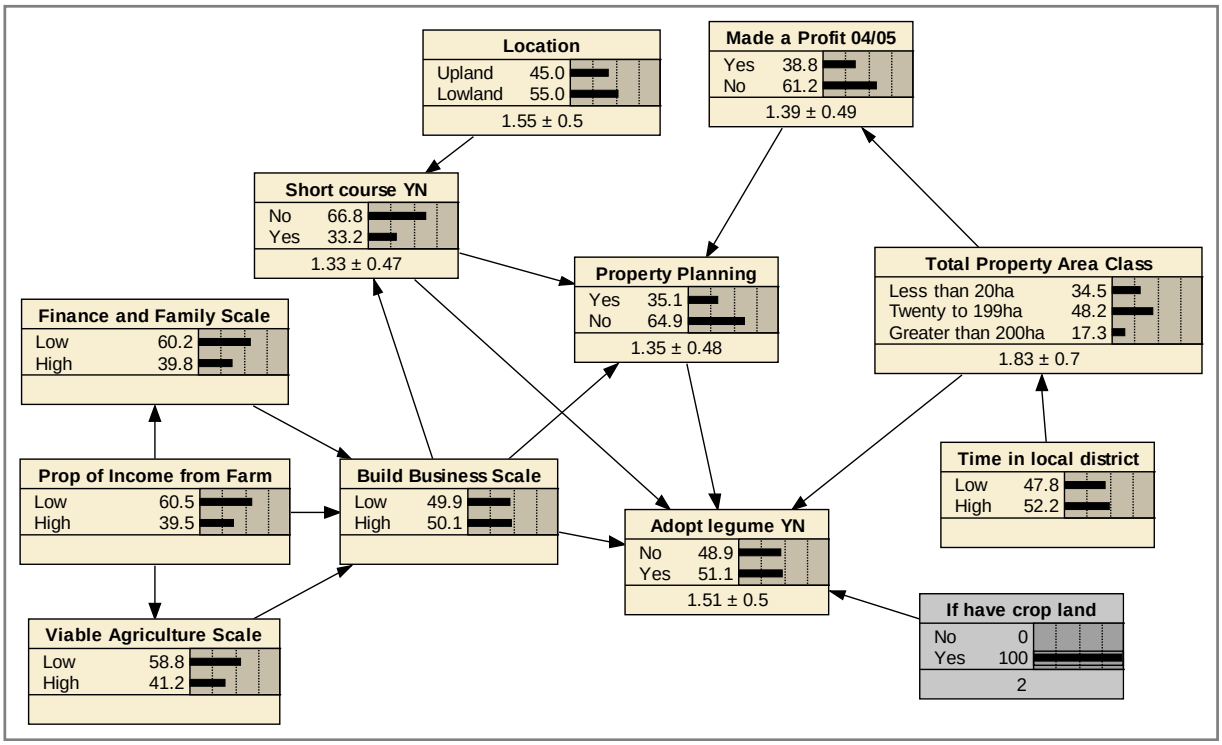

Figure 8: Bayesian Belief Network of the factors influencing landholders' adoption of legume rotations in their cropping enterprise.

Table 14: Results of sensitivity analysis of factors affecting the adoption of legume rotations in cropping enterprises.

Variable	Variance reduction	Variance reduction (%)
Adoption of legume rotations	0.2499	100.00
Management goal scale – build business	0.02141	8.57
Area of property owned	0.01959	7.84
Proportion of income earned on-property	0.006013	2.41
Regional issue scale – concern about future viability of agriculture	0.004098	1.64
Time lived in local district	0.003211	1.29
Information scale – usefulness of 'finance and family' sources	0.002523	1.01
If profitable in 2004/2005	0.002487	1.00
Short course	0.001416	0.57
If have a property plan	0.00103	0.41

An illustration of some of the inter-relationships between factors influencing the adoption of legume rotations is provided in Figure 9. Approximately 95% of respondents with property sizes of greater than 200 ha, with a relatively high dependence on their property for income, that have undertaken property planning activities, and have not attended a short course, use legume rotations. Note also that this combination of factors relates predominantly to respondents who have lived in the local district for a longer than average period of time and who have high scores on the 'build business' scale. Interestingly, the influence of attending short courses is reversed if the same combination of variables is used, apart from the property size variable. Where the property size variable is set to those in the 20-200 ha range with no short course attendance the proportion of respondents that have adopted legume rotations drops to less than half. Where these same landholders have attended short courses the adoption rate increases to 78%.

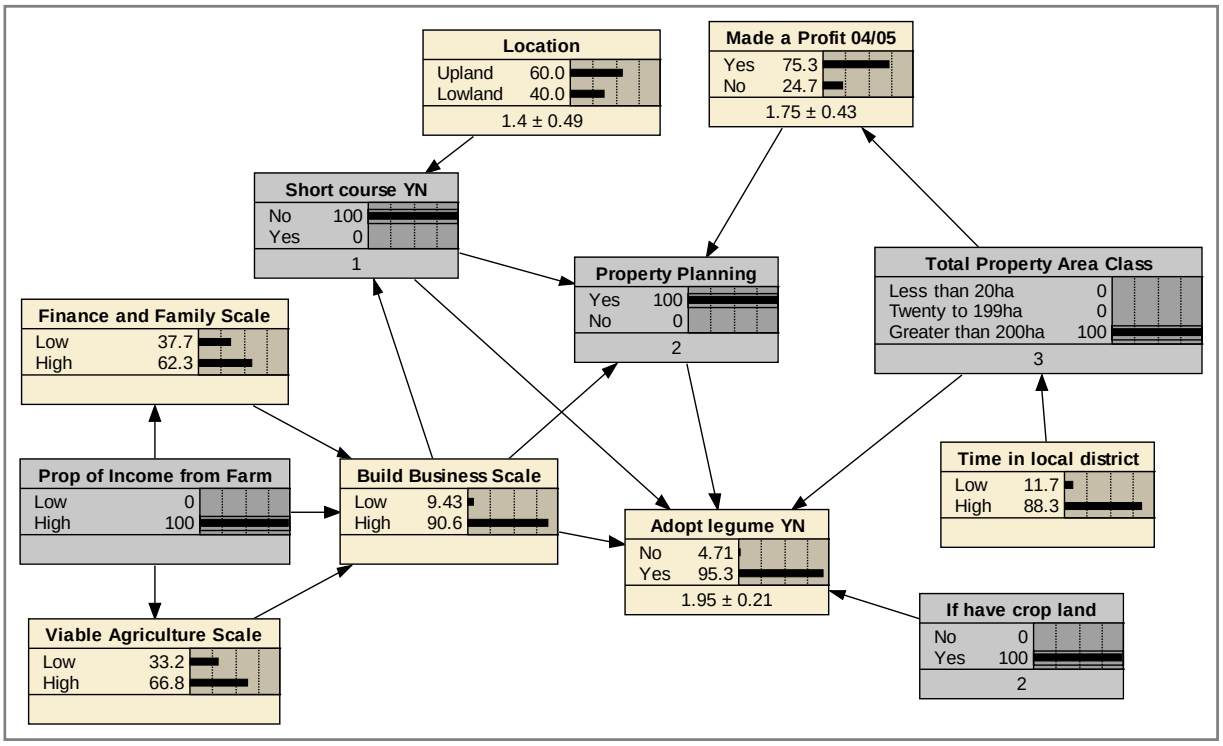

Figure 9: Bayesian Belief Network of the factors influencing landholders' adoption of legume rotations, illustrating the influence of short courses, property management planning, high reliance on property enterprises for income and property size.

Retention of stubble post-harvest

Approximately eighty percent of survey respondents with cropping land reported retaining stubble post-harvest on some or all of their cropping land. Compared to those who have not adopted the retention of stubble after harvest, those who have adopted this practice:

- own greater areas of cropping land;
- are more likely to be male;
- are more likely to live in the lowland parts of the region;
- have a higher proportion of land used for cropping activities;
- earn a higher proportion of their income from property enterprises and are more likely to be profitable;
- are more likely to have a property plan and have participated in a Government NRM program;
- have lived on rural properties, in the local district and on their current farm for a longer period of time;
- are more concerned about the future viability of agriculture;
- are more likely to be considering selling their property in the future;
- find information from ‘enterprise’ and ‘environment’ groups more useful; and
- have greater levels of trust for ‘productivity’ groups and less trust for state government agencies;

Of the respondents who do not currently use stubble retention practices, just over half reported that this practice is not compatible with either their management goals or their resources (Tables 15 and 16). Approximately 46% of these respondents reported they will or may adopt this practice in the future (Table 17).

Table 15: Landholders' views of the compatibility of retaining stubble post-harvest with their property management goals according to whether they have adopted the practice (proportion).

If currently retain stubble post-harvest	If stubble retention fits with goals				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	53.3	-	6.7	40.0	**100.0**
Partly	-	79.3	20.7	-	**100.0**
Yes	-	7.6	87.3	5.1	**100.0**
Total	6.5	23.6	61.8	8.1	**100.0**

Table 16: Landholders' views of the compatibility of retaining stubble post-harvest with their property management resources according to whether they have adopted the practice (proportion).

If currently retain stubble post-harvest	If stubble retention fits with resources				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	53.3	-	6.7	40.0	**100.0**
Partly	-	82.8	13.8	3.4	**100.0**
Yes	1.3	6.5	89.6	2.6	**100.0**
Total	7.4	24.0	61.2	7.4	**100.0**

Table 17: Landholders' views of the likelihood of adopting or continuing the practice of stubble retention post-harvest according to whether they have adopted the practice (proportion).

If currently retain stubble post-harvest	If will adopt or continue the practice of stubble retention			Total
	No (%)	Maybe (%)	Yes (%)	
No	53.3	33.3	13.4	**100.0**
Partly	-	79.3	20.7	**100.0**
Yes	1.3	3.8	94.9	**100.0**
Total	7.4	25.4	67.2	**100.0**

Use of grass headlands

Approximately 90% of respondents with cropping land reported using grassed headlands on part or all of their property. Compared to those who have not adopted the use of grass headlands, those who have adopted this practice:

- earn a higher proportion of their income from property enterprises;
- use a higher proportion of their land for cropping enterprises;
- are more likely to live in the lowland parts of the region;
- are more concerned about the future viability of agriculture;
- are more motivated to build their property enterprises;
- find information from 'enterprise' and 'environment' groups more useful;
- have greater levels of trust for 'productivity' groups and their neighbours; and
- are more confident that timber can be sustainably produced from their areas of native vegetation.

The maintenance of grassed headlands is already widely adopted by respondents. Of the 10% of respondents who do not use the practice, half indicated that this practice does not fit with their management goals or resources (Tables 18 and 19) and further indicated they did not expect to use the practice in the future (Table 20).

Table 18: Landholders' views of the compatibility of using grass headlands with their property management goals according to whether they have adopted the practice (proportion).

If currently use grass headlands	If grass headlands fit with goals				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	50.0	-	-	50.0	**100.0**
Partly	4.2	83.3	8.3	4.2	**100.0**
Yes	-	6.3	91.6	2.1	**100.0**
Total	3.2	20.8	71.2	4.8	**100.0**

Table 19: Landholders' views of the compatibility of using grass headlands with their property management resources according to whether they have adopted the practice (proportion).

If currently use grass headlands	If grass headlands fit with resources				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	50.0	33.3	-	16.7	**100.0**
Partly	4.2	75.0	16.6	4.2	**100.0**
Yes	-	4.3	94.6	1.1	**100.0**
Total	3.2	19.4	75.0	2.4	**100.0**

Table 20: Landholders' views of the likelihood of adopting or continuing the use of grass headlands according to whether they have adopted the practice (proportion).

If currently use grass headlands	If will adopt or continue the use of grass headlands			Total
	No (%)	Maybe (%)	Yes (%)	
No	50.0	33.3	16.7	**100.0**
Partly	4.2	75.0	20.8	**100.0**
Yes	-	5.3	94.7	**100.0**
Total	3.2	20.0	76.8	**100.0**

Use of earthworks to control soil movement

Approximately eighty percent of respondents with cropping land reported using earthworks on some or all of their cropping land to control soil movement. . Compared with those who have not adopted the use of earthworks, those that have adopted this practice:

- own larger properties and have greater areas of cropping land;
- have a higher proportion of land used for cropping activities;
- work longer hours on their property, earn a higher proportion of their income from property enterprises and have a greater number of people that live on their property;
- are more likely to have attended a short course related to property management and have a property plan;
- are more likely to live in the lowland areas of the region;
- are more likely to be male;
- have lived in the local district and on their current farm for a longer period of time;
- are more concerned about the future viability of agriculture;
- are less concerned about the health of the natural environment on their own property;
- are more motivated to build their property enterprises;
- find information from ‘enterprise’, ‘finance and family’ and ‘environment’ sources more useful;
- have greater levels of trust for ‘productivity’ groups; and
- are more confident that timber can be sustainably produced from their areas of native vegetation.

Of the 20% of respondents who indicated they did not use any earthworks to control soil movement on their property, a relatively high proportion is ‘not sure’ whether this practice is compatible with their property management goals or resources (Tables 21 and 22). Just over sixty percent of these respondents indicated they will or may adopt the practice in the future (Table 23).

Table 21: Landholders' views of the compatibility of using earthworks to control soil movement with their property management goals according to whether they have adopted the practice (proportion).

If currently use earthworks for soil control	If use of earthworks fits with goals				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	38.1	9.5	9.5	42.9	**100.0**
Partly	-	84.4	15.6	-	**100.0**
Yes	-	7.9	92.1	-	**100.0**
Total	6.2	27.1	59.7	7.0	**100.0**

Table 22: Landholders' views of the compatibility of using earthworks to control soil movement with their property management resources according to whether they have adopted the practice (proportion).

If currently use earthworks for soil control	If use of eathworks fits with resources				Total
	No (%)	Partly (%)	Yes (%)	Not sure (%)	
No	42.9	14.3	9.5	33.3	**100.0**
Partly	-	71.9	25.0	3.1	**100.0**
Yes	-	7.8	92.2	-	**100.0**
Total	6.9	24.6	62.3	6.2	**100.0**

Table 23: Landholders' views of the likelihood of adopting or continuing the use of soil controlling earthworks according to whether they have adopted the practice (proportion).

If currently use earthworks for soil control	If will adopt or continue the use of earthworks			Total
	No (%)	Maybe (%)	Yes (%)	
No	38.1	38.1	23.8	**100.0**
Partly	3.2	71.0	25.8	**100.0**
Yes	-	2.6	97.4	**100.0**
Total	7.0	24.8	68.2	**100.0**

Adoption of currently recommended grazing practices

A total of 132 landholders or approximately 41% of the 320 respondents to the survey reported having some grazing land on their landholding, with approximately ten percent reporting some irrigated grazing land. Of the 132 landholders identified above, approximately 35% have less than 20 ha of grazing land (Figure 10). Approximately 100 respondents (30%) reported having some beef cattle, while 10% reported having some dairy cattle.

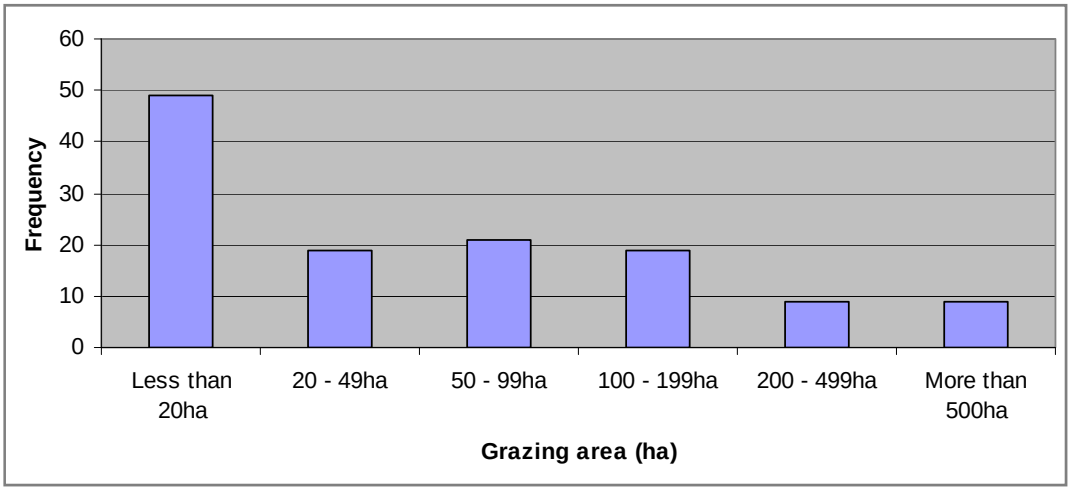

Figure 10: Frequency of respondents with various areas of grazing land (both irrigated and non-irrigated).

Use of fencing of native vegetation areas by landholders with grazing enterprises

Approximately 45% of survey respondents with stock and native vegetation areas reported having fenced some portion of these areas from their stock (Figure 11).

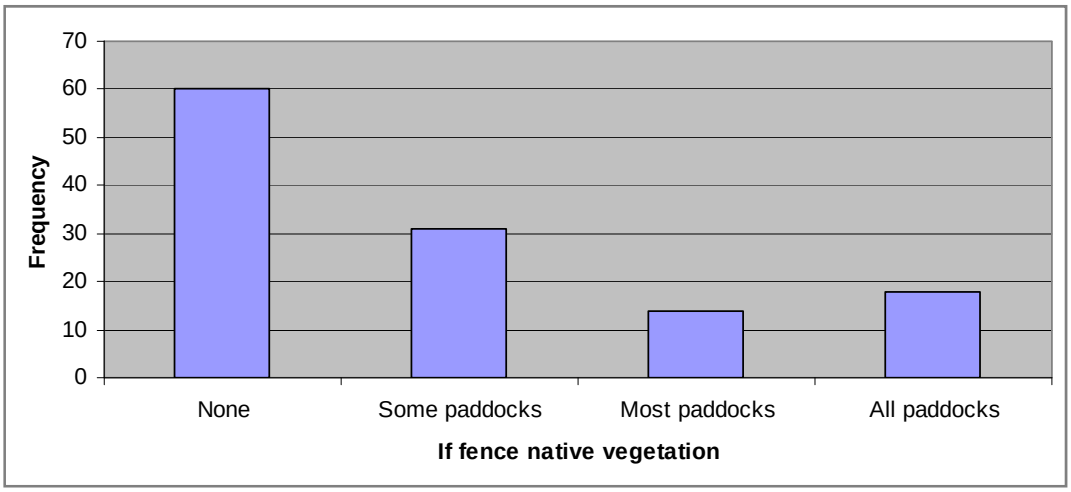

Figure 11: Frequency of respondents who fence various portions of their native vegetation from strock.

Those respondents who have fenced some areas of their native vegetation to exclude stock differ from those who have not in a number of ways. Those that have fenced some of their native vegetation areas are more dependent on their properties to provide income, employ a greater number of people on their properties and are more likely to occur in the 'lowland' parts of the region. Compared with those who have not fenced any native vegetation areas, they are also more:

- likely to use the native vegetation areas for recreation;
- likely to carry out maintenance of roads in these areas;
- confident they can access information to inform vegetation management activities;
- confident in the usefulness of information from 'enterprise', 'media' and 'environment groups'; and
- trusting of 'productivity groups'.

Fencing of waterways

Just over sixty percent of respondents with grazing enterprises reported establishing some fencing around their waterways (Tables 24 and 25).

Table 24: Extent of landholders' use of fenced waterways to control stock access.

Extent of fencing of waterways	Frequency	Percent	Valid Percent	Cumulative Percent
None	46	14.3	37.4	37.4
Some paddocks	38	11.8	30.9	68.3
Most paddocks	17	5.3	13.8	82.1
All paddocks	22	6.9	17.9	100.0
Total	**123**	**38.3**	**100.0**	
Missing System	**198**	**61.7**		
Total	**321**	**100.0**		

Pearson's chi-square = 9.836, d.f. = 1, sig. = 0.002: 0% of cells expected count < 5.

Table 25: Whether landholders have fenced at least some waterways to control stock access.

If fenced some waterways	Frequency	Percent	Valid Percent	Cumulative Percent
No	46	14.3	37.4	37.4
Yes	77	24.0	62.6	100.0
Total	**123**	**38.3**	**100.0**	
Missing System	**198**	**61.7**		
Total	**321**	**100.0**		

Landholders with grazing enterprises who have established fencing to exclude stock from waterways were found to differ in a number of ways from those with stock but who have not established such fencing. When compared with those who have not established fencing, those who have are:

- more concerned about the viability of agriculture;
- more likely to want to expand their business;
- more likely to want to sell their property;
- more concerned about the difficulties of managing native vegetation;
- more likely to regularly attend industry group meetings; and
- more likely to have mid-range (20-200ha) grazing areas than small or large areas.

Adoption of soil testing by graziers

Approximately sixty percent of respondents with grazing enterprises reported using soil tests to help determine fertiliser requirements in at least some of their grazing paddocks (Table 26).

Table 26: Whether landholders use soil testing to determine the fertiliser requirements of their landholdings.

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
None	50	15.6	41.0	41.0
Some paddocks	27	8.4	22.1	63.1
Most paddocks	16	5.0	13.1	76.2
All paddocks	29	9.0	23.8	100
Total	**122**	**38.0**	**100**	
Missing System	**199**	**62.0**		
Total	**321**	**100**		

Again those respondents that have used soil testing to help determine fertiliser requirements differ from those who have not in terms of the scale of their grazing operations and their dependence on agriculture for income. Relative to those who have not used soil testing, those who have used soil tests:

- work longer hours per week on their property;
- are more dependent on the property to provide income;
- support more people from their property enterprises;
- are more likely to be profitable;
- have greater intention to expand their business and improve the environment;
- have greater concern about the future viability of agriculture;
- are more confident they can obtain information about vegetation management and sustainably produce timber from their native forest areas;
- are more likely to have prepared a property or business plan and attended training courses related to land and water management;
- are more likely to have participated in Government NRM programs in the past;
- find information from 'enterprise', 'environment groups' and 'finance and family' more useful; and
- are more trusting of 'productivity' groups.

GIS assessment of attitudes to on-property and regional NRM issues by distance from the Wet Tropics World Heritage Area

The analysis of spatial relationships commenced with the assessment of variations in attitudes, characteristics of the landholdings and practices that differed between landholders and their holdings according to their proximity to the Wet Tropics World Heritage Area (WTWHA). Landholders' properties were classified into a series of classes according to the minimum distance they are to the boundary of the WTWHA. Of all the analyses undertaken, the only significant result was that landholders whose properties are within one hundred metres of the boundary of the WTWHA are more concerned about the impacts of 'pests and weeds' than those whose properties are more than two kilometers from the boundary (Table 27).

Table 27: Mean rating of the importance of the on-property NRM issue scale 'pest and weeds' by distance of the property boundary from the Wet Tropics World Heritage Area*.

Distance of property boundary from WTWHA	N	Mean	Std. Deviation	Std. Error
< 100m	48	3.09	1.228	.177
100-1,000m	27	2.46	1.356	.261
1,000-2,000m	34	2.83	1.248	.214
> 2,000m	161	2.41	1.182	.093
Total	**270**	**2.59**	**1.240**	**.075**

*Scale was measured from 1 = 'Not important' to 5 = 'Very important'. See Emtage and Herbohn (2009) for a description of how the scale was constructed.

Discussion of the findings

Testing for significant differences in the landholding characteristics and attitudes of landholders who have and have not adopted CRPs using chi-square analyses and one way ANOVA tests revealed similar differences related to many of the CRPs. In general, compared with those that have not adopted CRPs relating to agriculture (e.g. soil testing and the adoption of minimum tillage), those who have adopted industry CRPs:

- are more motivated to build their business;
- support a greater number of people with income from the property;
- operate larger scale enterprises;
- are more reliant on their property enterprises for income;
- tend to live in the 'lowland' areas of the region;
- more interested in information generally, particularly from 'enterprise' groups;
- have undertaken short courses on land management and have prepared a property or business plan;
- participate in more social groups (particularly 'industry' groups);
- have high levels of trust for 'productivity' groups; and
- are more concerned about the future viability of agriculture.

The pattern of differences between landholders and their landholdings with respect to the adoption of the CRPs relating to vegetation management differs to those related to agricultural industries, where the greatest adoption tends to be by those landholders with smaller landholding areas, who are less reliant on agriculture for their income. In relation to the adoption of CRPs within the cropping industry there is some evidence of differences in the rates of adoption between differing parts of the region, particularly between the 'upland' and 'lowland' areas. While these general patterns of differences are evident, it is also apparent that there are a number of differences in the characteristics of landholders' attitudes and their landholdings that are unique to each CRP.

Some limitations on the depth of investigation that could be undertaken were evident due to the relatively small sample size involved in the study. This limited the use of multivariate analyses and resulted in the need to join a number of categories for many variables in order to avoid violating the assumptions of the tests, for example the minimum number of replicates needed to produce valid tests.

