final report

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INCORPORATION OF PRACTICAL MEASURES TO ASSIST CONSERVATION OF BIODIVERSITY WITHIN SUSTAINABLE BEEF PRODUCTION IN NORTHERN AUSTRALIA

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Contents

Abstract 1
Executive summary 4
Background to the project and the industry context 6
Project objectives 6
Methods 7
Results and discussion 10
1. Understanding biodiversity in relation to grazing 10
2. Quantifying the relationships 17
3. Linking quantified relationships to enterprise returns 18
4. Practical measures to conserve biodiversity 21
5. Determining generality of the results 23
6. Communication of results 25
Success in achieving objectives 28
1. Learning module 28
2. Technical information manual 29
3. Implementation 29
4. Creating awareness 29
5. Communication 29
Impact on the industry 30
Conclusions and recommendations 31
Bibliography 33
Appendix 1 (presented as a separate volume) 35
Publications associated with the project 35
Appendix 2 (presented as a separate volume) 37
Appendix 3 (presented as a separate volume) 37
Assessment of the properties 37
Appendix 4 (presented as a separate volume) 37
Technical information manual 37
Appendix 5 38
Learning module pilot workshop report and game description 38
The game board 44
Appendix 6 46
Report on the use of the project information and communication resources in extension networks 46
Appendix 7 48
Evaluation of communication outputs 48
Appendix 8 52
Patch dynamics of grazed pastures near Crows Nest, south-east Queensland 52

Abstract

This project sought to identify and promote ecologically sustainable grazing management in grassy eucalypt woodlands in northern Australia. Through innovative interpretation and packaging of ecological information, and working with extension networks, we were able to change perceptions of conservation management amongst 942 landholders, of whom 418 changed their property management practices to incorporate some biodiversity conservation measures. However, our research has also identified significant economic and practical barriers to the adoption of sustainable management and biodiversity conservation. By raising awareness of the existence of ecological limits to land use (thresholds) amongst the scientific community and industry, we have provided a conceptual framework for improving our understanding of landscape management, and identifying practical ways forward in the quest for sustainability.

Executive summary

An understanding of the impact of grazing practices on biodiversity, and the identification of measures for improved practical management can benefit beef industry interests in two important ways i) to support their quest for sustainable resource management options; ii) to allow them to retain their rights to autonomy in deciding the best means for achieving this end. The wider community also stands to benefit from the move towards more sustainable use of grazing lands through sustained beef production. It also safeguards future land use options and the provision of ecosystem services.

This project combined the disciplines of agronomy, ecology and socio-economics to identify:

1. Limits to the use of grassy woodlands for grazing that will enable ecological sustainability (including maintenance of biodiversity) to be maintained.
2. The management changes required to achieve ecological sustainability.
3. The economic implications of moving from current practice to sustainable management.
4. The barriers and opportunities for producers to move towards ecological sustainability.

A technical reference panel and published information was used to develop a set of principles and thresholds for ecological sustainability. Four properties in SE QLD formed case-studies to explore the impact of moving towards more sustainable management. Production and economic models were used to calculate the economic impacts resulting from the minimum requirements for tree cover and protection of watercourses under the sustainability scenarios. We convened three management panels comprising the property owners and their peers and assessed the practical implications of implementing the principles.

Our project has substantially raised awareness of ecological sustainability and biodiversity conservation issues in northern Australia. The landscape management principles developed and the thresholds identified form a basis for the development of an Environmental Management System for the beef industry.

Communication outputs included a learning module for extension purposes (introduced to over 100 people in an innovative learning environment) and a technical information manual. We have been innovative in our presentation of technically difficult material into easily understood text, graphics and spoken presentations. An example of this innovation is a board game was developed to demonstrate a key aspect of landscape ecological theory.

An evaluation of the project indicated that as a result of the usage of the learning module, the content relating to the principles and thresholds reached 1543 landholders. The information contained in the module changed the perceptions of conservation management held by 942 landholders. These landholders now have a better understanding and greater awareness of the issues of conservation management in terms of their own properties. Of the 942 landholders, 418 have changed their property management practices to incorporate some conservation measures.