Implications of the testing for differences in the perception of the fit with resources and goals for various cropping CRPs

Of the practices that were assessed in this study, all except the use of legume rotations (at 60%) had full or partial adoption rates of greater than 75% (Table 28). Apart from minimum tillage, the majority of 'non-adopters' reported that they expect to take up the practices in the future. Resource constraints appear to be the greatest concern in relation to minimum tillage, possibly because of the need for new equipment, and legume rotations, as this can take land area out of production for a time even though it may be expected to save some funds that are usually needed for fertilisers. Concern about the compatibility of soil testing with management goals was the greatest concern of non-adopters of soil testing. Those who had not adopted stubble retention and the use of earthworks to control soil movement reported being equally unsure about the implications of these practices for both their resources and management goals.

Table 28: Summary of present and posible adoption of recommended cropping practices and key issues concerning their adoption.

Cropping practice	Present adoption (partial and full)	Possible future adoption by current 'non-adopters'	Primary issues preventing adoption
Minimum tillage	80	45	Resources
Soil testing	77	75	Goals
Legume rotations	60	70	Resources
Retain stubble	80	50	Many unsure – both resource and goals issues
Grass headlands	91	50	Many unsure – goals issues
Earthworks	79	60	Many unsure – both resource and goals issues

Interpretation of the Bayesian Belief Network models

The construction of Bayesian Belief Network (BBN) models provided the opportunity to assess the inter-relationships between factors related to the adoption of a number of currently recommended practices (CRPs). As for the other statistical tests undertaken for this report, the relatively small number of respondents limited the complexity of models that could be constructed. These models never the less proved to be valuable in improving understanding of some of the key drivers of adoption.

The use of chi-square and one-way ANOVA tests revealed a multitude of significant relationships between the adoption of CRPs and the socio-economic, demographic and attitudinal variables that were collected as a part of the survey (see Tables 36 and 37 for a summary of these tests). Many of these socio-economic, attitudinal and demographic variables are themselves inter-related, so it can be difficult to interpret which factors are the most critical. BBN models provide a dynamic, easily interpretable means of assessing the relative influence of a number of factors on an outcome such as the adoption of CRPs. It is difficult to illustrate the dynamic nature of these models in a report format. One of their strengths is the ability to quickly assess which factors are combining to produce notably high (or low) levels of adoption. When used within the *Netica* program, it is possible to select differing combinations of attributes on different variables and to then see the resulting change in the proportion of landholders that have adopted a CRP. In this report we have attempted to provide examples of scenarios where various combinations of factors produce a large increase in the proportion of respondents that have adopted a CRP.

The construction and testing of the BBN models provided results consistent with the results of the above mentioned analyses in that they indicated that those landholders who have adopted CRPs tend to have larger-scaled enterprises, are more reliant on their properties for income, are more likely to be motivated to build their business and have completed or at least started a property or business plan. In some instances, most notably the preparation of property or business plans, attendance at short courses related to land management has a strong influence. In other cases, short course attendance appears less influential (including participation in Government NRM programs), on the adoption of soil testing and the use of legume rotations. The relationship between the ratings of usefulness of various information sources and the adoption of various CRPs were identified as highly significant.

Future analyses using binary logistic regression tests, Bayesian Belief Networks and Geographic Information Systems

When the survey of rural landholders in the Wet Tropics was undertaken, details of the locations of respondents were retained to enable assessment of the relationships between their responses and the character of the landscape in which landholders live and work. The project team has begun to undertake a series of analyses of the survey responses examining the spatial patterns of responses and the relationships between responses and the biophysical and social character of the region where this data is available in a spatially explicit format.

The results of these analyses will serve several purposes. First, we wish to investigate the nature and strength of relationships between the responses to the survey and data about the biophysical and socioeconomic characteristics of the region that are available in a spatial form. The results of these analyses will help to better describe the character of landholders in the region in relation to NRM issues and to better understand the nature and extent of variation between these landholders with the region. Second, we want to investigate means to extrapolate results from the survey responses to the wider population of rural landholders. In other words where the initial analyses reveal strong and consistent relationships between the responses and data available in spatial form, we want to assess whether it is possible to reliably predict the attitudes, practices and socioeconomic characteristics of those landholders which did not participate in the survey. Third, the spatial analyses of the responses of the survey will allow the results to be reported using maps and could allow the inclusion of the data in 'atlas' projects such as the 'e-Atlas', currently being developed by the Reef and Rainforest Research Centre[4]. Finally, if the survey responses are linked to spatial data about the status and trends of natural resource assets, the results of the proposed analyses could assist in the analysis of the spatial dimensions of the perception of NRM issues in the region, the current responses to these issues as well as the potential impacts of policy NRM program options on the landscape (see Figure 12 for an overview of how this may be achieved).

[4] Atlas of Australia's Tropical Land and Seas: http://e-atlas.org.au/

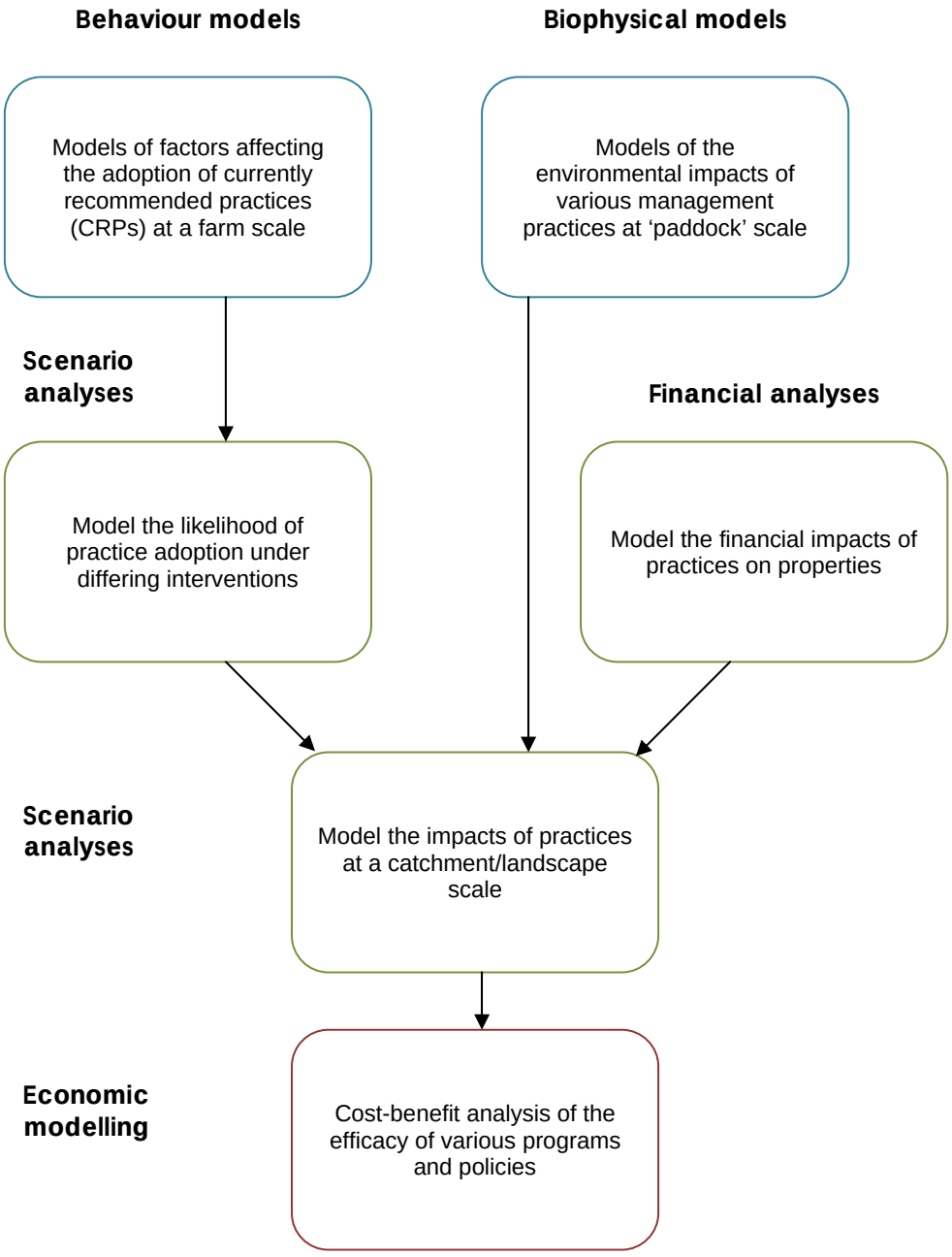

Figure 12: Outline of the information and modelling required to produce cost-benefit analyses of various policies and programs to support Natural Resource Management.

Summary of the purpose and data needs for GIS analyses from the Wet Tropics rural landholder sustainable agriculture survey

Some examples of specific research questions that could be addressed using the proposed analyses are listed below:

- Do landholders' perceptions of NRM issues, their intended management actions or current management activities vary with proximity to protected areas, urban areas and waterways?
- Is the current or intended adoption of recommended NRM practices related to particular attributes of the biophysical or social landscape?
- To what extent does participation in social groups, training and NRM programs vary with access to urban centres?
- Are particular 'types' of landholders associated with particular characteristics of the biophysical or social environment?
- What are the attitudes and NRM practices of landholders who live in or next to priority areas for NRM programs and policies?

Ethical considerations related to reporting GIS analyses

The proposed research activities have been submitted to the University Ethics Committee for approval and that approval has been granted. The conditions of the approval for the research project include the requirements that all survey respondents remain anonymous and their responses remain confidential. The implication is that the results of any analyses, including the presentation of maps, must be in a format that does not allow individuals to be identified. It is therefore necessary to present the data in an aggregated format that uses areas greater than a single landholding (e.g. sub-catchments). It is understood that under their existing data sharing agreement with State Government departments, Terrain NRM Ltd must also satisfy a number of requirements and these would need to be specified, discussed and complied with in order to access data held by Terrain NRM Ltd that is subject to such agreements.

GIS data sets being appraised for the development of revegetation assessment and practice adoption modelling

Table 29 describes the datasets that are being sought for use in the analyses, the custodians of the datasets and some notes about the potential use of the data.

Table 29: Data types and sources for future GIS analyses.

Topic	Custodian/s	Notes
Land values	DNRW	Unimproved land values data
Vegetation cover	EPA	Ecosystem type, conservation status of ecosystem, priority areas for revegetation, foliage projective cover (?)
Land use type	Terrain NRM, BRS, DPI, DNRW	
Infrastructure	Terrain NRM	
Waterways	Terrain NRM	
Soil types	DNRW	See Table 30
Land suitability	DNRW	See Table 30
Topography	Terrain NRM	Digital elevation model
Climate	Terrain NRM	
Socio-economic data	ABS	CURFs (confidentialised unit record files) indices of advantage/disadvantage (ABS) Income, age, education, employment

Table 30: Data relating to soil types available from the Queensland Department of Natural Resources and Water.

Project Title	Title	Scale
Soils and agricultural land suitability of the Atherton Tablelands, North Queensland	Soils and agricultural land suitability of the Atherton Tablelands, North Queensland	50,000
Mareeba Dimbulah Irrigation Area		50,000
Land resources and land suitability, Mulgrave Shire (Northern part)	Land resources and land suitability, Mulgrave Shire (Northern part)	50,000
Soils and agricultural land suitability of the Wet Tropical coast: Mossman-Julatten area	Soils and agricultural land suitability of the Wet Tropical coast: Mossman-Julatten area	31,680
Survey of the Burdekin-Townsville region		1,000,000
Soils and agricultural land suitability of the Wet Tropics coast of North Queensland: Ingham area	Soils and agricultural land suitability of the Wet Tropics coast of North Queensland: Ingham area	100,000
Land resources of the Dalrymple Shire	Land resources of the Dalrymple Shire	250,000
Land resources of the Einasleigh/Atherton Dry Tropics	Land resources of the Einasleigh/Atherton Dry Tropics	250,000

Table 31: Data relating to land suitability available from the Queensland Department of Natural Resources and Water.

Project Title	Title	Scale
North Queensland tea land suitability study	North Queensland tea land suitability study	100,000
Soils and agricultural land suitability of the Wet Tropical coast: Mossman-Julatten area	Soils and agricultural land suitability of the Wet Tropical coast: Mossman-Julatten area	31,680
Land suitability Babinda Cairns Wet Tropical coast		
Land resources and land suitability Mulgrave Shire (Northern part)	Land resources and land suitability Mulgrave Shire (Northern part)	50,000
Land suitability Cardwell Innisfail area Wet Tropical coast		500,000
Soils and agricultural land suitability of the Wet Tropics coast of North Queensland: Ingham area	Soils and agricultural land suitability of the Wet Tropics coast of North Queensland: Ingham area	100,000
Agricultural land suitability of Herberton Shire	Agricultural land suitability of Herberton Shire	250,000
Land resources of the Ravenshoe-Mt. Garnet area: Volume II Land suitability	Land resources of the Ravenshoe-Mt. Garnet area: Volume II Land suitability	100,000

Options for development of a GIS based assessment of the potential for revegetation

Principles for the development of a GIS based tool to assess revegetation options have been described by Pullar and Lamb (2008). First there is the issue of scale, involving the need to define and describe local-level vs. landscape-level impacts and indicators. Forman (1995) gives simple guidelines for understanding ecology organised around four geographical scales: landscapes and regions, patches and corridors, mosaics, and efficient landscape patterns (cited in Pullar and Lamb 2008: 236).

Principles for assessment of revegetation options include the following key features:

- capacity of degraded sites to recover without the need for external intervention;
- value of the restored area for in situ biodiversity conservation;
- biodiversity value of a linkage corridor; and
- context of the corridor within the landscape.

(Pullar and Lamb 2008: 239)

The following section describes how these features may be operationalised. Pullar and Lamb (2008) developed a series of simple scoring matrices for the above features which can be combined to produce an overall 'score' for a site. These scores indicate the likely development of biodiversity values given differing starting points for each site.

Pullar and Lamb (2008) define the capacity for a site to recover from disturbance as a function of the condition of the soils and vegetation on the site (Table 32) (following Gibbons and Freudenberger 2006). Sites that have been recently cleared but not cultivated and have native vegetation types are thought to have a high capacity to recover, contrasting with sites that were cleared more than two years ago and which have been cultivated and are dominated by exotic vegetation types.

Table 32: Decision classification for the recovery capacity of a degraded site (from Pullar and Lamb 2008: 241).

Disturbance		**Recently cleared (<2 years)**		**Historically cleared (>2 years)**	
	Soils	*Unmodified*	*Cultivated*	*Unmodified*	*Cultivated*
Vegetation	Native	High	Moderate	Moderate	Low
	Exotic dominated	Moderate	Low	Low	Very low

The combination of size, composition and proximity of remnant vegetation to other remnants is the second factor used to assess the capacity of a site to recover (Pullar and Lamb 2008: 241). Pullar and Lamb (2008: 241) developed subjective values for biodiversity based upon interpreted benefits for forest spatial structure and composition presented in Table 33. In general, larger areas of regrowth forest that are within close proximity to other remnant vegetation will have higher levels of biodiversity and will develop biodiversity more quickly than small remnants that are dominated by single species and are isolated from other remnant patches.

Table 33: Rating values (0-1, low-high) for biodiversity based on the type of forest, its size, and landscape context (from Pullar and Lamb 2008: 242).

Context	**Neighbouring forest**			**Isolated**		
Type	*Mono*	*Mixtures*	*Regrowth*	*Mono*	*Mixtures*	*Regrowth*
Small (<10ha)	0.1	0.2	0.5	0.1	0.1	0.3
Large (>10ha)	0.4	0.7	1.0	0.2	0.5	0.8

The capacity of a site to develop biodiversity values is also dependent on the size and shape of the ‘core’ area as well as the width of the remnant (Table 34).

Table 34: Ranked values for linkage quality based on the forest width, shape and core area (from Pullar and Lamb 2008: 243).

Shape		**Elongated**		**Regular**	
	Core area	*Small*	*Large*	*Small*	*Large*
Width	Narrow (<200m)	Very low	Low	Very low	Low
	Wide (>200m)	Low	Moderate	Moderate	High

The fourth feature used to assess the potential performance of a revegetation site by Pullar and Lamb (2008) is a measure of landscape connectivity. They propose two possible methods to calculate this measure, both without (Figure 13) and with measures of corridor width (Figure 14).

$$C_i = \sum_{j=1,n} A_j \exp(-\alpha \cdot d_{ij}) \qquad i \neq j$$

Figure 13: Equation for measuring landscape connectivity without the inclusion of corridor width.

Pullar and Lamb (2008: 243) stated, 'Whereis the index to adjoining patches with area weight *Aj* and distance *dij*. The influence of distance is controlled by the parameter *α*, if *α* = 0 then distance has no effect. This parameter is normally specific to the degree of dispersal of a species to a higher value, that is, a value of 5 means a species is sensitive to fragmentation (Vos *et al.* 2001).'

$$C_i^* = \sum_{j=1,n} A_j \exp(-\alpha \cdot d_{ij} / w_{ij}) \qquad i \neq j$$

Figure 14: Equation for measuring landscape connectivity with the inclusion of corridor width.

Pullar and Lamb (2008: 248) state that in their present model the scenarios are evaluated with indicator rules and scored to a uniform scale of 1 to 100 for comparison purposes using a linear scaling of raw indicator values to scores. They suggest that more comprehensive analysis might include other indicators. For instance, how recovery capacity is improved with seed dispersal around existing rainforest (White *et al.* 2004), reforesting riparian areas (Lawson *et al.* 2007) and forestation utilising plantation species (Kanowski *et al.* 2005; Lamb *et al.* 2005) would add further scenarios for consideration. The Biodiversity Monitoring Toolkit developed by Kanowski and others (2008) could provide a useful means of standardising measures of present biodiversity values of sites. Pullar and Lamb (2008) argued that a more comprehensive approach could be applied based upon stakeholder consultation to specify the utility function for scoring. Ian Jefferies has recently undertaken an extensive series of stakeholder interviews as part of his PhD studies that were used to develop multiple criteria assessments of stakeholders' revegetation preferences. The results of this study could be used to develop preference weights for various revegetation options in future studies. One way to further develop and refine the method could be to focus future studies within the regional priority areas for revegetation described in the Wet Tropics Regional NRM Plan (FNQ NRM Ltd and Rainforest CRC 2004).

Table 35: Summary of the significant relationships between the adoption of currently recommended practices and metric variables.

	Participate in NRM programs	Encourage regrowth	Participate in short courses	Property planning	Fenced waterways to control stock access	Fenced vegetation to control stock access	Soil testing by graziers	Minimum tillage	Soil testing by croppers	Use of legume rotations	Retain stubble	Use grass headlands	Use earthworks
Rural development scale – viable agriculture	0.002		0.000	0.000	0.026		0.001	0.040	0.000	0.002	0.012	0.001	0.001
Goal scale – build business	0.005	0.041	0.000	0.000	0.049		0.000	0.039	0.000	0.000		0.008	0.005
Information scale – enterprise information	0.000		0.000	0.000		0.008	0.000	0.014	0.000	0.000	0.019	0.010	0.004
Proportion of total income from farm	0.000		0.000	0.000		0.013	0.002	0.000	0.000	0.000	0.014	0.043	0.005
Information scale – Environment groups	0.000	0.003	0.000			0.002	0.031		0.013	0.000	0.030	0.028	0.005
Trust scale – productivity groups			0.000			0.037	0.005	0.028	0.000	0.014	0.000	0.050	
Information scale – Finance and family	0.000		0.000	0.000			0.024		0.001	0.000			0.042
Time lived in local district	0.003		0.000					0.000	0.000	0.000	0.003		0.002
Time lived on current property	0.001		0.000					0.001	0.000	0.001	0.003		0.047
Proportion of property used for cropping (%)	0.000		0.000							0.036	0.000	0.004	0.001
Vegetation scale – Timber			0.000	0.007			0.003			0.027		0.032	0.010
Average per week (hours)	0.000		0.000				0.015		0.000	0.000			0.015
Time lived on rural properties	0.016		0.000					0.009	0.001	0.003	0.001		
Number of people supported by property	0.000		0.000			0.039	0.008		0.018	0.031			
Total cropping land (ha)			0.000					0.041	0.012	0.008	0.020		
Goal scale – Improve environment	0.010		0.008	0.001			0.039			0.000			
Intention scale – Expand business		0.044	0.000	0.000			0.012						0.009
Vegetation scale – Clear forest		0.001	0.000	0.014					0.031				

	Participate in NRM programs	Encourage regrowth	Participate in short courses	Property planning	Fenced waterways to control stock access	Fenced vegetation to control stock access	Soil testing by graziers	Minimum tillage	Soil testing by croppers	Use of legume rotations	Retain stubble	Use grass headlands	Use earthworks
Number of people that live on property	0.000		0.000						0.011				0.028
Total land area (ha)		0.045		0.030						0.028			
Proportion of property under native vegetation (%)	0.007		0.000							0.017			
Vegetation scale – Management information				0.002		0.003	0.003						
Property scale – Environmental health		0.000											0.026
Intention scale – Sell property					0.012						0.036		
Vegetation scale – management difficulties			0.048		0.029								
Information scale – Media sources			0.003			0.016							
FTEs employed on-farm in past year	0.002		0.002										
Total grazing area (ha)			0.020										
Property scale – Soil health	0.003												
Property scale – Pests and weeds			0.000										
Rural development scale – Decline in services		0.000											
Intention scale – Lease property			0.030										
Trust scale – Environment groups		0.011											
Trust scale – State government											0.041		
Goal scale – Keep in family								0.001					
Trust scale – Neighbours													0.036

Table 36: Summary of the significant relationships between the adoption of currently recommended practices and nominal variables[5].

	Participate in NRM programs	Encourage regrowth	Participate in short courses	Property planning	Fenced waterways to control stock access	Fenced native vegetation	Soil testing by graziers	Minimum tillage	Soil testing by crop growers	Use legume rotations	Retained stubble post harvest	If use grass headlands	Use earthworks
Location class (upland and lowland)	**		***	***		**		***	***		**	**	*
If made a profit 2004/205	**		***	***			*	***	***		**		*
Short courses	***			***			*	**	***	**			*
If have property or business plan	***	*	***	-			***	**	***	**	**		**
Former local government areas	***	*	***	**				**	***	*			
Involvement in NRM programs		*		***			*	*	***	**	**		
Primary purpose for land ownership	**	**	***	***			***	***	***				
Land use type	***	*	***	***			***	***	***				
Gender	***		***	**				***			**		**
Industry groups	**		***		*				**				
Total property area classes	***	**		***						***			*
Local Landcare groups	***		**	**									
Catchment management groups	***		**	**									
Grazing area classes					*		**						
If have off-property income source							*			*			
Emergency services groups			*	**									
Church groups			**										

[5] * sig. 0.050-0.010; ** sig. 0.010-0.001; sig. <0.001.

	Participate in NRM programs	Encourage regrowth	Participate in short courses	Property planning	Fenced waterways to control stock access	Fenced native vegetation	Soil testing by graziers	Minimum tillage	Soil testing by crop growers	Use legume rotations	Retained stubble post harvest	If use grass headlands	Use earthworks
Formal education level		**							*				
Cropping area classes											*		
Involvement in off-property work								*					
Civic groups				*									
Lobby groups				**									
Native vegetation pruning		*											
Native vegetation track maintenance			*										
Native vegetation if maintain roads						**							
Native vegetation use for recreation		*				*							
Native vegetation gather NTFPs		*	*										

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Appendix A: Results of statistical analyses between socio-economic variables and the adoption of recommended practices

The following section provides details of the statistical tests used to compare survey respondents who had and had not adopted various current recommended practices (CRPs).

Property and business planning

Continuous variable	Property/ business plan?	N	Mean	Std. Deviation	Std. Error	Sig. level
Rural development scale – viable agriculture [a]	No	138	3.03	1.404	0.120	0.000
	Yes or in progress	95	3.89	0.977	0.100	
	Total	233	3.38	1.315	0.086	
Goal scale – build business [a]	No	184	3.11	1.607	0.118	0.000
	Yes or in progress	104	4.23	1.068	0.105	
	Total	288	3.51	1.532	0.090	
Goal scale – Improve environment [a]	No	185	3.65	1.145	0.084	0.001
	Yes or in progress	105	4.08	0.811	0.079	
	Total	290	3.81	1.055	0.062	
Intention scale – expand business [b]	No	176	-0.88	1.122	0.085	0.000
	Yes or in progress	101	-0.26	1.061	0.106	
	Total	277	-0.65	1.137	0.068	
Vegetation scale – clear forest [b]	No	136	-0.51	1.035	0.089	0.014
	Yes or in progress	67	-0.13	0.964	0.118	
	Total	203	-0.38	1.025	0.072	
Vegetation scale – management information [b]	No	136	0.16	0.729	0.063	0.002
	Yes or in progress	68	0.50	0.756	0.092	
	Total	204	0.28	0.753	0.053	
Vegetation scale – timber [b]	No	135	-0.27	1.054	0.091	0.007
	Yes or in progress	68	0.15	1.011	0.123	
	Total	203	-0.13	1.056	0.074	
Information scale – enterprise Information [a]	No	177	1.63	1.388	0.104	0.000
	Yes or in progress	95	2.66	1.228	0.126	
	Total	272	1.99	1.421	0.086	
Information scale – finance and family [a]	No	183	2.68	1.432	0.106	0.000
	Yes or in progress	98	3.43	1.075	0.109	
	Total	281	2.94	1.365	0.081	
Information scale – media sources [a]	No	184	2.74	1.345	0.099	0.002
	Yes or in progress	98	3.22	0.963	0.097	
	Total	282	2.91	1.245	0.074	

Continuous variable	Property/ business plan?	N	Mean	Std. Deviation	Std. Error	Sig. level
Trust scale – productivity groups [c]	No	76	1.48	0.855	0.098	0.000
	Yes or in progress	77	2.00	0.643	0.073	
	Total	153	1.74	0.797	0.064	
Proportion of total income from farm (%)	No	151	21.11	33.0	2.683	0.000
	Yes or in progress	79	54.86	35.6	4.005	
	Total	230	32.70	37.4	2.469	
Total size of farm (ha)	No	194	174.9	922.0	66.194	0.030
	Yes or in progress	105	1820.5	10431.6	1018.021	
	Total	299	752.8	6256.7	361.836	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

[c] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

Relationships between property planning and categorical variables

Whether landholders have or are preparing a property plan by former Local Government Area (LGA).									
	LGA (%)								
If have a property plan	**Atherton**	**Cairns**	**Douglas**	**Eacham**	**Herberton**	**Hinchinbrook**	**Johnstone**	**Mareeba**	**Cardwell**
No	72.4	69.7	66.7	71.4	79.2	48.9	50.0	84.6	52.4
Yes, or in progress	27.6	30.3	33.3	28.6	20.8	51.1	50.0	15.4	47.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 22.409, d.f. = 8, sig. = 0.004: 0% of cells expected count < 5.

If have a property plan	**Location class (%)**		**Total (%)**
	Upland	**Lowland**	
No	76.9	55.4	64.9
Yes, or in progress	23.1	44.6	35.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 15.138, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If have a property plan	Primary purpose for land ownership (%)					Total (%)
	Agriculture	Conservation	Hobby/ lifestyle farm	Residential	Other	
No	49.7	68.2	92.5	87.5	100.0	64.1
Yes, or in progress	50.3	31.8	7.5	12.5		35.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 46.521, d.f. = 4, sig. = 0.000: 0% of cells expected count < 5.

If have a property plan	Land use types recorded (%)					Total (%)
	Residential only	Grazing	Cropping	Grazing and cropping	Other	
No	89.4	53.7	49.5	53.6	81.6	65.1
Yes, or in progress	10.6	46.3	50.5	46.4	18.4	34.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 35.995, d.f. = 4, sig. = 0.000: 0% of cells expected count < 5.

If have a property plan	Gender (%)		Total (%)
	Female	Male	
No	79.2	58.5	79.2
Yes, or in progress	20.8	41.5	20.8
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.958, d.f. = 1, sig. = 0.002: 0% of cells expected count < 5.

If have a property plan	If profit made in 2004/2005 (%)		Total (%)
	No	Yes	
No	77.4	43.6	77.4
Yes, or in progress	22.6	56.4	22.6
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 33.760, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If have a property plan	Civic groups (e.g. Rotary, Lions Club) (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	67.2	75.0	46.2	16.7	58.8	65.0
Yes, or in progress	32.8	25.0	53.8	83.3	41.2	35.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.416, d.f. = 4, sig. = 0.049: 40% of cells expected count < 5.

If have a property plan	Emergency services (e.g. Bush Fire Brigade, SES) (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	73.3	50.0	53.5	45.5	40.0	64.9
Yes, or in progress	26.7	50.0	46.5	54.5	60.0	35.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 16.328, d.f. = 4, sig. = 0.003: 20% of cells expected count < 5.

If have a property plan	Local Landcare group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	70.6	54.5	42.3	30.0	50.0	64.4
Yes, or in progress	29.4	45.5	57.7	70.0	50.0	35.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 16.020, d.f. = 4, sig. = 0.003: 30% of cells expected count < 5.

If have a property plan	Catchment / sub-regional NRM group (e.g. Barron Integrated Catchment Management Association) (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	69.6	36.8	42.9	40.0	40.0	65.0
Yes, or in progress	30.4	63.2	57.1	60.0	60.0	35.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 14.610, d.f. = 4, sig. = 0.006: 50% of cells expected count < 5.

If have a property plan	Industry group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	77.7	73.3	47.2	40.5	27.3	64.9
Yes, or in progress	22.3	26.7	52.8	59.5	72.7	35.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 36.213, d.f. = 4, sig. = 0.000: 10% of cells expected count < 5.

If have a property plan	Political / lobby group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	67.8	55.6	56.3	45.5	-	63.8
Yes, or in progress	32.2	44.4	43.8	54.5	100.0	36.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearsons chi-square = 16.485, d.f. = 4, sig. = 0.002: 30% of cells expected count < 5.

If have a property plan	If attended short training course (%)		Total (%)
	No	Yes	
No	78.0	37.4	64.1
Yes, or in progress	22.0	62.6	35.9
Total	**100.0**	**100.0**	**100.0**

Pearsons chi-square = 46.812, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If have a property plan	If involved in Government NRM program in the last five years (%)		Total (%)
	No	Yes	
No	69.6	42.3	64.7
Yes, or in progress	30.4	57.7	35.3
Total	**100.0**	**100.0**	**100.0**

Pearsons chi-square = 13.929, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

Encouraging regrowth of native vegetation

Continuous variable	If encouraged regrowth of vegetation?	N	Mean	Std. Deviation	Std. Error	Sig. level
Total size of farm	No	128	1576.8	9513.34	840.87	.045
	Yes or in progress	176	135.2	336.70	25.38	
	Total	304	742.2	6205.45	355.91	
Property scale – environmental health [a]	No	101	1.0	.69	.07	.000
	Yes or in progress	151	1.4	.97	.08	
	Total	252	1.3	.90	.06	
Rural development scale – decline in services [a]	No	94	2.2	1.24	.13	.003
	Yes or in progress	152	2.6	1.12	.09	
	Total	246	2.5	1.19	.08	
Rural development scale – lack of environmental health [a]	No	98	1.2	.90	.09	.000
	Yes or in progress	153	1.9	1.20	.10	
	Total	251	1.6	1.14	.07	
Goal scale – build business [a]	No	120	3.8	1.49	.14	.041
	Yes or in progress	173	3.4	1.50	.11	
	Total	293	3.6	1.50	.09	
Intention scale – expand business [b]	No	116	-.5	1.13	.10	.044
	Yes or in progress	168	-.7	1.13	.09	
	Total	284	-.6	1.14	.07	
Vegetation scale – prefer to clear forest [b]	No	60	.0	.91	.12	.001
	Yes or in progress	149	-.5	1.03	.08	
	Total	209	-.4	1.02	.07	
Information scale – environment groups [a]	No	123	1.8	1.48	.13	.003
	Yes or in progress	174	2.3	1.46	.11	
	Total	297	2.1	1.49	.09	
Trust scale – environment groups [c]	No	111	1.7	.57	.05	.011
	Yes or in progress	168	1.9	.66	.05	
	Total	279	1.8	.63	.04	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

[c] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

Whether landholders have encouraged regrowth of native vegetation by former Local Government Area (LGA).									
	LGA (%)								
If encouraged regrowth	Atherton	Cairns	Douglas	Eacham	Herberton	Hinchinbrook	Johnstone	Mareeba	Cardwell
No	66.7	50.0	23.5	32.6	26.9	43.5	46.2	38.5	33.3
Yes	33.3	50.0	76.5	67.4	73.1	56.5	53.8	61.5	66.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 16.048, d.f. = 8, sig. = 0.042: 0% of cells expected count < 5.

If encouraged regrowth	Total farm area size class (%)						Total (%)
	Less than 20 ha	20-49 ha	50-99 ha	100-199 ha	200-499 ha	More than 500 ha	
No	27.9	54.1	58.9	40.0	37.1	61.1	42.0
Yes	72.1	45.9	41.1	60.0	62.9	38.9	58.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 20.434, d.f. = 5, sig. = 0.001: 0% of cells expected count < 5.

If encouraged regrowth	Primary purpose for land ownership (%)					Total (%)
	Agriculture	Conservation	Hobby/ lifestyle farm	Residential	Other	
No	47.3	4.5	42.9	32.7	62.5	41.7
Yes	52.7	95.5	57.1	67.3	37.5	58.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 18.043, d.f. = 4, sig. = 0.001: 20% of cells expected count < 5.

If encouraged regrowth	Land use types recorded (%)					Total (%)
	Residential only	Grazing	Cropping	Grazing and cropping	Other	
No	33.3	51.8	48.4	46.4	30.4	41.8
Yes	66.7	48.2	51.6	53.6	69.6	58.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.852, d.f. = 4, sig. = 0.043: 0% of cells expected count < 5.

If encouraged regrowth	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	45.5	32.1	40.7
Yes	54.5	67.9	59.3
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 5.126, d.f. = 1, sig. = 0.024: 0% of cells expected count < 5.

If encouraged regrowth	Whether prune native vegetation (%)		Total (%)
	No	Yes	
No	33.3	18.0	29.5
Yes	66.7	82.0	70.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 4.239, d.f. = 1, sig. = 0.039: 0% of cells expected count < 5.

If encouraged regrowth	Whether gather NTFPs (%)		Total (%)
	No	Yes	
No	32.2	11.4	28.8
Yes	67.8	88.6	71.2
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 6.154, d.f. = 1, sig. = 0.013: 0% of cells expected count < 5.

If encouraged regrowth	Whether use forests for recreation (%)		Total (%)
	No	Yes	
No	34.5	21.9	28.8
Yes	65.5	78.1	71.2
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 4.074, d.f. = 1, sig. = 0.049: 0% of cells expected count < 5.

If encouraged regrowth	Level of formal education achieved (%)					Total (%)
	Primary school	High school Year 10	High school Year 12	Dimploma or degree	Post-graduate degree	
No	51.6	50.0	43.8	35.6	11.5	41.2
Yes	48.4	50.0	56.3	64.4	88.5	58.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 14.926, d.f. = 4, sig. = 0.005: 0% of cells expected count < 5.

If encouraged regrowth	If involved in Government NRM program in last five years (%)		Total (%)
	No	Yes	
No	44.7	26.4	41.4
Yes	55.3	73.6	58.6
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 5.982, d.f. = 1, sig. = 0.014: 0% of cells expected count < 5.

Participation in Government NRM programs

Variable	If participated in Government NRM program(s)	N	Mean	Std. Deviation	Std. Error	Sig. level
Average per week (hours)	No	210	31.2	25.32	1.75	0.000
	Yes	54	49.2	23.65	3.22	
	Total	264	34.9	25.98	1.60	
FTEs employed on-farm in past year	No	185	1.3	1.54	.11	0.002
	Yes	50	3.6	9.29	1.31	
	Total	235	1.8	4.56	.30	
Proportion of total income from farm	No	194	27.6	36.03	2.59	0.000
	Yes	37	55.7	33.32	5.48	
	Total	231	32.1	37.00	2.43	
Time lived on rural properties	No	236	28.5	21.28	1.38	0.016
	Yes	53	36.3	20.67	2.84	
	Total	289	30.0	21.35	1.26	
Time lived in local district	No	233	30.5	22.71	1.49	0.003
	Yes	53	40.8	20.75	2.85	
	Total	286	32.4	22.68	1.34	
Time lived on current property	No	233	20.7	18.69	1.22	0.001
	Yes	52	30.1	19.72	2.73	
	Total	285	22.4	19.20	1.14	
Number of people that live on property	No	234	2.7	2.23	.15	0.000
	Yes	53	4.8	4.08	.56	
	Total	287	3.1	2.78	.16	
Number of people supported by property	No	224	1.9	2.55	.17	0.000
	Yes	53	5.2	9.19	1.26	
	Total	277	2.5	4.79	.29	
Property scale – soil health [a]	No	134	1.2	.88	.08	0.003
	Yes	43	1.7	.77	.12	
	Total	177	1.3	.87	.07	

Variable	If participated in Government NRM program(s)	N	Mean	Std. Deviation	Std. Error	Sig. level
Rural development scale – viable agriculture [a]	No	184	3.2	1.36	.10	0.002
	Yes	48	3.9	.92	.13	
	Total	232	3.4	1.31	.09	
Goal scale – build business [a]	No	233	3.4	1.52	.10	0.005
	Yes	53	4.0	1.31	.18	
	Total	286	3.5	1.50	.09	
Goal scale – improve environment [a]	No	233	3.7	1.10	.07	0.010
	Yes	54	4.1	.75	.10	
	Total	287	3.8	1.05	.06	
Information scale – enterprise information [a]	No	223	1.8	1.40	.09	0.000
	Yes	48	2.8	1.21	.17	
	Total	271	2.0	1.41	.09	
Information scale – finance and family [a]	No	230	2.8	1.38	.09	0.000
	Yes	51	3.5	1.01	.14	
	Total	281	2.9	1.35	.08	
Information scale – environment groups [a]	No	237	1.9	1.48	.10	0.000
	Yes	52	3.0	1.18	.16	
	Total	289	2.1	1.49	.09	
Proportion of property under native vegetation	No	135	47.8	33.01	2.84	0.007
	Yes	28	28.9	33.24	6.28	
	Total	163	44.5	33.71	2.64	
Proportion of property used for cropping	No	248	21.2	37.51	2.38	0.000
	Yes	53	44.8	44.16	6.07	
	Total	301	25.3	39.72	2.29	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

Whether landholders have participated in a Government NRM program in the last five years by former Local Government Area (LGA).

If participated in Govt. NRM program	LGA (%)								
	Atherton	Cairns	Douglas	Eacham	Herberton	Hinchinbrook	Johnstone	Mareeba	Cardwell
No	93.1	67.6	94.1	72.1	100.0	76.2	80.4	100.0	65.0
Yes	6.9	32.4	5.9	27.9	-	23.8	19.6	-	35.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 30.867, d.f. = 8, sig. = 0.000: 16.7% of cells expected count < 5.

If participated in Govt. NRM program	Location class (%)		Total (%)
	Upland	Lowland	
No	89.6	76.2	82.3
Yes	10.4	23.8	17.7
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.131, d.f. = 1, sig. = 0.003: 0% of cells expected count < 5.

If participated in Govt. NRM program	Total farm area size class (%)						Total (%)
	Less than 20 ha	20-49 ha	50-99 ha	100-199 ha	200-499 ha	More than 500 ha	
No	95.1	81.6	78.2	78.4	67.6	60.0	82.4
Yes	4.9	18.4	21.8	21.6	32.4	40.0	17.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 23.110, d.f. = 5, sig. = 0.000: 0% of cells expected count < 5.

If participated in Govt. NRM program	Primary purpose for land ownership (%)					Total (%)
	Agriculture	Conservation	Hobby/ lifestyle farm	Residential	Other	
No	74.6	85.0	93.0	95.8	100.0	82.0
Yes	25.4	15.0	7.0	4.2		18.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 18.382, d.f. = 4, sig. = 0.001: 20% of cells expected count < 5.

If participated in Govt. NRM program	Land use types recorded (%)					Total (%)
	Residential only	Grazing	Cropping	Grazing and cropping	Other	
No	95.7	78.2	75.8	58.3	91.0	82.0
Yes	4.3	21.8	24.2	41.7	9.0	18.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 22.355, d.f. = 4, sig. = 0.000: 10% of cells expected count < 5.

If participated in Govt. NRM program	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	88.2	70.6	82.0
Yes	11.8	29.4	18.0
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 13.929, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If participated in Govt. NRM program	Local Landcare group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	87.9	67.7	63.0	50.0	50.0	81.5
Yes	12.1	32.3	37.0	50.0	50.0	18.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 24.950, d.f. = 4, sig. = 0.000: 30% of cells expected count < 5.

If participated in Govt. NRM program	Catchment / sub-regional NRM group (e.g. Barron Integrated Catchment Management Association) (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	85.8	63.2	66.7	20.0	60.0	81.6
Yes	14.2	36.8	33.3	80.0	40.0	18.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 23.520, d.f. = 4, sig. = 0.000: 60% of cells expected count < 5.

If participated in Govt. NRM program	Industry group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	88.4	80.0	75.5	68.4	54.5	81.8
Yes	11.6	20.0	24.5	31.6	45.5	18.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square =16.350, d.f. = 4, sig. = 0.003: 20% of cells expected count < 5.

If participated in Govt. NRM program	Gender (%)		Total (%)
	Female	Male	
No	97.3	76.1	81.4
Yes	2.7	23.9	18.6
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 16.131, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If participated in Govt. NRM program	If attended short training course (%)		Total (%)
	No	Yes	
No	88.7	68.7	81.9
Yes	11.3	31.3	18.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 17.648, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If participated in Govt. NRM program	If profit made in 2006/2007 (%)		Total (%)
	No	Yes	
No	87.8	72.2	81.9
Yes	12.2	27.8	18.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 11.039, d.f. = 1, sig. = 0.001: 0% of cells expected count < 5.

Participation in short courses related to land management

Variable	If participated in Government NRM program(s)	N	Mean	Std. Deviation	Std. Error	Sig. level
Total cropping land (ha)	No	198	15.6	47.32	3.36	0.000
	Yes	105	133.9	277.36	27.07	
	Total	303	56.6	176.46	10.14	
Total grazing area (ha)	No	198	35.4	123.87	8.80	0.020
	Yes	105	1774.3	10472.05	1021.97	
	Total	303	638.0	6201.78	356.28	
Average per week (hours)	No	163	27.0	23.74	1.86	0.000
	Yes	103	48.4	23.89	2.35	
	Total	266	35.3	25.94	1.59	
FTEs employed on-farm in past year	No	144	1.1	1.26	.10	0.002
	Yes	93	3.0	6.95	.72	
	Total	237	1.8	4.55	.30	
Proportion of total income from farm	No	158	22.9	34.07	2.71	0.000
	Yes	76	54.0	35.11	4.03	
	Total	234	33.0	37.31	2.44	
Time lived on rural properties	No	189	26.1	19.90	1.45	0.000
	Yes	102	38.3	21.88	2.17	
	Total	291	30.4	21.38	1.25	
Time lived in local district	No	187	27.9	22.81	1.67	0.000
	Yes	103	42.6	19.80	1.95	
	Total	290	33.1	22.87	1.34	
Time lived on current property	No	187	18.9	18.03	1.32	0.000
	Yes	101	30.5	19.74	1.96	
	Total	288	23.0	19.43	1.14	
Number of people that live on property	No	187	2.6	2.18	.16	0.000
	Yes	103	4.0	3.52	.35	
	Total	290	3.1	2.81	.17	

Variable	If participated in Government NRM program(s)	N	Mean	Std. Deviation	Std. Error	Sig. level
Number of people supported by property	No	183	1.7	2.51	.19	0.000
	Yes	98	4.3	7.04	.71	
	Total	281	2.6	4.78	.29	
Proportion of property under native vegetation	No	110	52.6	32.42	3.09	0.000
	Yes	54	25.4	28.20	3.84	
	Total	164	43.6	33.55	2.62	
Proportion of property used for cropping	No	198	14.8	33.07	2.35	0.000
	Yes	104	46.5	42.98	4.21	
	Total	302	25.7	39.70	2.28	
Property scale – soil health [a]	No	101	1.1	.89	.09	0.000
	Yes	77	1.6	.79	.09	
	Total	178	1.4	.88	.07	
Property scale – pests and weeds [a]	No	163	2.3	1.27	.10	0.000
	Yes	96	3.1	1.06	.11	
	Total	259	2.6	1.24	.08	
Rural development scale – viable agriculture [a]	No	140	3.0	1.40	.12	0.000
	Yes	93	4.0	.86	.09	
	Total	233	3.4	1.32	.09	
Goal scale – build business [a]	No	187	3.1	1.64	.12	0.000
	Yes	100	4.2	1.02	.10	
	Total	287	3.5	1.54	.09	
Goal scale – improve environment [a]	No	185	3.7	1.18	.09	0.008
	Yes	103	4.0	.80	.08	
	Total	288	3.8	1.07	.06	
Intention scale – expand business [b]	No	174	-.8	1.14	.09	0.000
	Yes	102	-.3	1.08	.11	
	Total	276	-.6	1.14	.07	
Intention scale – lease property [b]	No	180	-1.5	.85	.06	0.030
	Yes	103	-1.3	.87	.09	
	Total	283	-1.4	.86	.05	
Vegetation scale – prefer to clear forest [b]	No	130	-.6	.97	.08	0.000
	Yes	71	.0	.99	.12	
	Total	201	-.4	1.02	.07	
Vegetation scale – management difficulties [b]	No	126	.4	.77	.07	0.048
	Yes	70	.6	.70	.08	
	Total	196	.5	.75	.05	
Vegetation scale – produce sustainable timber [b]	No	132	-.4	1.05	.09	0.000
	Yes	70	.2	1.00	.12	
	Total	202	-.2	1.06	.07	

Variable	If participated in Government NRM program(s)	N	Mean	Std. Deviation	Std. Error	Sig. level
Information scale – enterprise information [a]	No	180	1.5	1.31	.10	0.000
	Yes	94	3.0	1.03	.11	
	Total	274	2.0	1.42	.09	
Information scale – finance and family [a]	No	184	2.6	1.42	.10	0.000
	Yes	99	3.6	1.03	.10	
	Total	283	3.0	1.37	.08	
Information scale – environment groups [a]	No	188	1.9	1.50	.11	0.000
	Yes	101	2.6	1.32	.13	
	Total	289	2.1	1.48	.09	
Information scale – media sources [a]	No	185	2.7	1.34	.10	0.003
	Yes	100	3.2	1.00	.10	
	Total	285	2.9	1.25	.07	
Trust scale – productivity groups [c]	No	81	1.5	.86	.10	0.000
	Yes	71	2.1	.61	.07	
	Total	152	1.7	.80	.07	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

[c] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

Whether landholders have participated in short course(s) related to land management by former Local Government Area (LGA).

If participated in short course(s)	LGA (%)								
	Atherton	Cairns	Douglas	Eacham	Herberton	Hinchinbrook	Johnstone	Mareeba	Cardwell
No	82.1	52.9	62.5	85.4	76.0	43.2	58.5	87.2	45.0
Yes	17.9	47.1	37.5	14.6	24.0	56.8	41.5	12.8	55.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 37.157, d.f. = 8, sig. = 0.000: 0% of cells expected count < 5.

If participated in short course(s)	Location class (%)		Total (%)
	Upland	Lowland	
No	83.5	52.1	66.0
Yes	16.5	47.9	34.0
Total	**100.0**	**100.0**	**100.0**

Pearsons chi-square = 32.453, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If participated in short course(s)	Primary purpose for land ownership (%)					Total (%)
	Agriculture	Conservation	Hobby/ lifestyle farm	Residential	Other	
No	47.3	4.5	42.9	32.7	62.5	41.7
Yes	52.7	95.5	57.1	67.3	37.5	58.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearsons chi-square = 63.984, d.f. = 4, sig. = 0.000: 10% of cells expected count < 5.

If participated in short course(s)	Land use types recorded (%)					Total (%)
	Residential only	Grazing	Cropping	Grazing and cropping	Other	
No	33.3	51.8	48.4	46.4	30.4	41.8
Yes	66.7	48.2	51.6	53.6	69.6	58.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearsons chi-square = 72.062, d.f. = 4, sig. = 0.000: 0% of cells expected count < 5.

If participated in short course(s)	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	80.1	40.4	65.9
Yes	19.9	59.6	34.1
Total	**100.0**	**100.0**	**100.0**

Pearson’s chi-square = 46.812, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If participated in short course(s)	Native vegetation – track maintenance (%)		Total (%)
	No	Yes	
No	60.1	80.9	65.3
Yes	39.9	19.1	34.7
Total	**100.0**	**100.0**	**100.0**

Pearson’s chi-square = 6.693, d.f. = 1, sig. = 0.010: 0% of cells expected count < 5.

If participated in short course(s)	Native vegetation – whether gather NTFPs (%)		Total (%)
	No	Yes	
No	61.8	82.4	65.2
Yes	38.2	17.6	34.8
Total	**100.0**	**100.0**	**100.0**

Pearson’s chi-square = 5.293, d.f. = 1, sig. = 0.021: 0% of cells expected count < 5.

If participated in short course(s)	Emergency services (e.g. Bush Fire Brigade, SES) (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	73.6	52.8	50.0	63.6	54.5	66.2
Yes	26.4	47.2	50.0	36.4	45.5	33.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 13.245, d.f. = 4, sig. = 0.010: 20% of cells expected count < 5.