We have identified that while producers generally have a positive view of ecologically sustainable management, they face substantial barriers to implementation e.g.

- The economic penalties of restoring landscapes to adequate tree cover and appropriate patterns of grazing are substantial. When farm profitability is low, the impacts can be very high. Attempts to increase profitability by raising stocking rates, or expanding areas of crops and improved pasture will likely accelerate damage to natural resources and further contribute to losses of biodiversity.
- The areas that have the greatest need for conservation management are the riparian areas and fertile land types. These are the most desirable areas for production and involve the greatest attitudinal and financial barriers to change.
- The benefits of improved landscape management are long-term, while the costs of implementation are immediate. The benefits may not be fully captured by producers, or at least be perceived as beneficial to them. For example, fencing and regenerating riparian areas offers considerable

advantages for biodiversity conservation and water quality improvement. These may be valued more by downstream and off-site users than by producers.

We identified the major threats to ecological sustainability in grazing lands in Queensland to be in three areas:

- *Lack of long-term protection of native grasslands and pastures*. Grasslands and the grassy layer of eucalypt woodlands are not protected under the Vegetation Management Act 1999, QLD. This is a problem as most of the diversity in grassy woodlands is in the grassy layer, and its condition determines the health of tree and wildlife populations. Sown pastures and fertilizer are a greater threat to grassland than grazing. Protection is currently afforded only by the economic circumstances; it is not perceived to be profitable to expand these technologies.
- *Loss of tree regeneration capacity*. Tree control is a major management input for producers, and there is a prevailing view that this burden should be eliminated. However, the loss of tree regeneration processes on the landscape is the beginning of a tree decline process. Initially this might provide relief to producers, but decades later, biodiversity losses will be felt and salinity hazards will become salinity problems. From a practical management perspective, is easier to kill trees than to establish them.
- *Failure to protect riparian areas.* Watercourses and their adjoining lands are key parts of the landscape that need protection. Dysfunctional landscapes leak soil, excess water, nutrients and organic matter which leave the catchment via watercourses. This reduces water quality and results in a loss of production resources from the catchment. Riparian vegetation retains these resources and provides a keystone habitat for wildlife.

Because native pastures play a key role in maintaining ecological functioning and biodiversity in grassy woodlands, we recommend that the industry seriously reviews new or proposed technologies that expand the areas of intensively used land. Crop, fertilizer and sown pasture technologies, that exceed critical thresholds in terms of their extent, threaten the long-term ecological sustainability of landscapes.

Suggested areas of future research include further exploring the financial and practical barriers to adoption of ecologically sustainable management in more detail. We also need to determine the limits of private responsibility for natural resource management, and the point at which it is replaced by public responsibility. This will enable equitable cost-sharing arrangements to be negotiated to balance private and public contributions to the cost of achieving sustainability.

Some beef producers are in a position to immediately undertake management actions towards ecological sustainability, either through self-interest or regulatory requirements. For these, continued exploration for practical solutions is important. An aspect of this will be the availability of technical support for farm planning and decision making. Salinity hazard mapping, soil maps, topographical maps etc are examples of information that is required at specific scales for farm planning, but which may not be easily accessible.

Another important area is to further refine the boundaries of the thresholds, how they vary, and what are the trade-offs under different levels of management. This will provide a more accurate assessment of landscapes to better identify practical solutions. Management options informed by scientific observations of landscape function are critical. Our work has structured current knowledge to identify important questions that require research *viz*:

- What are the limits to intensive land uses at the landscape scale in terms of vegetation health and the condition of riparian zones?
- What ecological attributes are maintained by providing riparian vegetation of different widths and different combinations of structural attributes (e.g. grazed sward, ungrazed sward, shrubs, trees)?
- What birds and mammals are adversely affected by different levels of vegetation clearing in the landscape?
- What are appropriate spatial scales to apply the different land-use thresholds (property, sub-catchment, catchment)?