If participated in short course(s)	Local Landcare group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	71.5	47.1	50.0	33.3	50.0	65.2
Yes	28.5	52.9	50.0	66.7	50.0	34.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 15.743, d.f. = 4, sig. = 0.003: 30% of cells expected count < 5.

If participated in short course(s)	Catchment / sub-regional NRM group (e.g. Barron Integrated Catchment Management Association) (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	70.6	40.0	53.3	40.0	20.0	66.1
Yes	29.4	60.0	46.7	60.0	80.0	33.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 15.568, d.f. = 4, sig. = 0.004: 40% of cells expected count < 5.

If participated in short course(s)	Industry group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	81.1	53.3	50.0	32.5	36.4	65.6
Yes	18.9	46.7	50.0	67.5	63.6	34.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square =47.000, d.f. = 4, sig. = 0.000: 10% of cells expected count < 5.

If participated in short course(s)	Church group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	70.3	30.0	33.3	76.9	59.5	66.2
Yes	29.7	70.0	66.7	23.1	40.5	33.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 14.648, d.f. = 4, sig. = 0.005: 30% of cells expected count < 5.

If participated in short course(s)	Gender (%)		Total (%)
	Female	Male	
No	85.7	57.7	64.5
Yes	14.3	42.3	35.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 18.162, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If participated in short course(s)	If made a profit 2006/2007 (%)		Total (%)
	Female	Male	
No	77.5	46.4	65.5
Yes	22.5	53.6	34.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 29.430, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

Adoption of mínimum tillage practices

Variable	If use soil testing	N	Mean	Std. Deviation	Std. Error	Sig. level
Total cropping land (ha)	1	32	34.3	95.9	17.0	0.041
	2	115	108.5	197.0	18.4	
	Total	147	92.32	182.2	15.0	
Proportion of total income from farm (%)	1	22	13.1	25.2	5.4	0.000
	2	92	55.8	34.8	3.6	
	Total	114	47.6	37.2	3.5	
Time lived on rural property (years)	1	29	27.4	22.0	4.1	0.009
	2	114	39.0	20.7	1.9	
	Total	143	36.6	21.4	1.8	
Time lived in local district (years)	1	29	26.2	23.0	4.3	0.000
	2	114	43.3	19.6	1.8	
	Total	143	39.8	21.4	1.8	
Time lived on current property (years)	1	29	16.4	17.3	3.2	0.001
	2	113	30.9	20.3	1.9	
	Total	142	27.9	20.5	1.7	
Rural development scale – viable agriculture	1	25	3.60	1.0	0.2	0.040
	2	102	4.00	0.8	0.1	
	Total	127	3.92	0.9	0.1	
Goal scale – build business [a]	1	30	3.86	1.3	0.2	0.039
	2	111	4.31	1.0	0.1	
	Total	141	4.22	1.1	0.1	
Information scale –	1	29	2.31	1.3	0.2	0.014

Variable	If use soil testing	N	Mean	Std. Deviation	Std. Error	Sig. level
enterprise information [a]	2	103	2.89	1.1	0.1	
	Total	132	2.76	1.1	0.1	
Trust scale – productivity groups [b]	1	14	1.57	0.8	0.2	0.028
	2	76	2.01	0.7	0.1	
	Total	90	1.94	0.7	0.1	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

Relationships between crop growers' use of mínimum tillage and non-metric variables

Whether landholders use minimum tillage by former Local Government Area (LGA).

If use minimum tillage	LGA (%)								
	Atherton	Cairns	Douglas	Eacham	Herberton	Hinchinbrook	Johnstone	Mareeba	Cardwell
No	43.8	15.8	66.7	45.5	25.0	8.3	12.1	62.5	7.1
Yes	56.3	84.2	33.3	54.5	75.0	91.7	87.9	37.5	92.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 27.525, d.f. = 8, sig. = 0.001: 50% of cells expected count < 5.

If use minimum tillage	Location class (%)		Total (%)
	Upland	Lowland	
No	46.2	12.4	21.5
Yes	53.8	87.6	78.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 19.201, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If use minimum tillage	Primary purpose for land ownership (%)					Total (%)
	Agriculture	Conservation	Hobby/ lifestyle farm	Residential	Other	
No	16.9	25.0	53.8	66.7	100.0	22.1
Yes	83.1	75.0	46.2	33.3	-	77.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 16.553, d.f. = 2, sig. = 0.000: 70% of cells expected count < 5.

If use minimum tillage	Land use types recorded (%)					Total (%)
	Residential only	Grazing	Cropping	Grazing and cropping	Other	
No	66.7	45.5	13.2	5.0	42.9	22.5
Yes	33.3	54.5	86.8	95.0	57.1	77.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 22.286, d.f. = 4, sig. = 0.000: 50% of cells expected count < 5.

If use minimum tillage	Gender (%)		Total (%)
	Female	Male	
No	55.6	16.5	21.6
Yes	44.4	83.5	78.4
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 14.101, d.f. = 1, sig. = 0.000: 25% of cells expected count < 5.

If use minimum tillage	Involvement in off-farm work (%)				Total (%)
	None	Casual	Part-time	Full-time	
No	15.4	5.9	20.7	38.5	20.2
Yes	84.6	94.1	79.3	61.5	79.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 8.305, d.f. = 3, sig. = 0.040: 12.5% of cells expected count < 5.

If use minimum tillage	If made a profit 2006/7 (%)		Total (%)
	No	Yes	
No	35.9	7.9	20.7
Yes	64.1	92.1	79.3
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 16.636, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If use minimum tillage	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	32.9	11.1	21.8
Yes	67.1	88.9	71.2
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.835, d.f. = 1, sig. = 0.002: 0% of cells expected count < 5.

If use minimum tillage	If attended short course(s) (%)		Total (%)
	No	Yes	
No	31.0	10.8	20.7
Yes	69.0	89.2	79.3
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 8.988, d.f. = 1, sig. = 0.003: 0% of cells expected count < 5.

If use minimum tillage	If involved in Government NRM program in the last five years (%)		Total (%)
	No	Yes	
No	25.0	7.9	20.4
Yes	75.0	92.1	79.6
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 5.011, d.f. = 1, sig. = 0.025: 0% of cells expected count < 5.

Adoption of soil testing by crop growers

Variable	If use soil testing	N	Mean	Std. Deviation	Std. Error	Sig. level
Total cropping land (ha)	No	37	26	123.4	20.3	0.012
	Yes	119	110	188.6	17.3	
	Total	156	90	178.6	14.3	
Average per week (hours)	No	33	26.7	24.31	4.23	0.000
	Yes	116	49.8	20.93	1.94	
	Total	149	44.7	23.68	1.94	
Proportion of total income from farm (%)	No	31	25.5	34.58	6.21	0.000
	Yes	89	56.6	34.44	3.65	
	Total	120	48.6	36.96	3.37	
Time lived on rural property (years)	No	35	26.0	20.37	3.44	0.001
	Yes	116	39.7	20.90	1.94	
	Total	151	36.5	21.50	1.75	
Time lived in local district (years)	No	35	24.3	21.18	3.58	0.000
	Yes	116	45.3	19.39	1.80	
	Total	151	40.5	21.66	1.76	
Time lived on current property (years)	No	35	14.5	15.70	2.65	0.000
	Yes	115	32.5	19.98	1.86	
	Total	150	28.3	20.50	1.67	
Number of people who live on property	No	35	2.5	2.68	0.45	0.011
	Yes	115	4.1	3.33	0.31	
	Total	150	3.7	3.25	0.27	

Variable	If use soil testing	N	Mean	Std. Deviation	Std. Error	Sig. level
Number of people supported by property	No	32	1.5	1.52	0.27	0.018
	Yes	110	4.3	6.62	0.63	
	Total	142	3.7	5.98	0.50	
Rural development scale – viable agriculture [a]	No	27	3.2	1.10	0.21	0.000
	Yes	108	4.1	0.68	0.07	
	Total	135	3.9	0.86	0.07	
Goal scale – build business [a]	No	35	3.2	1.40	0.24	0.000
	Yes	115	4.5	0.72	0.07	
	Total	150	4.2	1.06	0.09	
Vegetation scale – prefer to clear forest [b]	No	28	-0.4	1.07	0.20	0.031
	Yes	65	0.1	0.91	0.11	
	Total	93	0.0	0.98	0.10	
Information scale – enterprise information [a]	No	33	1.8	1.03	0.18	0.000
	Yes	104	3.1	0.97	0.09	
	Total	137	2.8	1.13	0.10	
Information scale – finance and family [a]	No	33	3.0	1.16	0.20	0.001
	Yes	112	3.7	0.97	0.09	
	Total	145	3.5	1.05	0.09	
Information scale – environment groups [a]	No	35	2.0	1.41	0.24	0.013
	Yes	114	2.6	1.34	0.13	
	Total	149	2.5	1.38	0.11	
Trust scale – productivity groups [c]	No	17	1.3	0.85	0.21	0.000
	Yes	81	2.1	0.62	0.07	
	Total	98	2.0	0.72	0.07	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

[c] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

Whether landholders have adopted soil testing by former Local Government Area (LGA).

If have adopted soil testing	LGA (%)								
	Atherton	Cairns	Douglas	Eacham	Herberton	Hinchinbrook	Johnstone	Mareeba	Cardwell
No	41.2	20.0	66.7	45.5	100.0	7.9	14.3	45.5	14.3
Yes	58.8	80.0	33.3	54.5	-	92.1	85.7	54.5	85.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 31.908, d.f. = 8, sig. = 0.000: 50% of cells expected count < 5.

If have adopted soil testing	Location class (%)		Total (%)
	Upland	Lowland	
No	48.8	14.5	24.2
Yes	51.2	85.5	75.8
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 19.828, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If have adopted soil testing	Primary purpose for land ownership (%)					Total (%)
	Agriculture	Conservation	Hobby/ lifestyle farm	Residential	Other	
No	13.0	50.0	85.7	100.0	100.0	23.4
Yes	87.0	50.0	14.3	-	-	76.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 56.252, d.f. = 4, sig. = 0.000: 70% of cells expected count < 5.

If have adopted soil testing	Land use types recorded (%)					Total (%)
	Residential only	Grazing	Cropping	Grazing and cropping	Other	
No	100.0	31.8	7.6	17.4	69.6	24.5
Yes	-	68.2	92.4	82.6	30.4	75.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 51.054, d.f. = 4, sig. = 0.000: 20% of cells expected count < 5.

If have adopted soil testing	Level of formal education achieved (%)					Total (%)
	Primary school	High school Year 10	High school Year 12	Dimploma or degree	Post-graduate degree	
No	19.0	19.1	17.9	28.1	58.3	23.8
Yes	81.0	80.9	82.1	71.9	41.7	76.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.768, d.f. = 4, sig. = 0.045: 10% of cells expected count < 5.

If have adopted soil testing	If made a profit 2006/7 (%)		Total (%)
	No	Yes	
No	41.5	8.4	23.0
Yes	58.5	91.6	77.0
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 22.576, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If have adopted soil testing	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	37.3	8.0	22.7
Yes	62.7	92.0	77.3
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 18.408, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If have adopted soil testing	Industry group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	40.0	30.8	8.1	13.8	-	23.8
Yes	60.0	69.2	91.9	86.2	100.0	76.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 18.149, d.f. = 4, sig. = 0.001: 20% of cells expected count < 5.

If have adopted soil testing	If attended short course(s) (%)		Total (%)
	No	Yes	
No	35.6	12.5	23.5
Yes	64.4	87.5	76.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 11.336, d.f. = 1, sig. = 0.001: 0% of cells expected count < 5.

If have adopted soil testing	If involved in Government NRM program in the last five years (%)		Total (%)
	No	Yes	
No	30.6	5.3	24.2
Yes	69.4	94.7	75.8
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.942, d.f. = 1, sig. = 0.001: 0% of cells expected count < 5.

Adoption of legume rotations

Variable	If have adopted legume rotations	N	Mean	Std. Deviation	Std. Error	Sig. level
Total size of farm	No	63	121.0	186.42	23.49	.028
	Yes	89	254.5	452.03	47.92	
	Total	152	199.1	371.08	30.10	
Total cropping land	No	63	47.4	107.24	13.51	.008
	Yes	92	125.2	212.90	22.20	
	Total	155	93.6	181.34	14.57	
Average per week (hours)	No	60	34.4	23.83	3.08	.000
	Yes	87	51.6	21.09	2.26	
	Total	147	44.6	23.75	1.96	
Proportion of total income from farm	No	53	31.7	32.24	4.43	.000
	Yes	66	61.4	35.06	4.32	
	Total	119	48.1	36.81	3.37	
Time lived on rural properties	No	60	30.2	21.87	2.82	.003
	Yes	89	40.7	20.11	2.13	
	Total	149	36.5	21.39	1.75	
Time lived in local district	No	60	32.9	23.72	3.06	.000
	Yes	89	45.4	18.81	1.99	
	Total	149	40.3	21.73	1.78	
Time lived on current property	No	60	21.8	18.92	2.44	.001
	Yes	88	32.6	20.08	2.14	
	Total	148	28.2	20.27	1.67	
Number of people supported by property	No	57	2.4	2.37	.31	.031
	Yes	84	4.6	7.48	.82	
	Total	141	3.7	6.05	.51	
Rural development scale – viable agriculture [a]	No	54	3.7	1.04	.14	.002
	Yes	81	4.1	.68	.08	
	Total	135	3.9	.87	.07	
Goal scale – build business [a]	No	62	3.8	1.20	.15	.000
	Yes	87	4.5	.85	.09	
	Total	149	4.2	1.06	.09	
Goal scale – improve environment [a]	No	59	3.8	.80	.10	.000
	Yes	88	4.2	.74	.08	
	Total	147	4.0	.80	.07	
Vegetation scale – timber	No	36	-.3	1.06	.18	.027
	Yes	58	.2	1.08	.14	
	Total	94	.0	1.10	.11	

Variable	If have adopted legume rotations	N	Mean	Std. Deviation	Std. Error	Sig. level
Information scale – enterprise information [a]	No	54	2.4	1.18	.16	.000
	Yes	84	3.1	1.01	.11	
	Total	138	2.8	1.13	.10	
Information scale – finance and family [a]	No	59	3.1	1.05	.14	.000
	Yes	86	3.8	.98	.11	
	Total	145	3.5	1.06	.09	
Information scale – environment groups [a]	No	61	2.0	1.44	.18	.000
	Yes	87	2.8	1.19	.13	
	Total	148	2.5	1.36	.11	
Trust scale – productivity groups [b]	No	37	1.7	.77	.13	.014
	Yes	61	2.1	.65	.08	
	Total	98	1.9	.72	.07	
Proportion of property under native vegetation (%)	No	29	36.8	23.52	4.37	.017
	Yes	42	21.8	26.65	4.11	
	Total	71	27.9	26.32	3.12	
Proportion of property used for cropping (%)	No	63	37.3	45.16	5.69	.036
	Yes	91	52.5	42.75	4.48	
	Total	154	46.3	44.24	3.57	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

Whether landholders have adopted use of legume rotations by former Local Government Area (LGA).

If have adopted legume rotations	LGA (%)								
	Atherton	Cairns	Douglas	Eacham	Herberton	Hinchinbrook	Johnstone	Mareeba	Cardwell
No	40.0	45.0	100.0	41.7	75.0	28.2	48.6	63.6	15.4
Yes	60.0	55.0	-	58.	25.0	71.8	51.4	36.4	84.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 15.631, d.f. = 8, sig. = 0.048: 33% of cells expected count < 5.

If have adopted legume rotations	Total farm area size class (%)						Total (%)
	Less than 20 ha	20-49 ha	50-99 ha	100-199 ha	200-499 ha	More than 500 ha	
No	79.2	52.9	41.9	23.8	28.6	40.0	41.4
Yes	20.8	47.1	58.1	76.2	71.4	60.0	58.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 22.304, d.f. = 8, sig. = 0.000: 8.3% of cells expected count < 5.

If have adopted legume rotations	Property or business plan preparation (%)			Total (%)
	No	In progress	Yes	
No	54.2	17.6	28.8	39.9
Yes	45.8	82.4	71.2	60.1
Total	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 12.650, d.f. = 2, sig. = 0.002: 0% of cells expected count < 5.

If have adopted legume rotations	If attended short course(s) (%)		Total (%)
	No	Yes	
No	52.1	30.0	40.4
Yes, or in progress	47.9	70.0	59.6
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 7.639, d.f. = 1, sig. = 0.006: 0% of cells expected count < 5.

If have adopted legume rotations	If have income from off-property (%)		Total (%)
	No	Yes	
No	25.7	46.4	41.5
Yes, or in progress	74.3	53.6	58.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 4.731, d.f. = 1, sig. = 0.030: 0% of cells expected count < 5.

If have adopted legume rotations	If involved in Government NRM program in the last five years (%)		Total (%)
	No	Yes	
No	49.5	18.4	41.5
Yes, or in progress	50.5	81.6	58.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 11.240, d.f. = 1, sig. = 0.001: 0% of cells expected count < 5.

Retention of stubble post-harvest

Variable	If retain stubble post-harvest	N	Mean	Std. Deviation	Std. Error	Sig. level
Total cropping land	No	29	19.9	51.66	9.59	.020
	Yes	118	104.0	189.97	17.49	
	Total	147	87.4	174.81	14.42	
Proportion of total income from farm	No	23	31.9	38.65	8.06	.014
	Yes	93	53.2	35.96	3.73	
	Total	116	49.0	37.32	3.46	
Time lived on rural properties	No	27	24.0	22.05	4.24	.001
	Yes	116	39.5	20.60	1.91	
	Total	143	36.6	21.67	1.81	
Time lived in local district	No	27	29.7	24.56	4.73	.003
	Yes	116	43.3	20.33	1.89	
	Total	143	40.7	21.77	1.82	
Time lived on current property	No	27	18.2	19.56	3.77	.003
	Yes	115	31.2	20.06	1.87	
	Total	142	28.7	20.54	1.72	
Rural development scale – viable agriculture [a]	No	23	3.5	1.09	.23	.012
	Yes	104	4.0	.81	.08	
	Total	127	3.9	.88	.08	
Intention scale – sell property [b]	No	25	-.9	.92	.18	.036
	Yes	114	-.4	1.10	.10	
	Total	139	-.5	1.08	.09	
Information scale – enterprise information [a]	No	24	2.3	1.17	.24	.019
	Yes	106	2.9	1.09	.11	
	Total	130	2.8	1.12	.10	
Information scale – environment groups [a]	No	29	2.0	1.36	.25	.030
	Yes	112	2.6	1.32	.13	
	Total	141	2.4	1.35	.11	
Trust scale – productivity groups [c]	No	15	1.4	.79	.20	.000
	Yes	75	2.1	.65	.08	
	Total	90	2.0	.72	.08	
Trust scale – State government [c]	No	25	1.9	.45	.09	.041
	Yes	99	1.6	.51	.05	
	Total	124	1.7	.50	.05	
Proportion of property used for cropping	No	29	17.5	36.20	6.72	.000
	Yes	117	52.4	43.59	4.03	
	Total	146	45.5	44.36	3.67	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

[c] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

If retain stubble post-harvest	Location class (%)		Total (%)
	Upland	Lowland	
No	35.0	14.4	20.1
Yes	65.0	85.6	79.9
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 7.605, d.f. = 1, sig. = 0.006: 0% of cells expected count < 5.

If retain stubble post-harvest	Total farm area size class (%)						Total (%)
	Less than 20 ha	20-49 ha	50-99 ha	100-199 ha	200-499 ha	More than 500 ha	
No	50.0	13.3	8.3	4.3	7.1	-	11.4
Yes	50.0	86.7	91.7	95.7	92.9	100.0	88.6
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 14.017, d.f. = 5, sig. = 0.015: 0% of cells expected count < 5.

If retain stubble post-harvest	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	28.2	9.9	19.0
Yes	71.8	90.1	81.0
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 7.729, d.f. = 1, sig. = 0.005: 0% of cells expected count < 5.

If retain stubble post-harvest	Gender (%)		Total (%)
	Female	Male	
No	44.4	17.1	20.6
Yes	55.6	82.9	79.4
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 7.201, d.f. = 1, sig. = 0.007: 0% of cells expected count < 5.

If retain stubble post-harvest	If involved in Government NRM program in the last five years (%)		Total (%)
	No	Yes	
No	25.7	2.8	19.9
Yes	74.3	97.2	80.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 8.862, d.f. = 1, sig. = 0.003: 0% of cells expected count < 5.

If retain stubble post-harvest	If made a profit 2004/2005		Total (%)
	No	Yes	
No	29.0	11.5	19.3%
Yes	71.0	88.5	80.7%
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 6.791, d.f. = 1, sig. = 0.009: 0% of cells expected count < 5.

Use of grass headlands

Variable	If use grass headlands	N	Mean	Std. Deviation	Std. Error	Sig. level
Proportion of total income from farm	No	9	24.8	36.06	12.02	.043
	Yes	107	50.7	36.60	3.54	
	Total	116	48.7	37.06	3.44	
Rural development scale – viable agriculture [a]	No	12	3.2	1.26	.36	.001
	Yes	118	4.0	.80	.07	
	Total	130	3.9	.88	.08	
Goal scale – build business [a]	No	14	3.5	1.28	.34	.008
	Yes	130	4.3	1.01	.09	
	Total	144	4.2	1.06	.09	
Vegetation scale – timber [b]	No	8	-.8	1.13	.40	.032
	Yes	79	.0	1.05	.12	
	Total	87	.0	1.08	.12	
Information scale – enterprise information [a]	No	12	2.0	1.13	.33	.010
	Yes	120	2.9	1.11	.10	
	Total	132	2.8	1.13	.10	
Information scale – environment groups [a]	No	14	1.7	1.36	.36	.028
	Yes	129	2.6	1.34	.12	
	Total	143	2.5	1.36	.11	
Trust scale – productivity groups [c]	No	9	1.5	.73	.24	.050
	Yes	86	2.0	.71	.08	
	Total	95	1.9	.72	.07	
Trust scale – neighbours [c]	No	13	2.0	.82	.23	.037
	Yes	127	2.4	.56	.05	
	Total	140	2.3	.59	.05	
Proportion of property used for cropping	No	14	15.4	31.85	8.51	.004
	Yes	134	50.6	44.25	3.82	
	Total	148	47.3	44.37	3.65	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

[c] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

If use grass headlands	Location class (%)		Total (%)
	Upland	Lowland	
No	23.1	4.6	9.5
Yes	76.9	95.4	90.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 11.316, d.f. = 1, sig. = 0.001: 25% of cells expected count < 5.

Use of earthworks to control soil movement

Variable	If use earthworks to control soil movement	N	Mean	Std. Deviation	Std. Error	Sig. level
Average hours worked on property per week (hours)	No	29	34.72	26.317	4.887	.015
	Yes	116	46.73	22.641	2.102	
	Total	145	44.33	23.818	1.978	
Proportion of total income from farm	No	28	31.39	37.348	7.058	.005
	Yes	91	53.34	35.323	3.703	
	Total	119	48.18	36.854	3.378	
Time lived in local district	No	30	29.87	23.471	4.285	.002
	Yes	116	43.44	20.379	1.892	
	Total	146	40.65	21.676	1.794	
Time lived on current property	No	30	21.67	18.689	3.412	.047
	Yes	115	29.94	20.495	1.911	
	Total	145	28.23	20.352	1.690	
Number of people that live on property	No	30	2.53	2.763	.505	.028
	Yes	115	3.90	3.069	.286	
	Total	145	3.62	3.051	.253	
Property scale – environmental health [a]	No	25	1.6400	.85440	.17088	.026
	Yes	99	1.2586	.73137	.07351	
	Total	124	1.3355	.76956	.06911	
Rural development scale – viable agriculture [a]	No	27	3.4362	1.11662	.21489	.001
	Yes	104	4.0534	.75645	.07418	
	Total	131	3.9262	.87496	.07645	
Goal scale – build business [a]	No	31	3.7634	1.21242	.21776	.005
	Yes	114	4.3582	.96120	.09002	
	Total	145	4.2310	1.04457	.08675	
Intention scale – expand business [b]	No	29	-.7816	1.06635	.19802	.009
	Yes	113	-.2065	1.03540	.09740	
	Total	142	-.3239	1.06373	.08927	

Variable	If use earthworks to control soil movement	N	Mean	Std. Deviation	Std. Error	Sig. level
Vegetation scale – timber [b]	No	18	-.5556	1.01299	.23876	.010
	Yes	74	.1622	1.03734	.12059	
	Total	92	.0217	1.06625	.11116	
Information scale – enterprise information [a]	No	27	2.2407	.98115	.18882	.004
	Yes	106	2.9269	1.11067	.10788	
	Total	133	2.7876	1.11697	.09685	
Information scale – finance and family [a]	No	30	3.1667	1.19202	.21763	.042
	Yes	111	3.6072	.99815	.09474	
	Total	141	3.5135	1.05351	.08872	
Information scale – environment groups [a]	No	31	1.8495	1.23780	.22231	.005
	Yes	113	2.6136	1.33969	.12603	
	Total	144	2.4491	1.35146	.11262	
Proportion of property used for cropping	No	32	23.9590	39.12350	6.91612	.001
	Yes	118	53.0715	43.49282	4.00384	
	Total	150	46.8608	44.12503	3.60279	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

If use earthworks to control soil movement	Location class (%)		Total (%)
	Upland	Lowland	
No	35.0	15.7	20.9
Yes	65.0	84.3	79.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 6.538, d.f. = 1, sig. = 0.011: 0% of cells expected count < 5.