MAIN RESEARCH REPORT

Background to the project and the industry context

Interest in the linkage between pastoral management and maintenance of biodiversity in production landscapes is increasing rapidly. It accompanies a growing demand from both beef producers and the wider community for sustainable resource management. Property management practice is incomplete when key attributes of ecosystem health are ignored or misunderstood. While beef producers are keen to obtain this information, community concerns are acute in the face of continued decline of native plant and animal communities. This project has taken a whole property perspective, to enable producers and other stakeholders to consider trade-offs that occur between animal production and conservation of biodiversity. Ecological research has identified how property management influences plant diversity and ecological functioning of grazed pastures. This new information is to be used to refine management principles and indicators of ecological health and biodiversity status. Parallel research examined the economic implications of moving from current management to 'best-bet' scenarios based on our existing understanding of ecological sustainability. On-going communication activities were built into the research through management panels, involvement of producers managing the case-study properties, and the location of ecological research on the case-study properties. Explicit communication activities involved producer networks and extension specialists.

This project was conceived and designed alongside the socio-economic project 'Applying management principles on variegated landscapes: identifying production/conservation trade-offs' (Land and Water Australia /Environment Australia Project CTC9). Land and Water Australia and Environment Australia also contributed to NAP3.222.

Project objectives

The broad scientific and communication goals set by Meat and Livestock Australia were, by June 2001, to:

1. Significantly advance conceptual understanding of the relationships between the grazing of cattle and grazing management, and the conservation of regional biodiversity within the variegated landscapes of the north.
2. Quantify these relationships for at least one ecosystem that is economically important to the northern beef industry.
3. Link these quantified relationships to measures of productivity, and thence to economic indicators of enterprise returns, and assess alternative management strategies for both economic and biodiversity costs and benefits.
4. Identify practical measures to conserve biodiversity that producers can incorporate within their sustainable management practices, together with simple indicators they can use to assess results and continue to adapt and improve management.
5. Assess whether the results of this project can be used to assist management for conservation of biodiversity in other ecosystems within northern Australia.
6. Proactively publicise and disseminate project results to the industry and others concerned with natural resource management in northern Australia, including providing assistance to producer-led management within NAP3.

The specific project objectives are by June 2001 to:

1. Develop a learning module introducing concepts of ecological sustainability and biodiversity conservation in a whole property context.

2. Develop a manual providing appropriate technical information for producers and other resource managers wishing to implement sustainable management.

3. One hundred beef producers in northern Australia implementing management strategies on their properties to maintain biodiversity and sustainability.

4. At least 500 producers demonstrating awareness of the role of biodiversity on their properties.

5. Communication activities aimed at building the capacity of extension personnel to promote practices to maintain biodiversity and sustainability.

Methods

This project was conducted within a team environment[1] and combined the disciplines of agronomy, ecology and economics. It addressed the following key questions:

1. What are the limits to the use of grassy woodlands for grazing that will enable ecological sustainability, including the maintenance of biodiversity to be maintained?

2. What management changes might be required on properties to achieve ecological sustainability?

3. What are the economic implications of moving from current practice to ecologically sustainable management?

4. What are the barriers and opportunities for producers to move towards ecological sustainability?

To address question 1, we used a technical reference panel, combining expertise from a range of areas to complement the research team. Although we initially considered sustainable configurations for the four properties studied, to be able to generalize and communicate results to industry it was more appropriate to identify generic principles and land-use thresholds. The process of consultation, the principles and thresholds, and their scientific rationale are described in McIntyre, McIvor & MacLeod (2000).

We used four properties as case studies to address questions 2 - 4. Two properties were located in the Burnett region and two were located in the Crows Nest district. We surveyed the current natural resource condition of the four properties and assessed the extent and location of changes to grazing and tree cover that would be required to meet the minimum requirements for ecological sustainability. The assessments are documented in Martin *et al.* (2000).

We then explored the impact on the four properties of moving towards more sustainable management in terms of lost access to forage resulting from the minimum requirements for tree cover and protection of watercourses under the sustainability scenarios. The GRASP pasture simulation model (Littleboy & McKeon 1997; McKeon *et al.* 1998) was used to estimate the pasture production. An economic model was developed for each property to estimate the impact of production changes on property financial performance. These methods are described in Chapter 8, Appendix 4 and McIvor & MacLeod (1998).