If use earthworks to control soil movement	Total farm area size class (%)						Total (%)
	Less than 20 ha	20-49 ha	50-99 ha	100-199 ha	200-499 ha	More than 500 ha	
No	39.1	37.5	25.0	12.5	11.1	10.0	21.6
Yes	60.9	62.5	75.0	87.5	88.9	90.0	78.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 11.277, d.f. = 5, sig. = 0.046: 25% of cells expected count < 5.

If use earthworks to control soil movement	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	32.4	11.0	21.5
Yes	67.6	89.0	78.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.790, d.f. = 1, sig. = 0.002: 0% of cells expected count < 5.

If use earthworks to control soil movement	Gender (%)		Total (%)
	Female	Male	
No	32.4	11.0	21.5
Yes	67.6	89.0	78.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.790, d.f. = 1, sig. = 0.002: 0% of cells expected count < 5.

If use earthworks to control soil movement	If attended short course(s) (%)		Total (%)
	No	Yes	
No	30.0	12.8	20.9
Yes	70.0	87.2	79.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 6.575, d.f. = 1, sig. = 0.010: 0% of cells expected count < 5.

If use earthworks to control soil movement	If made a profit in 2006/2007 (%)		Total (%)
	No	Yes	
No	27.7	12.8	19.6
Yes	72.3	87.2	80.4
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 4.980, d.f. = 1, sig. = 0.026: 0% of cells expected count < 5.

Fencing of native vegetation by graziers

Variable	If fence native vegetation from stock	N	Mean	Std. Deviation	Std. Error	Sig. level
Proportion of total income from farm	No	50	31.0	36.55	5.17	0.013
	Yes	31	53.0	40.18	7.22	
	Total	81	39.4	39.24	4.36	
Number of people who are supported by farm	No	57	2.1	2.43	0.32	0.039
	Yes	40	5.1	10.35	1.64	
	Total	97	3.4	7.01	0.71	
Information scale – enterprise information [a]	No	56	2.0	1.40	0.19	0.008
	Yes	40	2.7	1.08	0.17	
	Total	96	2.3	1.32	0.13	
Vegetation scale – management information [b]	No	37	0.0	0.65	0.11	0.003
	Yes	37	0.5	0.71	0.12	
	Total	74	0.2	0.72	0.08	
Information scale – environment groups [a]	No	57	1.8	1.33	0.18	0.002
	Yes	43	2.7	1.33	0.20	
	Total	100	2.2	1.39	0.14	
Information scale – media sources [a]	No	58	2.9	1.25	0.16	0.016
	Yes	41	3.5	0.96	0.15	
	Total	99	3.2	1.17	0.12	
Trust scale – productivity groups [c]	No	22	1.5	0.70	0.15	0.037
	Yes	25	1.9	0.68	0.14	
	Total	47	1.7	0.72	0.10	

[a] Scale scores range from 0 = ‘Not important or useful’ to 5 = ‘Very important or useful’.

[b] Scale scores range from -2 = ‘Strongly disagree’ to 2 = ‘Strongly agree’.

[c] Scale scores range from 1 = ‘Low trust’ to 3 = ‘High trust’.

If fence native vegetation from stock	Location class (%)		Total (%)
	Upland	Lowland	
No	69.2	40.5	58.8
Yes	30.8	59.5	41.2
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 8.013, d.f. = 1, sig. = 0.005: 0% of cells expected count < 5.

If fence native vegetation from stock	If use native forest areas for recreation (%)		Total (%)
	No	Yes	
No	63.4	35.3	50.7
Yes	36.6	64.7	49.3
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 5.880, d.f. = 1, sig. = 0.014: 0% of cells expected count < 5.

If fence native vegetation from stock	Native vegetation – road maintenance (%)		Total (%)
	No	Yes	
No	75.9	38.1	53.5
Yes	24.1	61.9	46.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.836, d.f. = 1, sig. = 0.002: 0% of cells expected count < 5.

Fencing of waterways by graziers

Variable	If fence waterways from stock	N	Mean	Std. Deviation	Std. Error	Sig. level
Rural development scale – viable agriculture [a]	No	34	3.2	1.27	0.22	0.026
	Yes	60	3.7	0.83	0.11	
	Total	94	3.5	1.03	0.11	
Goal scale – build business [a]	No	42	3.4	1.62	0.25	0.049
	Yes	73	3.9	1.14	0.13	
	Total	115	3.7	1.35	0.13	
Intention scale – sell property [b]	No	45	-0.9	1.01	0.15	0.012
	Yes	71	-0.4	1.13	0.13	
	Total	116	-0.6	1.11	0.10	
Vegetation scale – management difficulties [b]	No	27	0.4	0.72	0.14	0.029
	Yes	54	0.7	0.66	0.09	
	Total	81	0.6	0.70	0.08	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

If fence waterways from stock	Total grazing area size class (%)						Total (%)
	Less than 20 ha	20-49 ha	50-99 ha	100-199 ha	200-499 ha	More than 500 ha	
No	45.7	25.0	10.5	36.8	55.6	62.5	36.8
Yes	54.3	75.0	89.5	63.2	44.4	37.5	63.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 11.427, d.f. = 5, sig. = 0.044: 16.7% of cells expected count < 5.

If fence waterways from stock	Industry group (%)					Total (%)
	None	Once a year or less	A few times a year	Every month or two	Weekly	
No	39.4	77.8	42.9	17.6	-	39.5
Yes	60.6	22.2	57.1	82.4	100.0	60.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 9.670, d.f. = 4, sig. = 0.046: 30% of cells expected count < 5.

Adoption of soil testing by graziers

Variable	If conduct soil testing	N	Mean	Std. Deviation	Std. Error	Sig. level
Average per week (hours)	No	43	30.1	26.83	4.09	0.015
	Yes	64	42.0	22.73	2.84	
	Total	107	37.2	25.04	2.42	
Proportion of total income from farm	No	42	21.0	33.05	5.10	0.002
	Yes	49	45.8	39.68	5.67	
	Total	91	34.4	38.62	4.05	
Number of people supported by property	No	49	1.2	1.86	0.27	0.008
	Yes	62	4.6	8.51	1.08	
	Total	111	3.1	6.67	0.63	
Rural development scale – viable agriculture [a]	No	38	3.1	1.21	0.20	0.001
	Yes	56	3.8	0.82	0.11	
	Total	94	3.5	1.05	0.11	
Goal scale – build business [a]	No	48	3.2	1.52	0.22	0.000
	Yes	66	4.1	1.10	0.14	
	Total	114	3.7	1.36	0.13	
Goal scale – improve environment [a]	No	48	3.7	1.09	0.16	0.039
	Yes	67	4.0	0.85	0.10	
	Total	115	3.9	0.97	0.09	
Intention scale – expand business [b]	No	45	-0.8	1.16	0.17	0.012
	Yes	69	-0.2	1.11	0.13	
	Total	114	-0.4	1.16	0.11	
Vegetation scale – management information [b]	No	38	0.0	0.74	0.12	0.003
	Yes	48	0.5	0.69	0.10	
	Total	86	0.3	0.75	0.08	
Vegetation scale – timber [b]	No	39	-0.4	1.09	0.17	0.003
	Yes	47	0.3	0.99	0.14	
	Total	86	-0.1	1.08	0.12	
Information scale – enterprise information [a]	No	48	1.6	1.32	0.19	0.000
	Yes	63	2.7	1.21	0.15	
	Total	111	2.2	1.36	0.13	
Information scale – finance and family [a]	No	48	3.0	1.36	0.20	0.024
	Yes	65	3.5	1.05	0.13	
	Total	113	3.3	1.21	0.11	
Information scale – environment groups [a]	No	49	1.9	1.50	0.21	0.031
	Yes	67	2.4	1.31	0.16	
	Total	116	2.2	1.42	0.13	
Trust scale – productivity	No	20	1.3	0.74	0.17	0.005

Variable	If conduct soil testing	N	Mean	Std. Deviation	Std. Error	Sig. level
groups [c]	Yes	37	1.9	0.64	0.11	
	Total	57	1.7	0.72	0.10	

[a] Scale scores range from 0 = 'Not important or useful' to 5 = 'Very important or useful'.

[b] Scale scores range from -2 = 'Strongly disagree' to 2 = 'Strongly agree'.

[c] Scale scores range from 1 = 'Low trust' to 3 = 'High trust'.

If conduct soil testing	Total grazing area size class (%)						Total (%)
	Less than 20 ha	20-49 ha	50-99 ha	100-199 ha	200-499 ha	More than 500 ha	
No	65.7	37.5	31.6	10.5	33.3	28.6	40.0
Yes	34.3	62.5	68.4	89.5	66.7	71.4	60.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 17.671, d.f. = 5, sig. = 0.003: 25% of cells expected count < 5.

If conduct soil testing	Property or business plan preparation (%)		Total (%)
	No	Yes or in progress	
No	53.9	14.6	40.2
Yes	46.1	85.4	59.8
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 17.126, d.f. = 1, sig. = 0.000: 0% of cells expected count < 5.

If conduct soil testing	If attended short course(s) (%)		Total (%)
	No	Yes	
No	49.3	27.9	41.5
Yes	50.7	72.1	58.5
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 5.167, d.f. = 1, sig. = 0.023: 0% of cells expected count < 5.

If conduct soil testing	If have income from off-farm (%)		Total (%)
	No	Yes	
No	25.8	47.7	41.9
Yes	74.2	52.3	58.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 4.477, d.f. = 1, sig. = 0.034: 0% of cells expected count < 5.

If conduct soil testing	If made profit 2006/7 (%)		Total (%)
	No	Yes	
No	50.0	27.9	41.9
Yes	50.0	72.1	58.1
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 5.454, d.f. = 1, sig. = 0.020: 0% of cells expected count < 5.

If conduct soil testing	If involved in Government NRM program in the last five years (%)		Total (%)
	No	Yes	
No	48.9	19.0	43.4
Yes	51.1	81.0	56.6
Total	**100.0**	**100.0**	**100.0**

Pearson's chi-square = 6.209, d.f. = 1, sig. = 0.013: 0% of cells expected count < 5.

Part B:
Development of Bayesian Belief Network models linking the characteristics and circumstances of North Queensland landholders to their adoption of recommended land management practices

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Acronyms Used In This Report

BBN.....Bayesian Belief Network
CRP.....Currently Recommended Practice
DERM.....Department of Envrionment and Resource Management (Queensland)
NRM .....Natural Resource Management
NTFP.....Non-timber forest product

Introduction

Currently recommended land management practices (CRPs) have been developed by the Queensland Department of Environment and Resource Management (DERM) as pivotal to enhancing the quality of land and water resources in the Wet Tropics region of far northern Queensland. This paper complements the report by Emtage *et al.* (Part A, this document), in which data analysis and modelling processes examining the adoption of land management practices are described. The analyses utilised data obtained from a survey of rural landholders (Emtage and Reghenzani 2008) which ascertained the characteristics of landowners' properties, their financial circumstances, demographics, information sources, attitudes, land management practices, motivations and other social data. Models were developed to assemble the data in ways meaningful to the design of policy interventions aimed at increasing landholder adoption of the CRPs.

This section, Part B, reviews the modelling presented in the earlier report, describes the development of further models and discusses the implications of their output to policy development.

Objectives

The objective of this project was to identify and quantify the influence of variables associated with the adoption of currently recommended land management practices.

The objective was achieved by utilising data concerning key variables obtained in the survey of rural landholders[6]. Knowledge of drivers of CRP adoption can be used to help design policies and programs to influence landholders' land management, thus influencing the condition of the region's natural resources.

The research questions addressed in this report are:

- What are the key social, economic and psychological factors influencing the adoption of currently recommended practices by rural landholders?
- Are Bayesian Belief Networks useful in the assessment and interpretation of the influence of these factors?

Flow structure of the analysis

Selected landholder variables associated with CRP adoption were identified from statistical tests on data collected from the survey of landholders in the Wet Tropics region and from the researchers' understanding of CRP adoption in the region. The roles of the variables in 'driving' the adoption of CRPs were modelled. The modelled relationships were analysed, with a view to obtaining insights useful to the shaping of policies to enhance land and water quality in the region.

Building on the modelling described by Emtage *et al.* (2009) (Part A – this document), three model structure templates were developed that focus attention on:

- Providing a sound appreciation of the scope of the factors associated with CRP adoption;
- Understanding the possible role of antecedent practices as precursors to adoption of land management practices; and
- Possible intervention points to influence adoption of CRPs.

Survey data and their statistical testing

The survey of rural landholders reported by Emtage and Reghenzani (2008) obtained data on landowners' biophysical and socio-economic characteristics and their adoption of key CRPs. These data were analysed using:

- Tests of correlation between continuous variables and the adoption of CRPs;
- Chi-square (Pearson's statistic) tests of relationships between categorical variables and the adoption of CRPs; and
- Discriminant and multiple regression analyses.

The tests identified characteristics having significant associations with CRP adoption. Table 1 presents the key variables and their associated CRPs, with the factors used in model

[6] A description of the basic survey design and responses are described in Emtage and Reghenzani (2008). Further description of subsequent analyses of the responses is provided in Emtage and Herbohn (2009).

development highlighted. Other factors (also highlighted) were included because they are known by the researchers to be associated with landowner behaviour, or because they are possible points for policy intervention.

Model development

Models were developed to understand better the modus operandi by which landowner characteristics and circumstances relate to CRP adoption. Model structures were developed that met the criteria of:

- Recognising the statistical relationships between the surveyed factors;
- Being consistent with relationships known through personal understanding of the situation to exist;
- Being consistent with the spread of data obtained in the landholder survey (i.e. without gaps capable of detracting from the models' veracity); and
- Directing attention to areas helpful to the development of effective policy interventions

The CRPs chosen for the modelling described in this report were categorised into two kinds:

1. Practices antecedent to the adoption of 'on-ground' practices

- The development of a formal property management plan;
- Participation in government-sponsored natural resource management programs; and
- Attendance at short courses related to land management.

  (Landholder participation in these activities does not in itself represent changes to land management practices, but may be precursors to adoption of the physical, on-ground CRPs.)

2. On-ground land management practices:

- Encouragement of native vegetation regrowth – a practice that can be adopted by all landholders regardless of the use they make of the land;
- The use of soil testing by crop growers to determine fertiliser requirements; and
- The use of legume rotations by crop growers.

  (These are examples of physical land management practices recommended by the DERM as likely to lead to improved natural resource outcomes for the region. Figure 1 illustrates the manner in which the modelling and analyses are structured.)

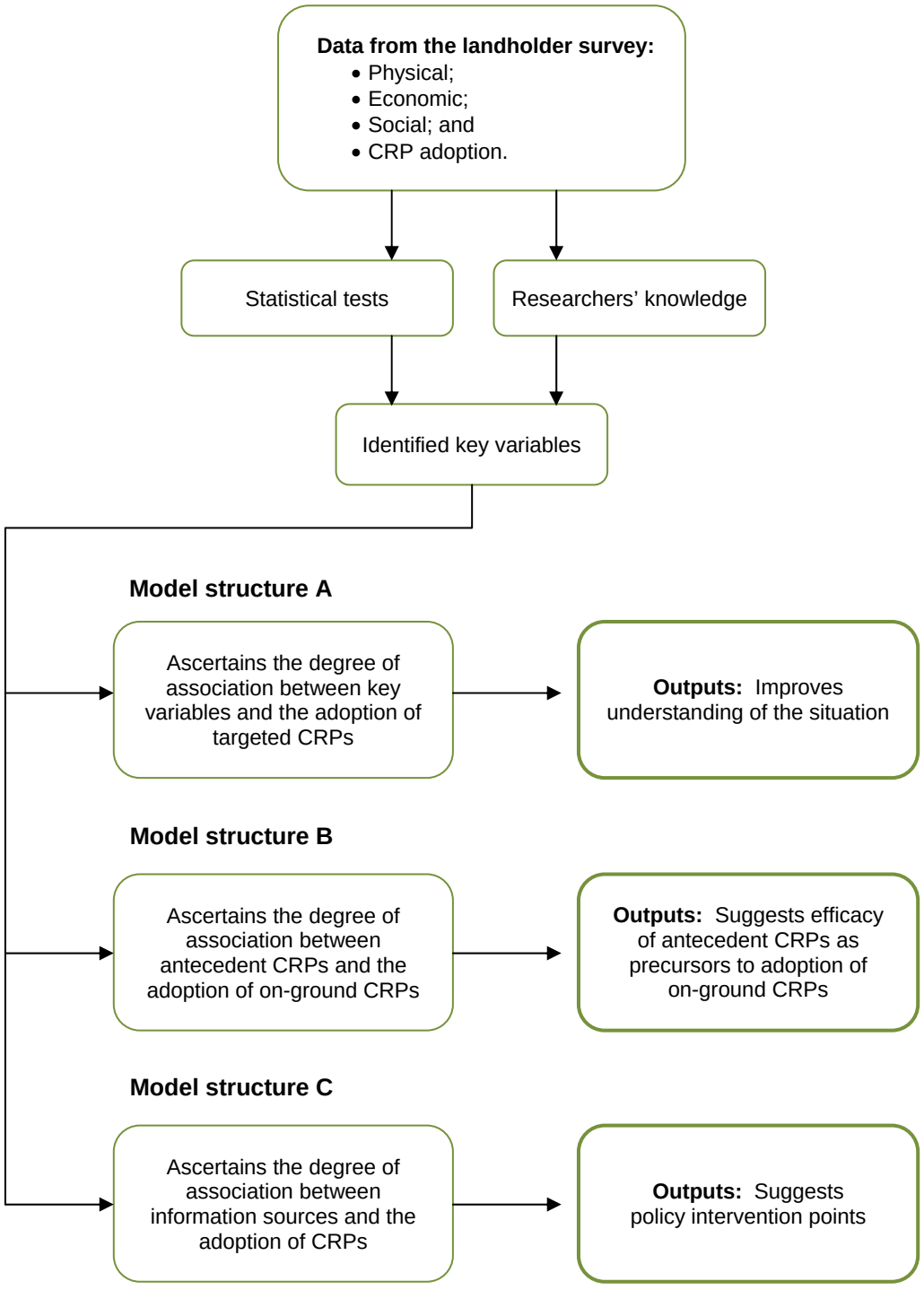

Figure 1: Overview of model structures and analyses.

Table 1: Landholder variables statistically associated with the adoption of CRPs. All variables included in the models described in this report are highlighted.

	The currently recommended practices targeted in this report:					
	Undertake property planning	Participation in NRM programs	Participation in short courses	Encourage regrowth of native veg.	Soil testing by croppers	Use legume rotations
	Significance levels of relationship to CRPs or designated *sig. 0.050 – 0.010; **sig. 0.010 – 0.001; ***sig. < 0.001.					
Variables associated with the physical landholding and its economic performance						
Location	***	**	***		***	
Total property size	***	***	included	**		***
Land use type	***	***	***	*	***	
Proportion of property under native vegetation		0.007	0.000	included		0.017
Proportion of property cropped		0.000	0.000		included	0.036
Proportion of income from farm	0.000	0.000	0.000		0.000	0.000
If profitable 2004/2005	***	**	***		***	
Number of people supported by the property		0.000	0.000		0.018	0.031
Property scale – Its environmental health				0.000		
Variables associated with the landholders' personal attitudes and characteristics						
Primary purpose for land ownership	***	**	***	**	***	
Number of people residing on property		0.000	0.000		0.011	
Average hours per week worked on farm		0.000	0.000		0.000	0.000
Time lived in local district		0.003	0.000		0.000	0.000
Whether resident on the property		0.001	0.000		0.000	0.001
Goal scale – Improve environment	0.001	0.010	0.008			0.000
Goal scale – Build business	0.000	0.005	0.000	0.041	0.000	0.000
Information scale – Enterprise information	0.000	0.000	0.000		0.000	0.000
Information scale – Environment groups		0.000	0.000	0.003	0.013	0.000
Information scale – Finance and family	0.000	0.000	0.000		0.001	0.000
Industry group involvement		**	***	included	**	included
Involvement in local Landcare group	**	***	**	included	included	included
Composite measure of landholders' involvement with social groups, e.g. emergency services, catchment management, church, lobby groups, civic groups	**		*	included	included	included
	**	***	**			
			**			
	*					
	**					
Rural development scale – Viable agriculture	0.000	0.002	0.000		0.000	0.002
Rural development scale – Decline in services				0.000		
Formal education level				**	*	
Gender	**	***	***			
Use native vegetation areas for recreation				*		
Landholder participation associated with the adoption of CRPs						
Short course attendance	***	***	self	Included	***	**
If have property or business plan	-	***	***	*	***	**
Involvement in NRM programs	***	-		*	***	**

Choice of modelling framework and sequence of analyses

In order to extract meaningful information from a set of data, it was necessary for the chosen analysis process to be capable of accommodating the peculiarities of the data. The dataset obtained in the survey of landholders exhibits the following distinctive characteristics:

- Multidisciplinary subjects, e.g. physical property-based data, economic performance data, attitudinal data, social data;
- Multiple data types associated with the disciplines – continuous, categorical, coarse and fine data;
- Data of variable specificity and completeness; and
- Probabilistic relationships between the associated factors and CRP outcomes – as opposed to certainty.

In addition, output from the analysis should be capable of guiding decision-making. Hence, the ability to model scenarios would be valuable, as would its intuitiveness, transparency, and simplicity.

Bayesian Belief Network (BBN) models were chosen as an analytical and decision-making framework because they explicitly accommodate uncertainty, can handle multidisciplinary data, suit the decision-making process and can be updated. Three model structures were developed, with output analysed as illustrated in Figure 2.

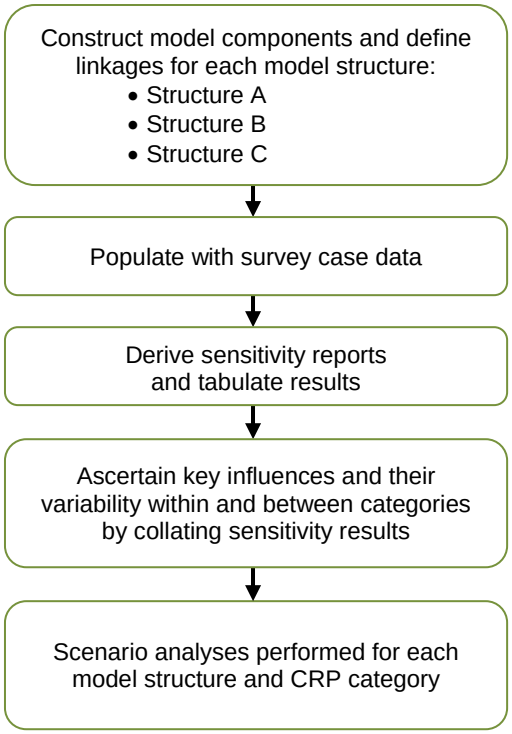

Figure 2: Outline of model analyses.

Model structure A

The structure shown in Figure 3 utilises a selection of variables identified through statistical associations and the researchers' understanding to be relevant to the adoption of CRPs. The number of variables was kept low to avoid gaps occurring in the informing dataset (and the possible consequent erratic and erroneous model performance). Inter-relationships between factors are shown by the various arrowed linkages.

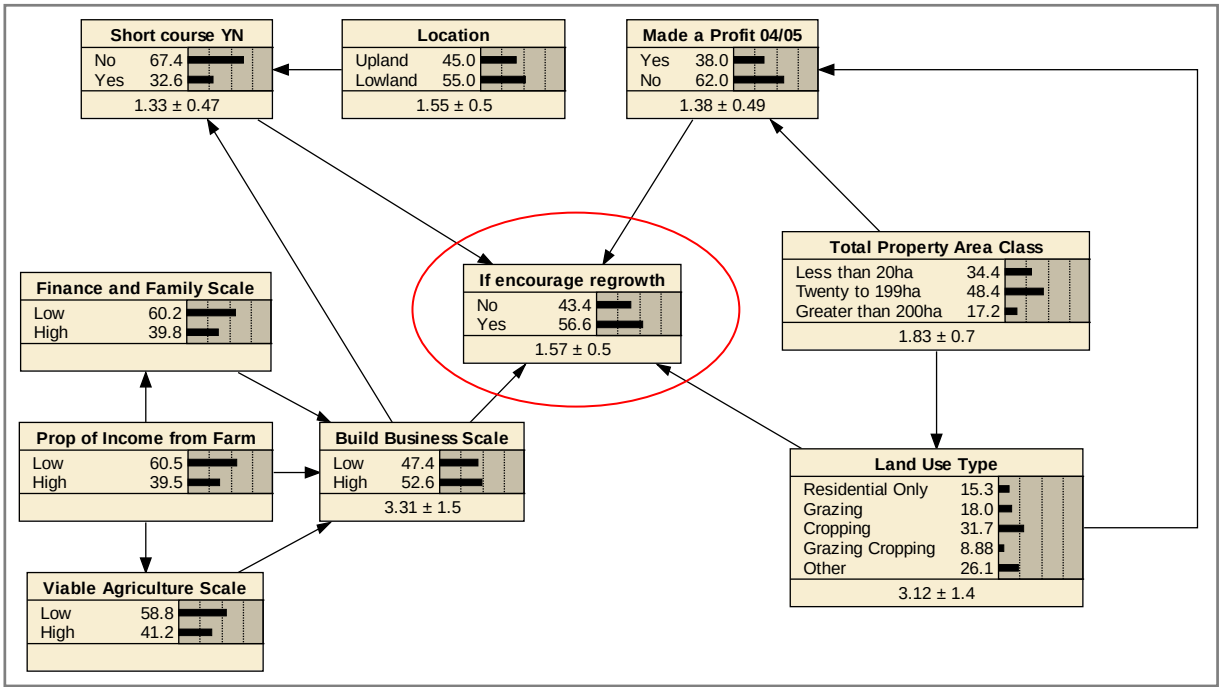

Figure 3: Model structure A with the targeted CRP circled.

Separate models were developed for each of the three antecedent CRPs and the three on-ground CRPs. The same model components and structure were retained in order to better identify common drivers of CRP adoption.

Sensitivity tests were used to ascertain the influence of individual contributing variables on the adoption of each CRP. The aggregate influence of the various characteristics and circumstances was then compiled for all of the CRPs. The results were tabulated and graphed to represent visually the patterns of influence on CRP adoption that may exist.

Model structure B

The second structure links the three antecedent practices as parent 'drivers' to the adoption of on-ground land management practices. The role of the antecedent factors (short course attendance, property planning, and NRM program participation) was modelled because their role as possible precursors to adoption may help identify policy intervention points aimed at achieving greater uptake of the on-ground practices. The factors 'proportion of land cropped' and 'proportion of native vegetation' were included where appropriate. Separate models were developed for each of the three on-ground land management practices. The same antecedent variables were retained for each CRP in order to better ascertain the efficacy and consistency of their influence. The structure is a simple converging causal network as shown in Figure 4.

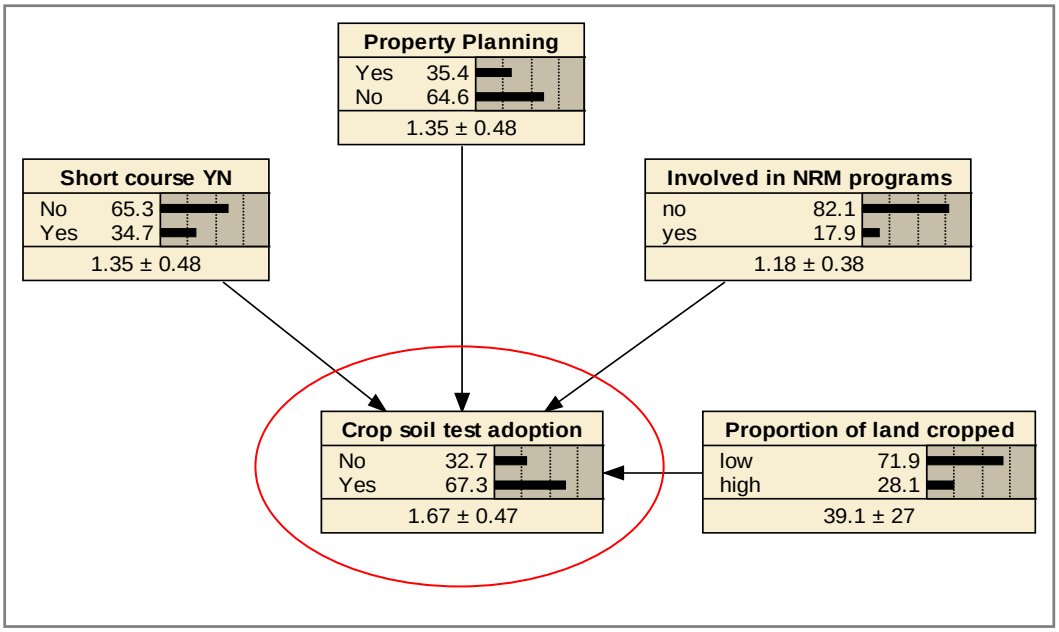

Figure 4: Model structure B with the targeted CRP circled.

Sensitivity tests were used to ascertain the influence of the parent variables on the adoption of on-ground CRPs. The influence of the antecedents was then aggregated across the CRP categories. Results of the sensitivity reports were then tabulated and graphed to represent visually the patterns of influence that may exist.

Scenario analyses were conducted to ascertain the efficacy of each driver of CRP adoption, and of synergies between the factors.

Model structure C

The third structure seeks to identify the role of information sources and social groups in shaping land management behaviour. An understanding of the factors that shape adoption of CRPs may suggest possible policy intervention points. The same model components were retained in order to provide a consistent basis for determining their role. The structure is a simple converging causal network as shown in Figure 5.

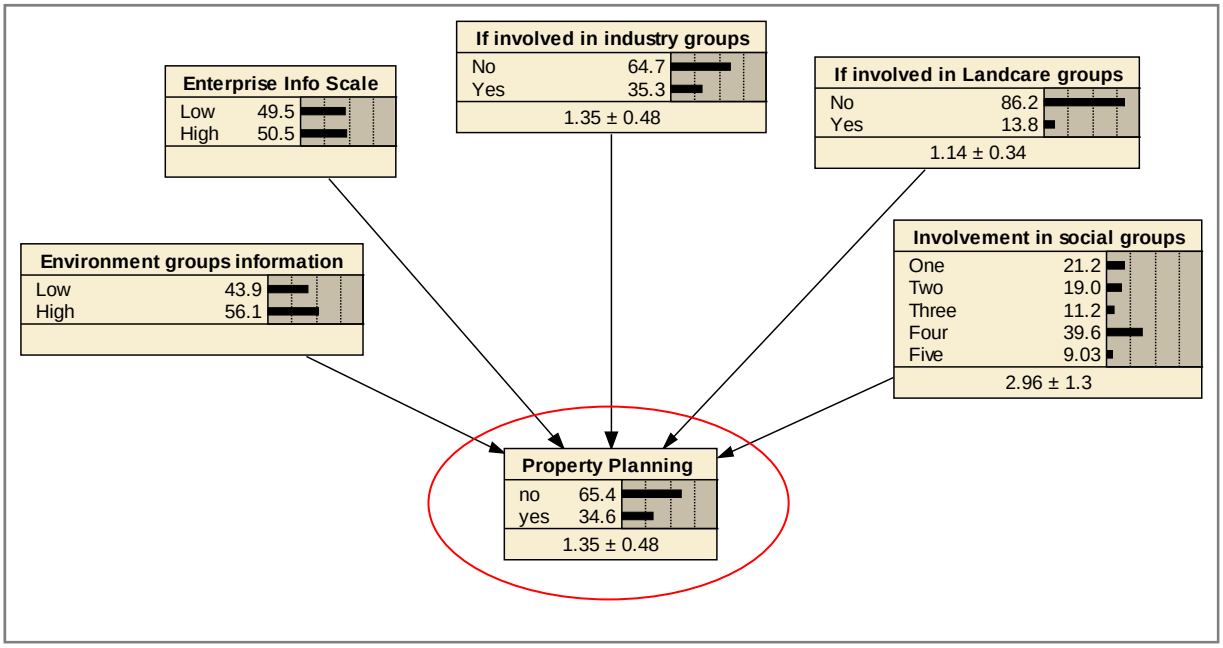

Figure 5: Model structure C with the targeted CRP circled.

Sensitivity tests were used to derive the influence of individual contributing variables on the adoption of each CRP. The influence of the various modelled information and group variables was then aggregated across the CRP categories, identifying their degree of influence on CRP adoption outcomes. Results of the sensitivity reports were also tabulated and graphed to represent visually any patterns of influence that may exist.

Table 2 summarises the application of model structures to the categories of CRPs, the nature of the model's output, and the possible use of the output.

Table 2: Inter-relationships between variables, CRPs, model structure and model output.

The modelled CRP category, model output and utility	The parent variables modelled (the 'drivers')		
	Physical, economic and social factors	**Antecedent CRPs**	**Information sources and group affiliations**
Antecedent CRPs	Structure A	N/A	Structure C
On-ground CRPs	Structure A	Structure B	Structure C
Nature of model output	Identifies a range of characteristics and circumstances associated with adopters and non-adopters	Identifies linkages between antecedents and on-ground CRPs	Identifies the sources of influence associated with CRP adoption
Utility of model output	Improves understanding by identifying the range of factors relevant to CRP adoption	Guides policy by identifying the efficacy of the antecedent CRPs as precursors to on-ground CRP adoption	Suggests possible intervention points to achieve adoption of both antecedent and on-ground CRPs

Results

Model structure and output from each of three approaches are now described, commencing with the influence of a broad range of factors, the role of antecedent activities on adoption of physical CRPs, and concluding with an assessment of the role of information sources and social group involvement on CRP adoption.

Model structure A: General factors that shape the adoption of antecedent CRPs

Property planning

The survey results described by Emtage and Reghenzani (2008) show that approximately 35% of respondents have completed or commenced a property plan. Statistical tests of relationship show that the principal landholding and economic circumstances associated with those who have undertaken property planning compared with those who have not, are a tendency to:

- Have a larger sized property;
- Have a higher degree of reliance on their properties to provide household income;
- Be more profitable;
- Be located on the coastal plains of the region compared to the highland areas;
- Have a land type more suited to agriculture.

Differentiating social, attitudinal and behavioural characteristics were:

- More concern regarding the future viability of agriculture in the region;
- A greater interest in building business and improving the environment;
- More concern about the continued viability of agricultural enterprises;
- Greater interest in obtaining information from ‘enterprise’ sources;
- Greater interest in obtaining information from ‘finance and family’ sources;
- More involvement in social groups (including civic groups, emergency services organisations, catchment management groups, industry organisations and lobby groups);
- Greater participation in short courses (training regarding land and water management);
- Greater involvement in publicly funded Natural Resource Management (NRM) programs; and
- Greater interest in obtaining information from ‘media’ sources.

Less significant associations included:

- Greater confidence in their capacity to manage native vegetation, sustainably producing timber on their property;
- More interest in clearing some vegetation; and
- Greater trust of ‘productivity groups’.

Respondents who adopted property planning were also more likely to have attended short courses and participated in NRM programs.

Model development and structure

Although it is acknowledged that many factors are associated with adoption of the CRPs, only those identified as having the most meaningful causal relationships are included. Thus, the key factors were compiled into a Bayesian network structure 'A' as shown in Figure 6. In this model, four inter-related factors related to the landowners' goals (in the lower left section), and property location are represented as influencing the likelihood of short course attendance. The likelihood of property planning being undertaken is shown as being directly associated with short course attendance, the personal goal scale (build a business), and by the inter-related factors of property size, profitability, and land use type.

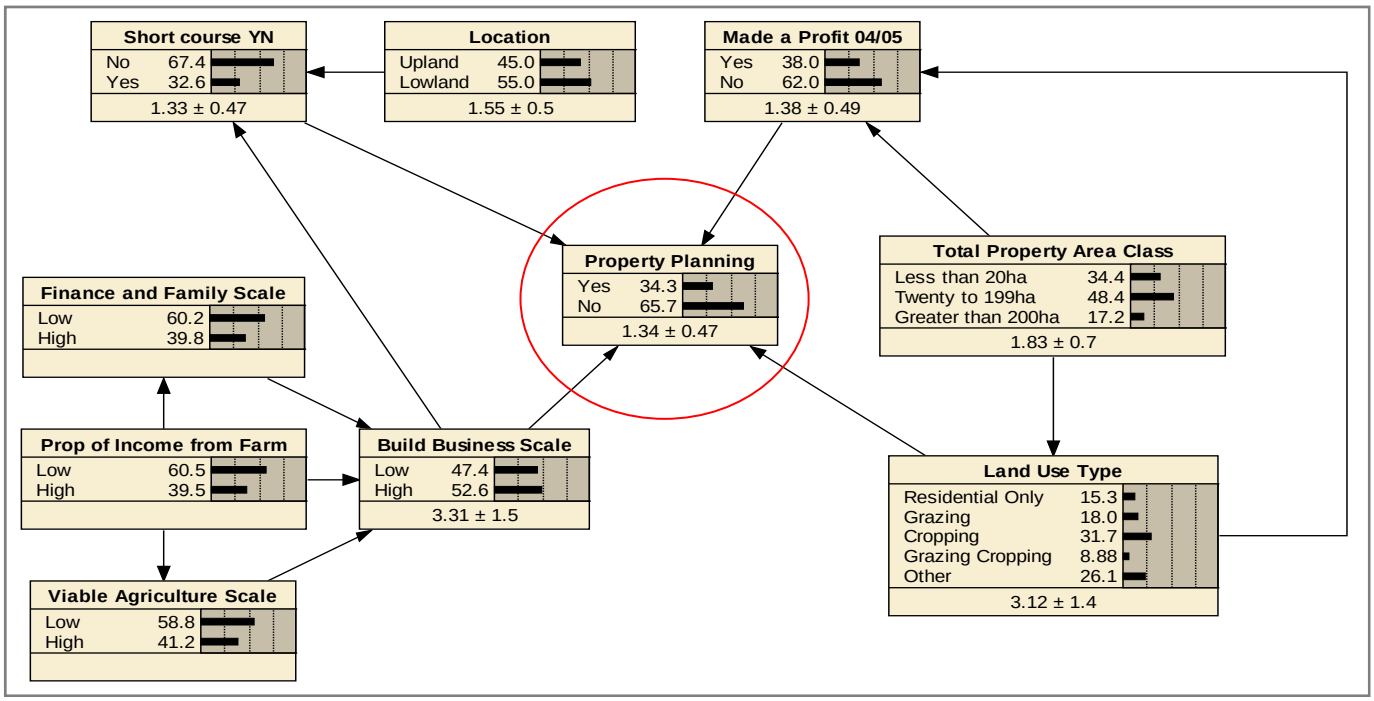

Figure 6: Model of factors influencing the adoption of property planning by landholders, with output CRP circled.

The strength of association found to exist between the parent landholder/property characteristics and the likelihood of property planning being undertaken is shown in Table 3. In this model, the adoption of property planning is seen to be associated strongly with attendance at short courses and with a high score on the landholder's goal of 'building the farm business'.

Table 3: Sensitivity of adoption of property planning to modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Property planning	0.225331	100.0%	
Short course attendance	0.025468	11.3%	32%
Goal scale – Build business	0.023968	10.6%	30%
If profitable in 2004/2005	0.007460	3.3%	9%
Proportion of income from property	0.006891	3.1%	9%
Concern with future viability of agriculture	0.004286	1.9%	5%
Land use type	0.003702	1.6%	5%
Information from 'finance and family' sources	0.003640	1.6%	5%
Property size	0.002283	1.0%	3%
Location	0.001563	0.7%	2%
Total	**0.079262**		**100%**

Model structure A, used here to model the adoption of property planning, was then applied to the two other practices considered antecedents (NRM program participation and short course attendance).

Participation in NRM programs

Emtage and Reghenzani (2008) described how approximately twenty percent of respondents have been involved in government NRM programs in the five years preceding the landholder survey. Differences between landholders who have and have not participated in NRM programs in the past were found regarding the following property and economic characteristics:

- Degree of dependence on the property for income;
- Proportion of the property used for cropping (lower);
- Proportion under native vegetation;
- Number of people supported by the property;
- Location;
- Profitability in 2004/2005;
- Land use type; and
- Property size.

Differences in personal and social characteristics between those who participated in NRM programs were based on:

- Viable agriculture scale;
- Goal scale – improve environment;
- Goal scale – build business;
- Information scale – enterprise information;
- Information scale – environment groups;
- Information scale – finance and family;
- Length of time lived in the district;
- Length of time lived on the current property;
- Hours worked per week;
- Number of people resident on the property;
- Primary purpose of ownership;
- Gender;
- Industry group involvement;
- Landcare group involvement; and
- Social group involvement.

Respondents who participated in NRM programs were also likely to have attended short courses related to land management and developed a property plan.

Model development and structure

Although it is acknowledged that many factors are associated with landholders' adoption of CRPs, only those identified as having the most meaningful causal relationships are included. Therefore the structural template used for modelling adoption of property planning was then applied to participation in NRM programs, as shown in Figure 7.

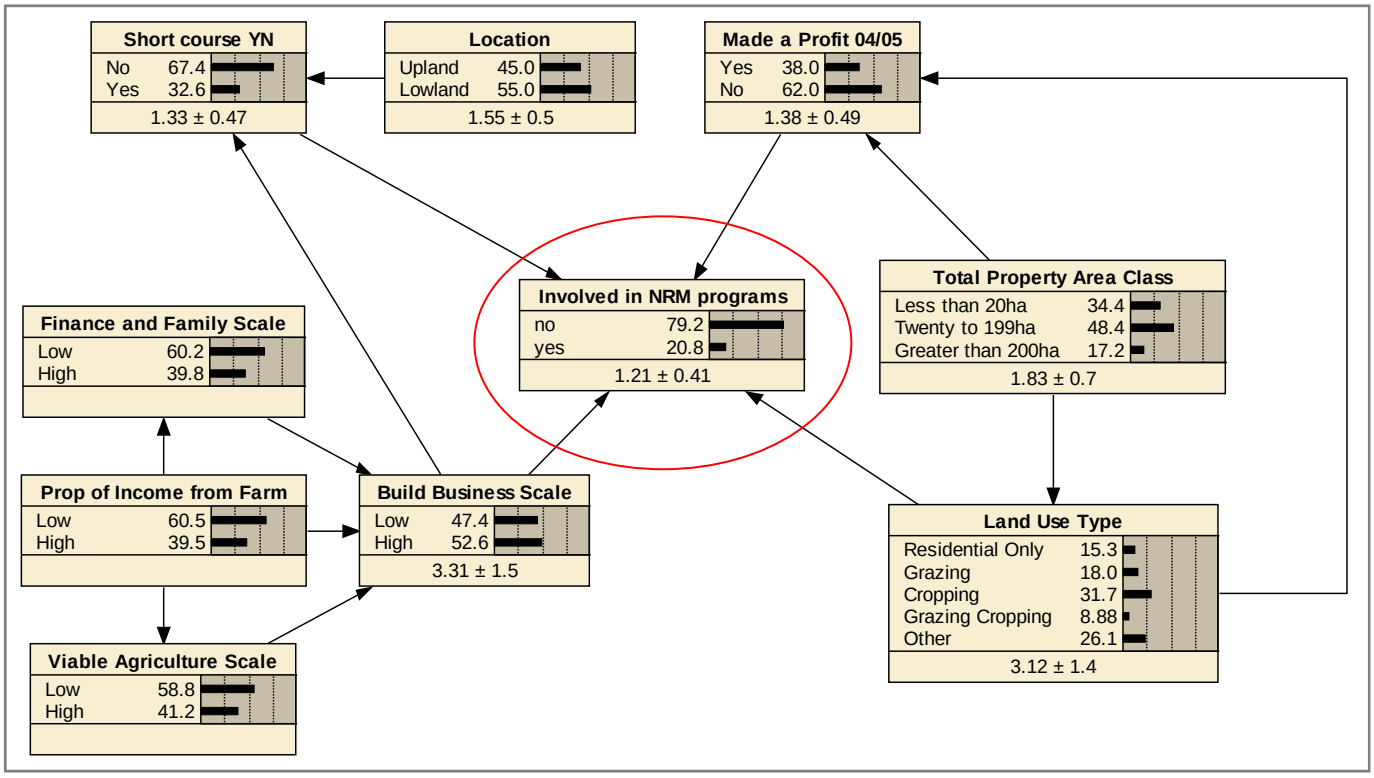

Figure 7: Model of factors influencing landholders' involvement in NRM programs, with output CRP circled.

The strength of association found to exist between the landholder/property characteristics and the likelihood of NRM program participation is shown in Table 4. Short course attendance and 'build a business' again rank highly, with 'land use type' listed next.

Table 4: Sensitivity of NRM program involvement to modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Involved in NRM programs	0.164487	100.0%	
Short course attendance	0.013073	7.9%	57%
Goal scale – build business	0.002756	1.7%	12%
Land use type	0.002366	1.4%	10%
If profitable in 2004/2005	0.001300	0.8%	6%
Location	0.001082	0.7%	5%
Property size	0.000796	0.5%	3%
Proportion of income from property	0.000792	0.5%	3%
Concern with future viability of agriculture	0.000493	0.3%	2%
Information 'finance and family' sources	0.000418	0.3%	2%
Total	**0.023075**		**100%**

The final model of antecedent adoption examines factors associated with short course participation.

Participation in short courses

Approximately 35% of respondents reported attending a short course relevant to land management within the five years preceding the landholder survey. Respondents who have and have not participated differ in a number of ways, including being or having:

- A larger area of land used for agricultural activities and a lower proportion under native vegetation;
- More reliance on the property for income, employing more people and working longer hours on their properties per week;
- A resident for longer periods of time on rural properties, in the local district and on their current property;
- More likely to be male;
- More likely to be making a profit;
- More likely to regularly attend either Landcare, industry, catchment, emergency services or church groups;
- Less likely to maintain tracks through their native forest areas or gather non-timber forest products (NTFPs) from these areas;
- More concern about the soil health and pests and weeds on their property;
- More likely to use legume rotations in their cropping activities;
- More concerned about the future viability of agriculture;
- More motivated to build their business and improve the environment;
- Greater motivation to clear native vegetation, more concern about the difficulties associated with vegetation management and more confidence they can sustainably produce timber from their property;
- More likely to find information from all sources as useful; and
- More trusting of ‘productivity’ groups.

Model development and structure

Although it is acknowledged that many factors are associated with adoption of the CRPs, only those identified as having the most meaningful causal relationships are included. The same variables used for modelling adoption of property planning and NRM program participation were therefore used for modelling short course participation, using Structure A as shown in Figure 8 (modified to the extent that short course participation already existed as a node in the previous models).

The strength of association found to exist between the landholder/property characteristics and short course attendance is shown in Table 5. Three variables stand out as most influential – land use type, farm profitability and property size as being associated most strongly with short course attendance.

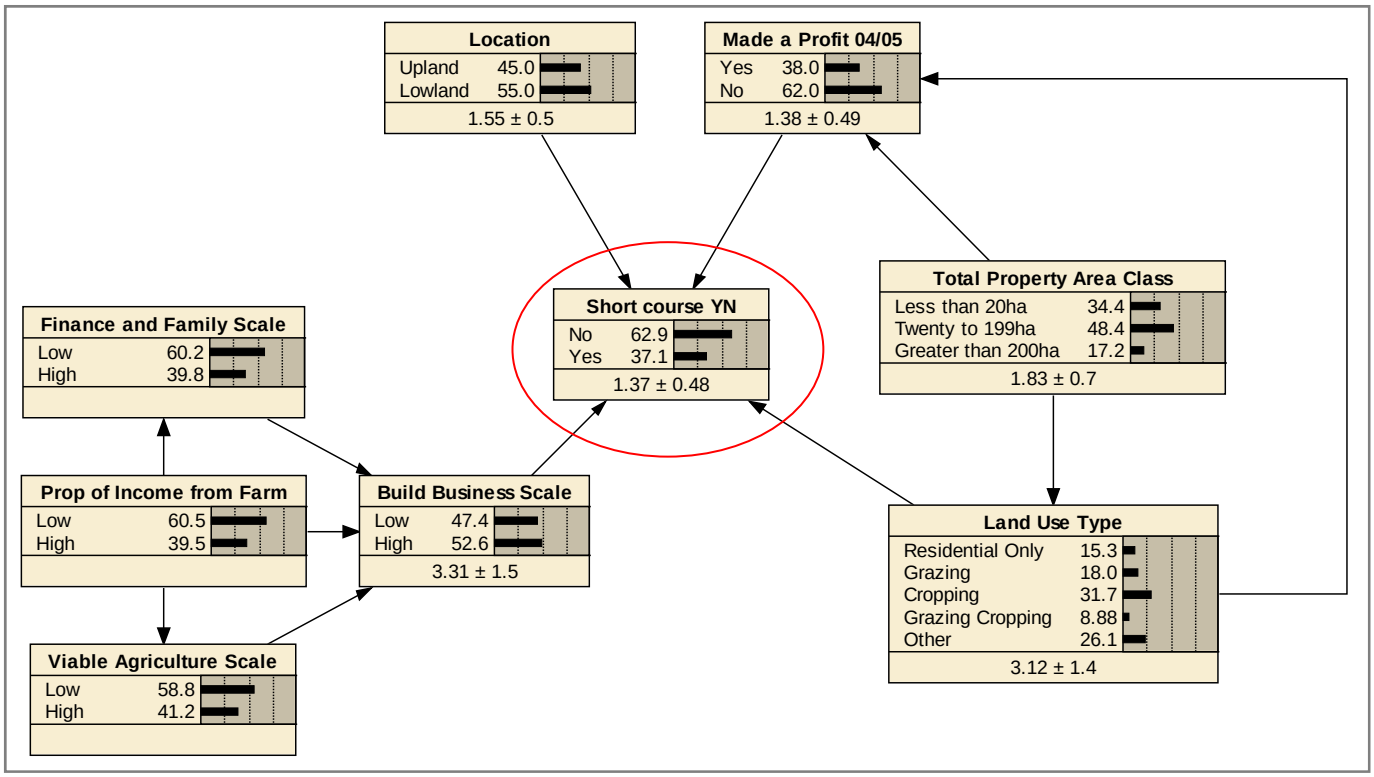

Figure 8: Model of factors influencing involvement in short courses, with output CRP circled.