Three Management Panels comprising the case property owners and a group of their selected peers were established at the beginning of the project (Auburn, Mundubbera and Crows Nest). These groups met with the research team periodically throughout the life of the project and discussions were held that provided information on what the project was about and how the case enterprises were managed. The key feature of this activity was that it was a two-way dialogue; the producers' and researchers' concepts of sustainability were discussed, as were the practical implications of implementing the principles. Semi-structured interviews further exploring these issues were conducted with participants towards the end of the project and these are summarized in Chapter 9, Appendix 4.

[1] Sue McIntyre, Neil MacLeod, John McIvor, John Hodgkinson, Katina Best, Tara Martin, John Ogden, Vaughan Frank, Vicki Noy and Jan Green. The latter four contributed for part of the project life.

Although we used existing ecological information to develop the principles, we also generated new information on the grassland biodiversity and the roles of grazing and other management factors on patterns of diversity. The choice of the grassy layer over studies of wildlife, soil fauna or trees reflected the expertise available to the group, but is also justified in that the grassy layer represents the source of income for producers and the majority of the plant diversity resides there as well. Methods are summarized in McIntyre & Martin (2001), McIntyre & Lavorel (2001) and Appendix 8.

Communication

Communication activities were an integral part of the research activities e.g. through producer participation in the case-study research, on-property experiments and the local network of extension officers. We also conducted many explicit communication activities throughout the life of the project. A communications officer was appointed during the project and a communication plan was developed in September 1999 (Appendix 1). During the course of the project, we shifted our communication priorities from direct contact with a small number of beef producers and their networks, towards wider extension networks. We targeted seven areas of communication activity:

1. A learning module designed for extension officers and the northern beef industry, introduced to stakeholders in a workshop environment;
2. A technical information manual to provide the technical background for the module;
3. Field days and meetings with the case study producers and the Management Panels to review and assess the scenarios;
4. Open field meetings for producers, landcare groups and extension officers in the regions;
5. Presentations to landholder meetings on an opportunistic basis;
6. Project newsletters produced on a six-monthly basis;
7. Media releases and popular articles.

The relationship between the various communication and research activities, and their logical flow, is summarized in Figure 1.

Evaluation

An evaluation of the project was conducted as a telephone survey in early 2001. The methods used are described in Appendix 7.