Table 5: Sensitivity of short course attendance to modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Short course attendance	0.233451	100.0%	
Land use type	0.051229	21.9%	48%
If profitable in 2004/2005	0.031768	13.6%	30%
Property size	0.020496	8.8%	19%
Location	0.001199	0.5%	1%
Goal scale – build business	0.00071	0.3%	1%
Proportion of income from property	0.000204	0.1%	0%
Concern with future viability of agriculture	0.000127	0.1%	0%
Information from ‘finance and family’ sources	0.000108	0.0%	0%
Total	**0.105841**		**100%**

Summaries of sensitivity reports

Results from the analyses of the individual antecedent CRPs were compiled in rank order of total variance reduction as shown in Table 9. Intensity of shading corresponds to the strength of association between the variable and CRP adoption. Themes from this table and from scenario analyses are discussed subsequently.

Table 6: Proportion of influence in Structure A models ranked in order of total variance reduction.

Variable	Short course	NRM program	Property planning	Summed variance reduction
Land use type	**48%**	**10%**	5%	0.0572970
If profitable in 2004/2005	**30%**	6%	**9%**	0.0405285
Short course attendance*		**57%**	**32%**	0.0385412
Goal scale – build business	1%	**12%**	**30%**	0.0274335
Property size	**19%**	3%	3%	0.0235739
Proportion of income from property	0%	3%	**9%**	0.0078876
Concern with future viability of agriculture	0%	2%	5%	0.0049061
Information 'finance and family' sources	0%	2%	5%	0.0041659
Location	1%	5%	2%	0.0038441

* The summed influence of only two models.

The factors to which the adoption of antecedent CRPs are most responsive are land use type, profitability, short course attendance, 'build a business' goal scale and property size.

Scenario analysis

As a further method of testing the responsiveness of CRP adoption to landowners' characteristics and circumstances, scenarios were run manually, observing changes in model output to switches in the states of parent variables. Although the existence of synergies can be explored using scenario analysis, in this case the role of only one variable at a time. Results are presented in Table 7.

Factors associated with adoption of the three antecedent activities are shown in order of influence in the upper portion of the table, while those associated with non-adoption are shown in reverse order of significance in the lower portion. The role of individual factors in the adoption of CRPs is shown by highlighting. Intensity of shading represents the strength of association between the variable and CRP adoption. Themes drawn from these analyses are discussed subsequently.

Table 7: Scenario analysis of the adoption of CRPs – property planning, involvement in NRM programs and short course attendance.

Parent variable	State	Property planning	NRM programs	Short courses	Aggregate
		Change to output node	Change to output node	Change to output node	Total changes
Profitability	Yes	**11.0**	4.6	**22.8**	38.4
Land use type	Cropping	5.9	-1.0	**27.5**	32.4
Location	Lowland	**23.0**	2.9	3.2	29.1
Build a business scale	High	**14.7**	4.9	2.6	22.2
Land use type	Grazing & cropping	2.1	**11.8**	7.8	21.7
Short course	Yes	3.6	**16.4**	n/a	20.0
Property size	>200 ha	2.3	2.6	**12.9**	17.8
Proportion of farm income	High	**10.3**	3.4	1.8	15.5
Property size	20-200 ha	3.8	1.8	9.5	15.1
Viable agriculture	High	7.8	2.6	1.4	11.8
Finance and family info. scale	High	7.4	2.5	1.3	11.2
Land use type	Grazing	4.8	0.2	5.0	10.0
Finance and family info. scale	Low	-4.9	-1.7	-0.8	-7.4
Viable agriculture	Low	-5.5	-1.9	-0.9	-8.3
Proportion of farm income	Low	-6.7	-2.3	-1.1	-10.1
Location	Upland	-4.4	-3.7	-3.8	-11.9
Short course	No	**-11.1**	**-8.0**	n/a	-19.1
Profitability	No	-6.8	-2.9	-13.9	-23.6
Build a business scale	Low	**-16.3**	-5.6	-2.8	-24.7
Property size	< 20 ha	-6.6	-3.9	**-19.7**	-30.2
Land use type	Residential	-5.4	**-8.2**	**-18.7**	-32.3
Land use type	Other	-8.1	1.7	**-28.4**	-34.8

Model structure A:
General factors that shape the adoption of on-ground CRPs

Structure A was then applied to the three 'on-ground' CRPs – encouragement of native vegetation regrowth, use of soil testing to determine fertiliser requirements, and the use of legume rotations. By using the same structural template, similarities and differences in the roles of the key behavioural drivers can be observed.

Encouraging regrowth of native vegetation

The survey showed that approximately 55% of respondents have encouraged regrowth of native vegetation on their landholding. Those who have encouraged the regrowth of native vegetation differ from those who have not based on the following principal distinctive physical and economic characteristics:

- The property's environmental health is better;
- Smaller property size; and
- The land type is not suitable for agricultural production.

Landowners who encourage native vegetation regrowth are:

- More likely to have a business or property plan;
- More likely to have been involved in NRM programs;
- Less likely to intend to build their on-property business activities;
- More trusting of information from 'environment' groups;
- More concerned about the decline of services in rural areas;
- Less likely to be operating an agricultural enterprise;
- More likely to have higher levels of formal education; and
- More likely to use the forest for recreation purposes.

Less statistically significant relationships include:

- More concern about the health of the environment on their property and in the region; and
- Have a higher proportion of their property under native vegetation.

Of the listed factors, only those previously identified as having the most meaningful causal relationships are included in the model of regrowth encouragement.

The results of sensitivity testing of the Structure A model are shown in Table 8. The key influencing factors are seen to be the land use type (whether suited to cropping, grazing or residential use), property size, and the landowners' goal of 'building a business'.

Table 8: Sensitivity of regrowth encouragement to modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
If encourages regrowth	0.2456710	100.0%	
Land use type	0.0138315	5.6%	60%
Property size	0.0049205	2.0%	21%
Goal scale – build business	0.0022570	0.9%	10%
If profitable 2004/2005	0.0006772	0.3%	3%
Proportion of income earned on-farm	0.0006489	0.3%	3%
Concern about future viability of agriculture	0.0004036	0.2%	2%
Information scale – 'finance and family'	0.0003427	0.1%	1%
Short course attendance	0.0000233	0.0%	0%
Location	0.0000001	0.0%	0%
Total	**0.0231048**		**100%**

Adoption of soil testing

Of the respondents with cropping land, approximately 56% reported using soil testing prior to applying fertiliser on all their cropping land with approximately 20% reporting use of soil testing for at least parts of their cropping land. Eighty-seven percent of those who stated the primary purpose for land ownership as ‘agriculture’ reported using some soil testing on their cropping land.

Tests of the socio-economic and attitudinal characteristics of those who had adopted some use of soil testing revealed a number of differences from those who had not. Those who have adopted soil testing are likely to:

- Have larger areas of land use for cropping;
- Obtain a greater share of their household income from agriculture;
- Have lived on rural properties, in their local district and on their current properties for a longer period of time;
- Be profitable;
- Have a greater number of people living on and supported by the property enterprises;
- Have a property or business plan;
- Have attended a short course about land and, or water management;
- Be motivated to build their business;
- Be more inclined to want to clear remnant vegetation;
- Be more concerned about the future viability of agriculture; and
- Be more trusting of ‘productivity’ groups and more interested in using information from ‘enterprise’ and ‘environment’ groups, and ‘finance and family’ sources.

Of the listed factors, only those factors previously identified as having the most meaningful causal relationships are included in the soil testing model.

The results of sensitivity testing of the Structure A model are shown in Table 9. The key influencing factors are seen to be the land use type (whether suited to cropping, grazing or residential use), the profitability of the landholding, property size, and the landowners' goal of 'building a business'.

Table 9: Sensitivity of adoption of soil testing to modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Soil test adoption	0.2457230	100%	
Land use type	0.0644017	26%	34%
If profitable 2004/05	0.0485766	20%	26%
Property size	0.0283641	12%	15%
Goal scale – build business	0.0270115	11%	14%
Proportion of income earned on-farm	0.0077663	3%	4%
Concern about future viability of agriculture	0.0048306	2%	3%
Information scale – 'finance and family'	0.0041018	2%	2%
Short course attendance	0.0021342	1%	1%
Location	0.0000299	0%	0%
Total	**0.1872167**		**100%**

Adoption of legume rotations

Of the respondents that reported having some cropping land, approximately 68% reported using legume rotations on part or all of their cropping land. Compared to those who have not adopted the use of legume rotations, those who have adopted this practice:

- Own larger properties and have greater areas of cropping land;
- Have a higher proportion of land used for cropping activities and lower proportion under native vegetation;
- Work longer hours on their property, earn a higher proportion of their income from property enterprises and support a greater number of people from these enterprises;
- Are more likely to have attended a short course related to property management, have a property plan and have participated in a government NRM program;
- Have lived on rural properties, in the local district and on their current farm for a longer period of time;
- Are more concerned about the future viability of agriculture;
- Are more motivated to build their property enterprises and protect the environment;
- Find information from 'enterprise' and 'finance and family' sources more useful;
- Have greater levels of trust for 'productivity' groups; and
- Are more confident that timber can be sustainably produced from their areas of native vegetation.

Of the listed factors, only those previously identified as having the most meaningful causal relationships are included in the legume rotation model.

The results of sensitivity testing of the Structure A model are shown in Table 10. The key influencing factors are seen to be the landowners' goal of 'building a business', the land use type (whether suited to cropping, grazing or residential use), and the proportion of the family's income earned from the landholding.

Table 10: Sensitivity of adoption of legume rotation to modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Adoption of legume rotations	0.2486400	100%	
Goal scale – build business	0.0407646	16%	42%
Land use type	0.0163166	7%	17%
Proportion of income earned on-farm	0.0117205	5%	12%
Concern about future viability of agriculture	0.0072900	3%	7%
Information scale – 'finance and family'	0.0061900	2%	6%
If profitable 2004/2005	0.0059852	2%	6%
Short course attendance	0.0049650	2%	5%
Property size	0.0046370	2%	5%
Location	0.0000561	0%	0%
Total	**0.0979254**		**100%**

Summaries of sensitivity reports

Results from the analyses of the three on-ground CRPs were compiled in rank order of total variance reduction as shown in Table 11. Intensity of shading represents the strength of association between the variables and CRP adoption. Themes from this table and from scenario analyses are discussed subsequently.

Table 11: Proportion of influence of Structure A models ranked in order of total variance reduction.

Variable	Regrowth	Soil testing	Legume rotation	Summed variance reduction
Land use type	**60%**	**34%**	**17%**	0.0945498
Goal scale – build business	**10%**	**14%**	**42%**	0.0700331
If profitable in 2004/2005	3%	**26%**	6%	0.0552390
Property size	21%	**15%**	5%	0.0379216
Proportion of income from property	3%	4%	**12%**	0.0201357
Concern with future viability of agriculture	**2%**	3%	7%	0.0125243
Info 'finance and family' sources	1%	2%	6%	0.0106348
Short course attendance	0%	1%	5%	0.0071225
Location	0%	0%	0%	0.0000861

Scenario analysis

As a further method of testing the responsiveness of CRP adoption to landowners' characteristics and circumstances, scenarios were run manually, observing changes in model output to switches in the states of parent variables. Although the existence of synergies can be explored using scenario analysis, in this case the role of only one variable at a time. Results are presented in Table 12.

Factors associated with adoption of the three on-ground CRPs are shown in order of influence in the upper portion of the table, while those associated with non-adoption are shown in reverse order of significance in the lower portion. The role of individual factors in the adoption of CRPs is shown by highlighting. Intensity of shading represents the strength of association between the variable and CRP adoption.

The order of influence of factors associated with 'regrowth encouragement' is generally in reverse to their influence over cropping practices. However, the impact of this on the rank order of aggregate influence is minimal. Themes drawn from these analyses are discussed subsequently.

Table 12: Scenario analysis of the adoption of CRPs – encouragement of native regrowth, soil testing by croppers and legume rotations.

Parent variable	State	Regrowth	Soil testing	Legume rotation	Aggregate
		Change to output node	Change to output node	Change to output node	Total changes
Land use type	Grazing & cropping	**-6.0**	**16.0**	**35.0**	45.0
Profitability	Yes	-3.3	**28.2**	**9.9**	34.8
Build a business scale	High	-4.5	**15.7**	**19.2**	30.4
Land use type	Cropping	-3.8	**32.1**	1.2	29.5
Proportion of farm income	High	-3.2	**10.9**	**13.4**	21.1
Property size	>200 ha	**-6.7**	**15.9**	**10.2**	19.4
Short course	Yes	-0.7	6.7	**10.2**	16.2
Viable agriculture	High	-2.4	8.3	**10.2**	16.1
Finance and family information scale	High	-2.3	7.9	**9.7**	15.3
Property size	20-200 ha	-4.5	**10.8**	2.5	8.8
Location	Lowland	0.0	0.5	0.7	1.2
Location	Upland	-0.1	-0.6	-0.8	-1.5
Short course	No	0.3	-3.2	-4.9	-7.8
Finance and family information scale	Low	1.5	-5.2	-6.4	-10.1
Viable agriculture	Low	1.7	-5.8	-7.1	-11.2
Proportion of farm income	Low	2.0	-7.1	**-8.7**	-13.8
Land use type	Other	**8.0**	**-25.4**	-0.1	-17.5
Profitability	No	2.0	**-17.2**	-6.0	-21.2
Property size	< 20 ha	**9.6**	**-23.1**	**-8.6**	-22.1
Land use type	Grazing	**-18.1**	-3.2	-3.4	-24.7
Land use type	Residential	**18.9**	**-28.6**	**-18.4**	-28.1
Build a business scale	Low	5.0	**-17.3**	**-21.2**	-33.5

Themes emerging from Structure A models

While the results of sensitivity tests exhibit considerable variation in the role of the parent 'drivers' of *antecedent activities*, some tentative conclusions can be drawn:

- Landowners are likely to engage in all three of the antecedent activities rather than just one;
- The suitability of the property to particular uses (land use type) strongly influences the likelihood of engaging in antecedent activities;
- Profitability of the farming operation is strongly associated with antecedent activities being adopted;
- Where landowners are keen to build the farm business, they are likely to engage in the three antecedent activities; and
- Where the property size is large, landowners are more likely to engage in the three antecedent activities.

The four variables above were also found to be strongly associated with adoption of *on-ground practices:*

- Land use type;
- The landowner's desire to build the farm business;
- Profitability of the farming operation; and
- Property size.

Model structure B:
Influence of antecedent factors on the adoption of on-ground CRPs

Structure B examines relationships between the activities described herein as antecedent CRPs (property planning, involvement in NRM programs and short course participation) and the adoption of on-ground, physical CRPs (encouragement of native vegetation regrowth, soil testing, and legume rotations). The influence of antecedent factors was explored by constructing a simple converging casual network for each of the on-ground practices. An additional factor – the proportion of cropped land (or native vegetation for the regrowth CRP) was included in each model on the basis that they are logically associated with the targeted management practice. Each of the three models is now described, together with the results of sensitivity tests and scenario analyses.

Encouraging regrowth of native vegetation

The model for adoption of regrowth encouragement is shown in Figure 9. The strength of association found to exist between the antecedent factors and the encouragement of native vegetation regrowth is shown in Table 13.

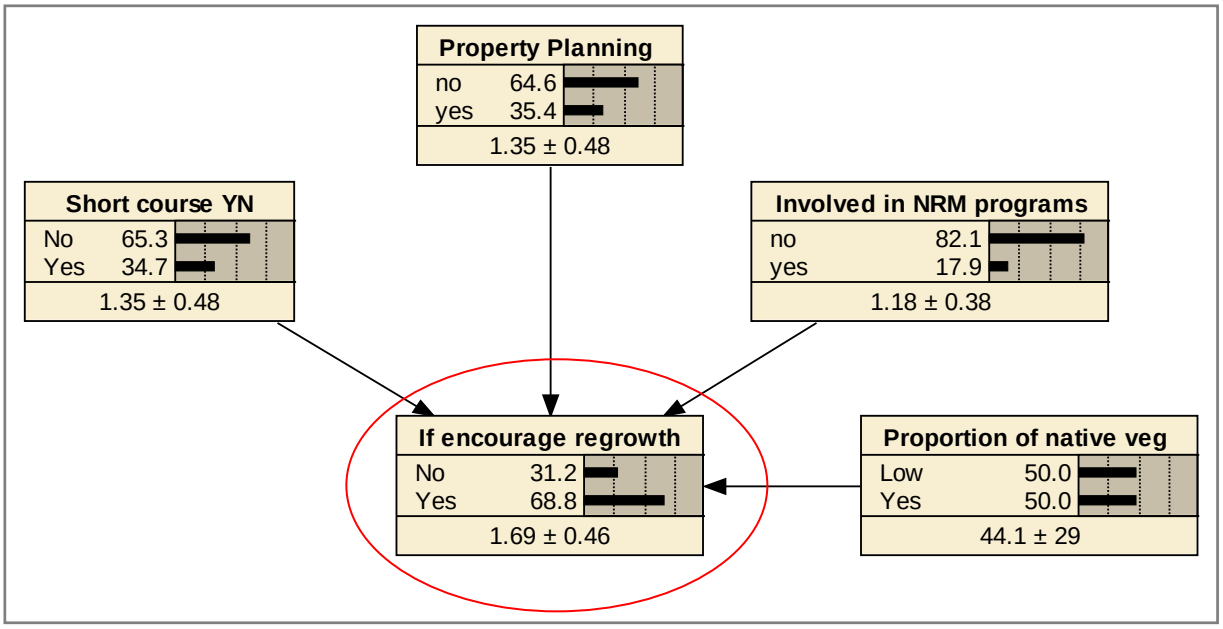

Figure 9: Model of antecedent activities influencing regrowth encouragement, with output CRP circled.

Table 13: Sensitivity of regrowth encouragement to the modelled antecedent variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Encourages native vegetation regrowth	0.214651	100%	
Property plan	0.007468	3%	66%
Proportion of native vegetation	0.002504	1%	22%
Short course	0.001179	1%	10%
NRM program	0.000248	0%	2%
Total	**0.011399**		**100%**

Prior participation in property planning is clearly the antecedent factor associated most with regrowth encouragement, while the current existence of a high proportion of native vegetation on the property is also strongly associated. The remaining factors of short course and NRM program participation play a minor role individually, but may have a synergistic role as described in the scenario analysis.

Scenario analysis

Scenario analysis in a BBN explores the influence of one or more factors on the likelihood of an outcome by manipulating the status of the component drivers. In the current model, the outcome (the likelihood of regrowth being encouraged by the landholder) is highly responsive to state of the parent drivers. The base level situation – when the model is informed by case data, the likelihood of landowners *encouraging native vegetation regrowth* is 69%. Where three parent nodes are in their favourable state (*the proportion of native vegetation* on a property is high, where the landholder *attends short courses* and is *involved in NRM programs),* one hundred percent adoption is modelled to occur. Under the least favourable mix of component factors, the modelled rate of adoption is still fifty percent.

Adoption of soil testing

The model for adoption of soil testing as a means of determining fertiliser requirements is shown in Figure 10. The strength of association found to exist between the antecedent factors and soil testing is shown in Table 14.

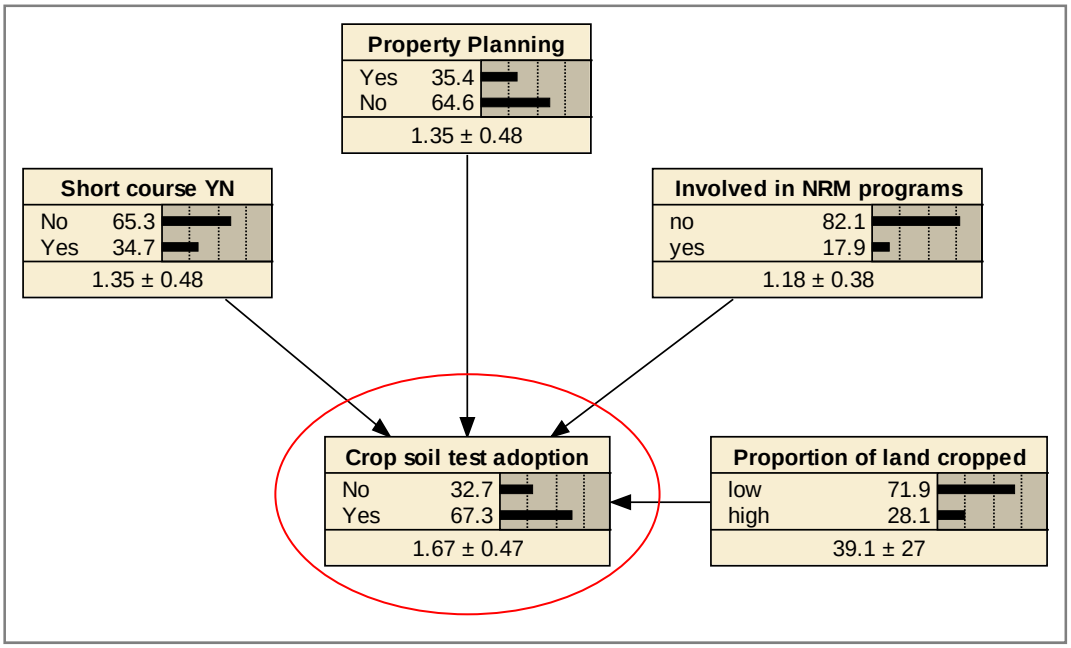

Figure 10: Model of antecedent activities influencing adoption of soil testing, with output CRP circled.

Table 14: Sensitivity of adoption of soil testing to the modelled antecedent variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Soil testing	0.219947	100%	
Proportion of land cropped	0.020326	9%	50%
Property planning	0.010616	5%	26%
NRM program involvement	0.006665	3%	16%
Short course participation	0.003200	1%	8%
Total	**0.040806**		**100%**

Factors most associated with adoption of soil testing were found to be *the proportion of land under cropping*, followed by *having a property plan* and *involvement in NRM programs*.

Scenario analysis

The base level of adoption of soil testing under this model is 67%. Under favourable scenarios, adoption rates are 100% f*or most permutations of the landholder/property characteristics*, as now described.

- Where all four of the modelled antecedents to soil testing are in their positive state, 100% of landholders practise soil testing.
- Where three of the antecedents are in their positive states, 100% of landholders practise soil testing.
- Provided the proportion of land used for cropping is high, adoption rate is 82%. Where any one of the other three antecedents is also positive, more than 90% of landholders practise soil testing,

Under the most unfavourable scenario, the adoption rate is 41%.

Adoption of legume rotations

The model for adoption of soil testing as a means of determining fertiliser requirements is shown in Figure 11. The strength of association found to exist between the antecedent factors and soil testing is shown in Table 15.

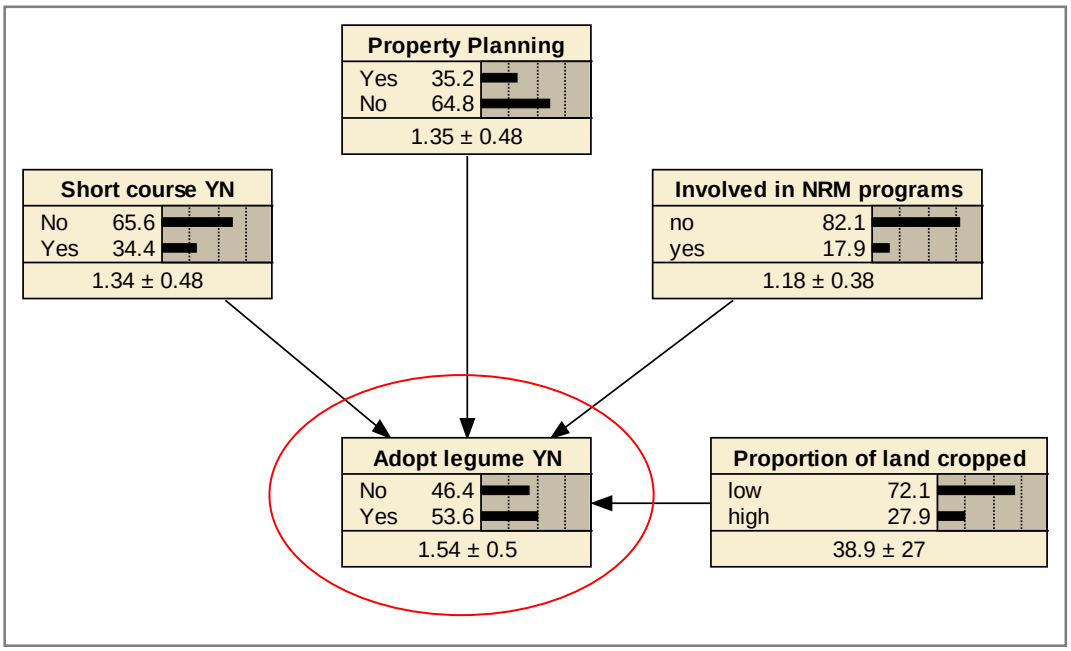

Figure 11: Model of antecedent activities influencing the adoption of legume rotation, with output CRP circled.

Table 15: Sensitivity of adoption of legume rotations to the modelled antecedent variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Legume rotations	0.248719	100%	
Property planning	0.012248	5%	79%
NRM program involvement	0.002768	1%	18%
Proportion of land cropped	0.000379	0%	2%
Short course participation	5.88E-05	0%	0%
Total	**0.015454**		**100%**

The overwhelmingly dominant predictor of the adoption of legume rotations was found to be the undertaking of property planning, with participation in NRM programs also a relevant factor.

Scenario analysis

The base rate for adoption of legume rotations among crop growers is 54%. This rate raises to 100% where the proportion of land cropped is high and when short course attendance and NRM program participation occur.

While there are some anomalous interactions evident, notably in short course attendance and proportion of land cropped, nonetheless where respondents are involved in all three of the antecedent activities, adoption rate is 100% regardless of the proportion of land cropped. Forty percent adoption was found under the least favourable scenario.

Summary of sensitivity reports

Results from the analyses of the three on-ground CRPs were compiled in rank order of total variance reduction as shown in Table 16. Intensity of shading represents the strength of association between the variables and CRP adoption. Themes from this table and from scenario analyses are discussed subsequently.

Table 16: Proportion of influence in Structure B models ranked in order of total variance reduction.

Variable	Regrowth	Soil testing	Legume rotation	Summed variance reduction
Property plan	**66%**	**26%**	**79%**	0.0303317
Proportion of land cropped*	na	**50%**	2%	0.0207044
NRM program	2%	**16%**	**18%**	0.0096813
Short course	**10%**	8%	0%	0.0044377
Proportion of native vegetation**	**22%**	na	na	0.0025036

* Two models are relevant.

** Only one model is relevant.

Scenario analysis

As a further method of testing the responsiveness of on-ground CRP adoption to antecedent activities, scenarios were run manually, observing changes in model output to switches in the states of parent variables. Although the existence of synergies can be explored using scenario analysis, in this case the role of only one variable at a time. Results are presented in Table 17.

Antecedent factors most associated with adoption of the three on-ground CRPs are shown in order of influence in the upper portion of the table. The role of individual factors in the adoption of CRPs is shown by highlighting. Intensity of shading represents the strength of association between the variable and CRP adoption.

Table 17: Scenario analysis of the adoption of CRPs – encouragement of native regrowth, soil testing by croppers and legume rotations.

Parent variable	State	Regrowth	Soil testing	Legume rotation	Aggregate
		Change to output node	Change to output node	Change to output node	Total changes
Property planning	Yes	**11.7**	**14.0**	**15.0**	40.7
NRM programs	Yes	3.4	**17.5**	**11.2**	32.1
Proportion cropping	Low		**22.8**	3.1	25.9
Short course	Yes	**4.7**	7.8	1.0	13.5
Proportion native veg	High	**5.0**			5.0
Proportion native veg	Low	**-5.0**			-5.0
NRM programs	No	-0.7	-3.8	-2.5	-7.0
Short course	No	-2.5	-4.1	-0.6	-7.2
Proportion cropping	High		**-8.9**	-1.2	-10.1
Property planning	No	**-6.4**	**-7.6**	**-8.2**	-22.2

Themes emerging from Structure B models

While the results of sensitivity tests presented indicate considerable variation in the role of the parent ‘drivers’, some tentative conclusions can be drawn:

- Having a property plan is highly associated with the likelihood of on-ground CRPs being adopted;
- The larger the proportion of land being cropped, the greater the likelihood of cropping CRPs being adopted; and
- Involvement in other antecedent activities, especially NRM programs is associated with adoption of on-ground CRPs.

Scenario analyses indicate strong synergies between parent factors, with several instances of one hundred percent probability of CRP adoption when more than one antecedent activity is undertaken.

Model structure C:
Cognitive and social influences on the adoption of antecedent CRPs

Structure C was devised in order to identify and better understand factors expected to be associated with the adoption of property planning, NRM program involvement and short course attendance. Modelling may allow their degree of relationship to be quantified, and their efficacy as intervention points can be predicted. Therefore, the role of cognitive influences (information sources) and social influences (group membership) were included as component factors in the third model structure.

Property planning

Property planning has been found in preceding models to be strongly associated with CRP adoption. Figure 12 illustrates its structure

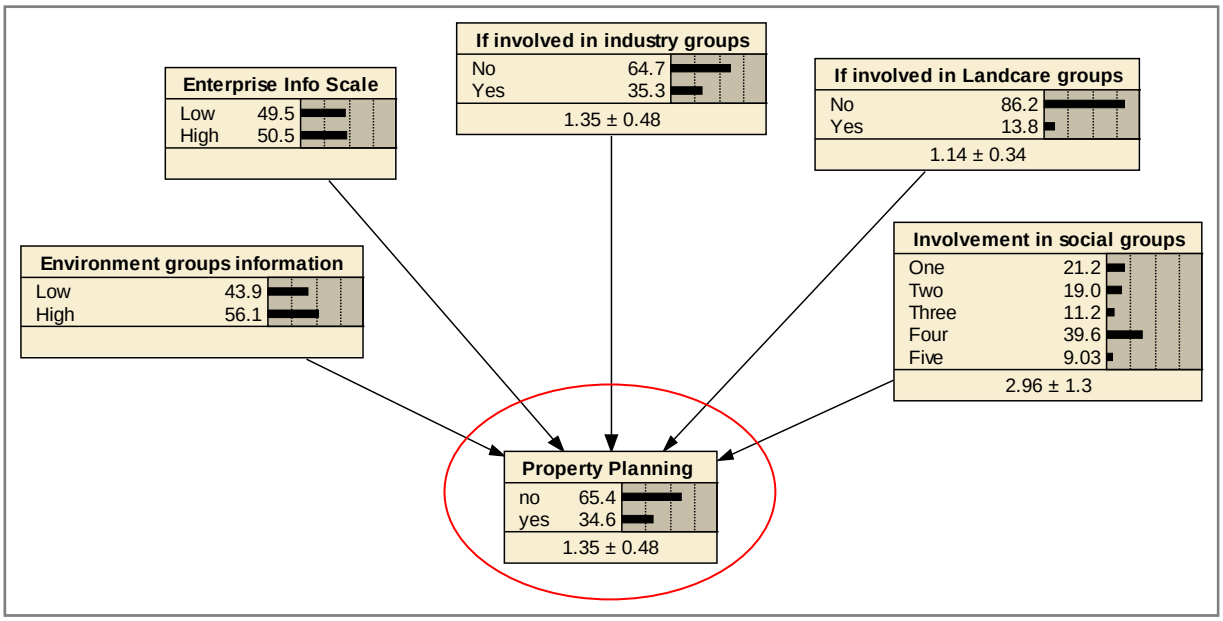

Figure 12: Model of cognitive and social factors influencing the adoption of property planning, with output CRP circled.

Table 18: Sensitivity of property planning to the modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Property planning	0.2263332	100%	
Social group involvement	0.0629252	28%	89%
Land care involvement	0.0047085	2%	7%
Environment group information sources	0.0020356	1%	3%
Industry group involvement	0.0006725	0%	1%
Enterprise information sources	0.0000065	0%	0%
Total	**0.0703483**		**100%**

The degree of social group involvement (emergency services, catchment management groups, church, lobby and civic groups) is seen to be a highly influential factor in the adoption of property planning.

Participation in NRM programs

The model of information sources and social group involvement follows the template described for adoption of property planning. The results of sensitivity tests are shown in Table 19. Again, landowners' involvement in social groups is the dominant indicator of adoption of this CRP, with participation in LandCare groups also significant.

Table 19: Sensitivity of NRM program involvement to the modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
NRM program involvement	0.1634311	100%	
Social group involvement	0.0284414	17%	83%
Land care involvement	0.0052481	3%	15%
Enterprise info sources	0.000706	0%	2%
Industry group involvement	0.0000125	0%	0%
Environment group info sources	0.0000002	0%	0%
Total	**0.0344082**		**100%**

Participation in short courses

Involvement in short courses concerned with property management was modelled similarly, with the results of sensitivity analysis shown in Table 20. Involvement in social groups is again the most potent indicator of attendance at short courses. Reliance on 'enterprise groups' as information sources is also significant, followed by involvement in LandCare groups.

Table 20: Sensitivity of short course attendance to the modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Short course attendance	0.2306529	100%	
Social group involvement	0.0604575	26%	80%
Enterprise info sources	0.0094349	4%	12%
Land care involvement	0.0052756	2%	7%
Environment group info sources	0.0003897	0%	1%
Industry group involvement	0.0000065	0%	0%
Total	**0.0755642**		**100%**

Summaries of sensitivity reports

Results from the analyses of the three on-ground CRPs were compiled in rank order of total variance reduction as shown in Table 21. Intensity of shading represents the strength of association between the variables and CRP adoption. Themes from this table and from scenario analyses are discussed subsequently.

Table 21: Proportion of influence in Structure C models ranked in order of total variance reduction.

Variable	Property planning	NRM programs	Short courses	Summed variance reduction
Social group involvement	**89%**	**83%**	**80%**	0.1518241
Land care involvement	7%	**15%**	7%	0.015232
Enterprise info sources	0%	2%	**12%**	0.010147
Environment group information sources	3%	0%	1%	0.002426
Industry group involvement	0%	0%	0%	0.000692

Scenario analysis

As a further method of testing the responsiveness of antecedent activities to information sources and social groups, scenarios were run manually, observing changes in model output to switches in the states of parent variables. Although the existence of synergies can be explored using scenario analysis, in this case the role of only one variable at a time. Results are presented in Table 22.

Factors most associated with adoption of antecedent activities are shown in order of influence in the upper portion of the table. Factors associated negatively with adoption of antecedent CRPs are in the lower portion of the table. The extent of the role of individual factors is shown by highlighting, with the intensity of shading representing the strength of association between the variable and CRP adoption.

Table 22: Scenario analysis of the adoption of CRPs – property planning, involvement in NRM programs and short course attendance.

Parent variable	State	Property planning	NRM programs	Short courses	Aggregate
		Change to output node	Change to output node	Change to output node	Total changes
Social groups	Three	**43.6**	**35.2**	**51.5**	130.3
Social groups	Five	**36.1**	**20.6**	**34.9**	91.6
Landcare groups	Yes	**17.2**	**18.1**	**18.1**	53.4
Social groups	Two	**18.4**	**6.7**	**8.3**	33.4
Enterprise info	High	0.3	-2.7	**9.6**	7.2
Industry groups	Yes	3.5	0.5	0.3	4.3
Environment groups information	High	4.0	0.0	-1.8	2.2
Industry groups	No	-1.9	-0.3	-0.2	-2.4
Environment groups information	Low	-5.1	-0.1	2.2	-3.0
Enterprise info	Low	-0.2	2.7	-9.8	-7.3
Landcare groups	No	-2.7	-2.9	-2.9	-8.5
Social groups	One	**-12.9**	-4.8	**-19.7**	-37.4
Social groups	Four	**-22.5**	**-15.4**	**-16.0**	-53.9

Model structure C:
Cognitive and social influences on the adoption of on-ground CRPs

Structure C is now continued for modelling information and social factors that influence the adoption of on-ground CRPs.

Regrowth of native vegetation

Figure 13 shows several sources of information and group affiliation, while Table 23 illustrates the degree of their influence on encouragement of native vegetation regrowth.

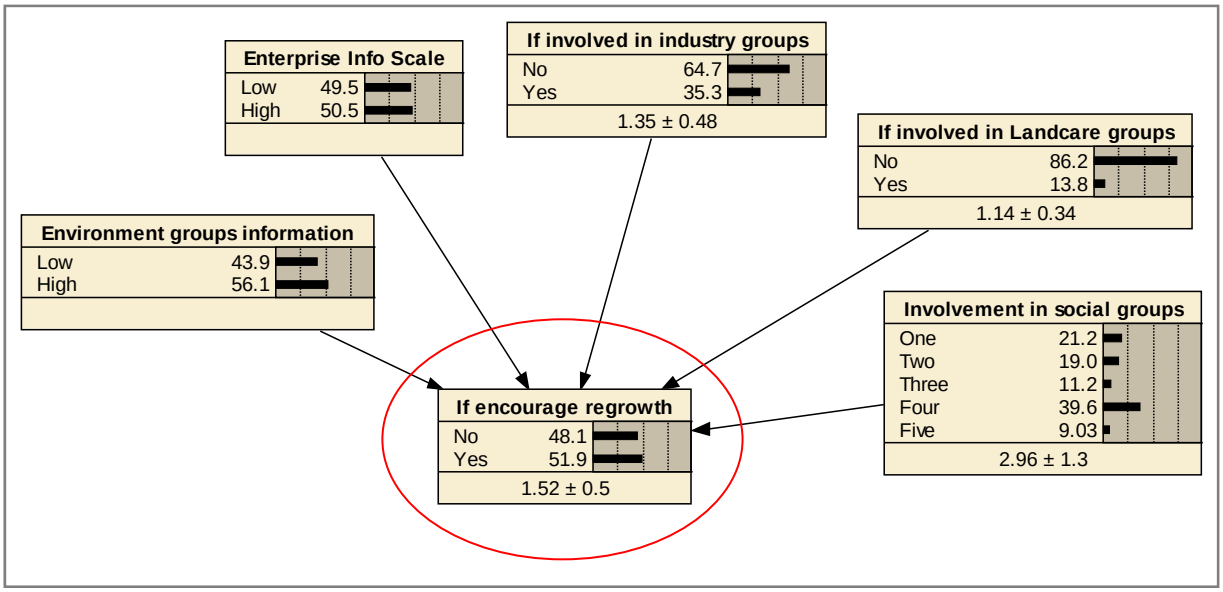

Figure 13: Model of cognitive and social factors influencing regrowth of native vegetation, with output CRP circled.

Table 23: Sensitivity of regrowth encouragement to the modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Encourages regrowth of native vegetation	0.249632	100%	
Social group involvement	0.025334	10%	79%
Industry group involvement	0.002860	1%	9%
Information sources – Enterprise groups	0.001928	1%	6%
Information sources – Environment group	0.001687	1%	5%
Involvement with Landcare groups	0.000197	0%	1%
Total	**0.032006**		

In this model, landholder participation in social groups (emergency services, catchment management groups, church, lobby and civic groups) is the dominant factor related to vegetation regrowth encouragement.

Soil testing

The modelling template used for previous CRPs was repeated for the encouragement of native vegetation regrowth. The results of sensitivity tests are shown in Table 24. Likelihood of adoption of soil testing is influenced most by reliance on *information from enterprise groups*. Involvement in social groups and industry-based groups were the other factors found to be influential.

Table 24: Sensitivity of adoption of soil testing to the modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Soil testing	0.249953	100%	
Information sources – Enterprise groups	0.040394	16%	71%
Involvement in social groups	0.007858	3%	14%
Involvement in industry groups	0.007812	3%	14%
Information source – Environment groups	0.000376	0%	1%
Involvement with Landcare groups	5.64E-05	0%	0%
Total	**0.056497**		**100%**

Legume rotations

The results of sensitivity tests on the model of adoption of legume rotations are shown in Table 25. Involvement in industry and social groups and reliance on environment groups as a source of information were associated with the adoption of legume rotations.

Table 25: Sensitivity of adoption of legume rotations to the modelled variables.

Variable	Variance reduction	Variance reduction (%)	Contribution to total influence
Legume rotations	0.249784	100%	
Involvement in industry groups	0.009820	4%	42%
Involvement in social groups	0.009735	4%	41%
Information sources – Envrionment groups	0.002745	1%	12%
Information sources – Enterprise groups	0.001058	0%	4%
Involvement in Landcare groups	0.000210	0%	1%
Total	**0.023568**		**100%**

Summaries of sensitivity reports

Results from the analyses of the three on-ground CRPs were compiled in rank order of total variance reduction as shown in Table 26. The intensity of shading represents the strength of association between the variables and CRP adoption. Themes from this table and from scenario analyses are discussed subsequently.

Table 26: Proportion of influence in Structure C models ranked in order of total variance reduction.

Variable	Regrowth	Soil testing	Legume rotation	Summed variance reduction
Information sources – Enterprise groups	6%	71%	4%	0.0433792
Involvement in social groups	79%	14%	41%	0.0429268
Involvement in industry groups	9%	14%	42%	0.0204919
Information sources – Environment groups	5%	1%	12%	0.0048087
Involvement in Landcare groups	0%	0%	1%	0.0004638

Scenario analysis

As a further method of testing the responsiveness of on-ground CRPs to information sources and social groups, scenarios were run manually, observing changes in model output to switches in the states of parent variables. Although the existence of synergies can be explored using scenario analysis, in this case the role of only one variable at a time. Results are presented in Table 27.

Factors most associated with adoption of on-ground CRPs are shown in order of influence in the upper portion of the table. Factors associated negatively with adoption of antecedent CRPs are in the lower portion of the table. The extent of the role of individual factors is shown by highlighting, with the intensity of shading representing the strength of association between the variable and CRP adoption.

Table 27: Scenario analysis of the adoption of CRPs – encouragement of native vegetation regrowth, soil testing by croppers and legume rotation.

Parent variable	State	Encourage regrowth	Soil testing	Legume rotation	Aggregate
		Change to output node	Change to output node	Change to output node	Total changes
Social groups	Two	11.2	11.6	15.9	38.7
Social groups	One	22.0	-4.7	3.4	20.7
Social groups	Five	9.5	6.4	4.1	20.0
Enterprise information	High	-4.3	19.9	3.2	18.8
Industry groups	Yes	7.3	12.0	-13.5	5.8
Social groups	Three	-10.0	12.7	0.9	3.6
Environment group information	High	-3.6	1.7	4.6	2.7
Landcare groups	No	-0.5	0.3	0.5	0.3
Landcare groups	Yes	3.5	-1.9	-3.7	-2.1
Industry groups	No	-3.9	-6.5	7.3	-3.1
Environment group information	Low	4.7	-2.2	-6.0	-3.5
Enterprise information	Low	4.5	-20.3	-3.3	-19.1
Social groups	Four	-16.5	-8.2	-10.7	-35.4

Themes emerging from Structure C models

While the results of sensitivity tests presented indicate a high level of consistency, with the following key insights:

- Social group involvement is by far the leading factor associated with landowners' participation in the *antecedent activities* of property planning, NRM programs and short courses.
- LandCare group involvement is also a relevant factor in adoption of the *antecedent activities.*
- Enterprise sources of information and social group involvement are key factors associated with the *on-ground practices* of regrowth encouragement, soil testing and legume rotations.
- Industry group involvement is another factor relevant to adoption of *on-ground CRPs.*

Scenario analyses indicated a degree of volatility that rendered their use unproductive in this case.

Error rates

Error rates obtained from the modelling software indicate the predictive veracity of the model. Predictive error rates were obtained for the models developed by Emtage *et al.* (2009) and for those obtained under Structures A, B and C. Results as shown in Table 28 reveal no material changes to mean error rates between the approaches for CRPs in Structure A. In Structure B, error rates are higher, while for Structure C, rates are comparable to those obtained in Structure A.

Table 28: Comparison of error rates obtained for two modelling approaches.

Model structure and target CRP		Error rate in modelling approaches			
		Approach by Emtage *et al.* (2009)	Mean	Current approach	Mean
Structure A	Property planning*	24%	19%	24%	22%
	NRM program	18%		16%	
	Short course			21%	
	Regrowth encouragement			35%	
	Soil testing	11%		10%	
	Legume rotations	21%		26%	
Structure B	Regrowth encouragement			41%	30%
	Soil testing			20%	
	Legume rotations			29%	
Structure C	Property planning			16%	20%
	NRM program			14%	
	Short course			13%	
	Regrowth encouragement			32%	
	Soil testing			15%	
	Legume rotations			27%	

* These models are identical and used as Structure A for the remaining CRPs.

Discussion

Approaches to model structure

The reasons underlying the use of models are, in broad terms, to improve understanding and to make predictions. Models go beyond merely noting that various factors are statistically or logically related. The analyses undertaken by Emtage *et al.* (2009), identified related factors, and described their inter-relationships. Customised Bayesian Belief Network (BBN) models were then constructed for each targeted land management practice. The BBN models assembled survey data in ways that reflected the inter-relationships between variables.

In developing their model structures, Emtage *et al.* (2009) drew on several broad sources of guiding data:

- Factors shown to have significant statistical association (e.g. correlation, Chi Square and regression analyses);
- Factors shown by other statistical analyses to be associated with each other, not necessarily significantly; and
- The researchers' understanding of landholders' characteristics and circumstances, and how these relate to adoption of CRPs.

The three model structures described in this document were developed and applied to six land management practices for which available data were adequate. The model structures also overtly anticipated their output having utility. Thus, the models were structured so that their output comprises actionable areas suited to policy intervention. Model predictions contribute to the utility of output by estimating the efficacy of identified actions.

The approach taken in this paper relies less on local knowledge of the Wet Tropics region and more on using statistically related factors and on elementary principles of human behaviour. Choice of the models' input and output variables also anticipate that the models' purpose is to support policy interventions aimed at influencing landowners' management behaviour.

Thus, Structure A (as used by Emtage *et al.* (2009) for the CRP of property planning) was used as a template for each of the six target CRPs. This approach aimed to identify the degree of commonality of selected landowner and property-based factors associated with adoption.

Structure B tested the proposition that three management/learning activities – property planning, NRM program participation and short course attendance – were likely to be precursors to adoption of the three targeted physical land management practices.

Structure C presaged that policy interventions may be aimed at influencing the cognitive components of landowners' attitudes (especially the action-tendency component of attitudes) towards adoption of certain land management practices. Knowledge of the information sources used by adopters and non-adopters may guide policy decisions. Similarly, knowledge of the influence of social groups in shaping landowners' attitudes may suggest channels of communication.

The approach taken for the modelling described in this report is useful in corroborating the findings of the earlier models. This was achieved for the two on-ground practices modelled by Emtage *et al* (2009). For the adoption of soil testing, 'property size', 'build a business' and 'profitability' were identified in the top four influencing factors. Similarly, for the adoption of

legume rotations, 'build a business', 'proportion of income earned on-farm' and 'concern about the viability of agriculture' were identified among the top four influencing factors.
The property planning models were identical, hence their outputs are identical. In the model of NRM program involvement, only one of the top four factors was common (land use type).

Error rates

The predictive error rates for model structures A and C are both approximately 20%, so neither approach represents any significant change from the approach used by Emtage *et al.* (2009). The 30% error rate derived for Structure B would infer that its output is less dependable. However, that inference should be balanced by noting the results of Structure B scenario analyses.

Themes identified through sensitivity and scenario analyses

Model Structure A

A high level of commonality was found to occur between factors associated with antecedent and on-ground management practices, although the rank order of these factors varied between CRP categories. The four leading factors in each case were:

- Land use type;
- The goal of building the farm business;
- Profitability of the farm business; and
- Property size.

Model Structure B

Model output from Structure B confirmed that the three activities postulated to be 'antecedents' are indeed precursors to the adoption of on-ground CRPs.

Model Structure C

Social group score is the single factor most indicative of engagement in property planning, NRM program participation and short course attendance. Involvement in Landcare groups is also relevant.

Adoption of on-ground CRPs is strongly associated with 'enterprise' sources of information, and with social group score. Industry group involvement is also relevant.

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Further Information

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