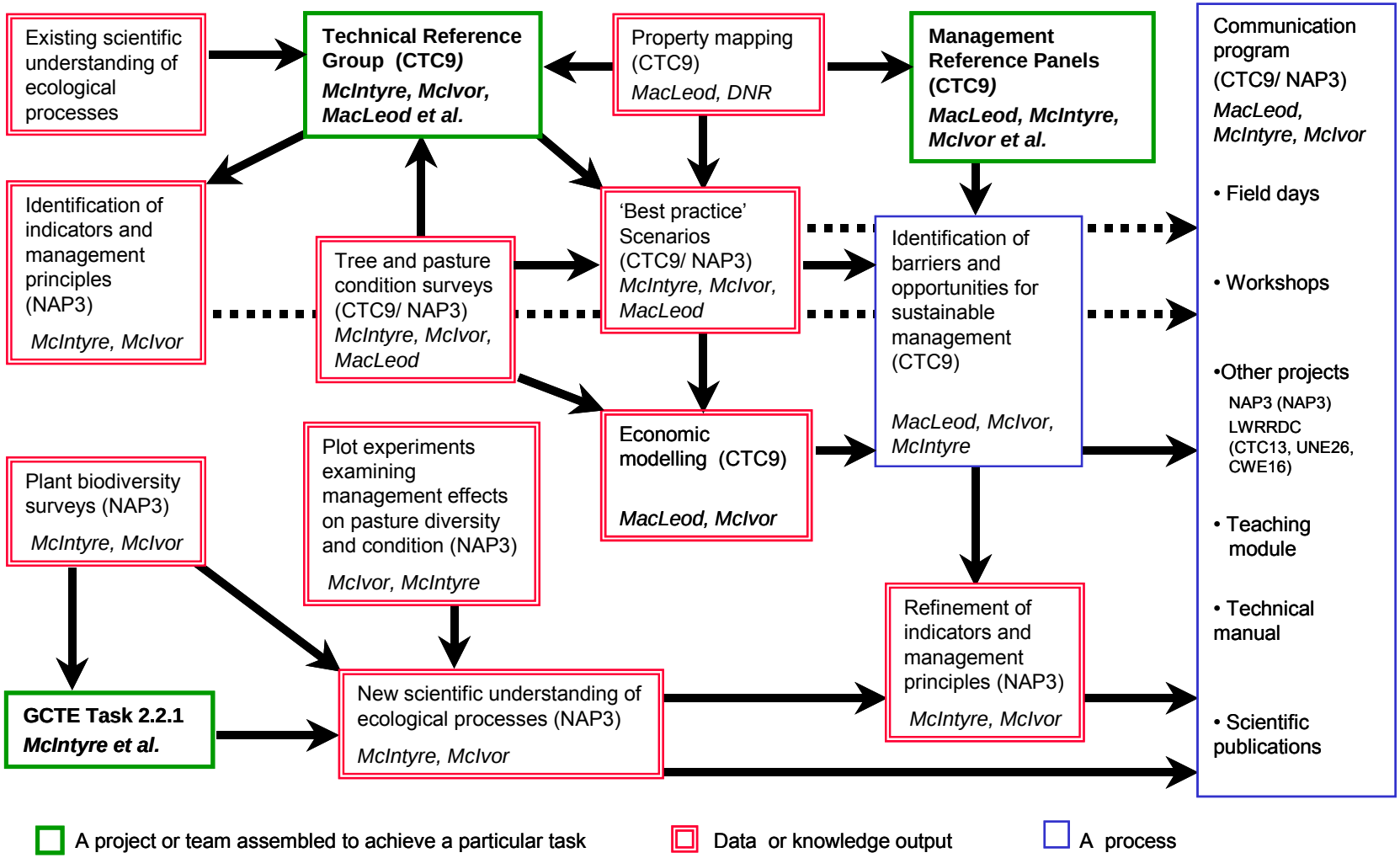


Figure 1. Flow diagram of the methodologies incorporating activities associated with NAP3.222 and EA/LWA CTC9.

Results and discussion

These will be discussed under headings corresponding to the six broad project goals.

1. Understanding biodiversity in relation to grazing

Objective: Significantly advance conceptual understanding of the relationships between the grazing of cattle and grazing management, and the conservation of regional biodiversity within the variegated landscapes of the north.

This objective was addressed in two ways:

- We conducted original research on the two case properties in the Crows Nest district, to better understand the effects of grazing, and other management associated with beef cattle production, on native grasslands.
- Existing knowledge on the ecological functioning of grassy woodlands and landscape processes was synthesized. This provided a starting point for communication and for the economic modelling.

The results are discussed in sub-sections below.

Pasture productivity, diversity and stability

In eucalypt woodlands, the grassy layer is the primary source of animal feed. It is also where most of the biodiversity is concentrated. We recorded 400 types of grassland plant in two seasons' sampling (McIntyre, Best & Martin, submitted). The insects, spiders and other invertebrates living amongst the grass and soil account for many more species. They are responsible for maintaining plant production through nutrient recycling and soil engineering. The structural condition of the grasslands, in turn, affects the ability of birds, reptiles and mammals to survive. These larger animals depend on plant growth and litter to provide food and tall grass tussocks to provide shelter and nesting sites.

The way grazing affects the biodiversity of grasslands has major implications for plant production, and ulitimately, livestock production.

The native pastures in the Crows Nest district were originally dominated by tall tussock grasses (species of *Themeda*, *Cymbopogon*, *Bothriochloa*, *Dichanthium*, *Aristida* and *Heteropogon*), but livestock grazing can cause obvious structural modifications. In these pastures it is possible to identify three patch types in paddocks:

- Tall tussock (dominated by some of the original species listed above);
- Short tussock (dense turf of small tussock species, especially *Eremochloa*, *Chloris*, *Eragrostis* and *Bothriochloa*);
- Lawn (a short dense turf of rhizomatous and/or stoloniferous species e.g. *Cynodon*, *Digitaria*).

The two short patch types vary in size, ranging from a square metre to a hectare. We hypothesized that the short tussock and lawn patches are similar to the short patches associated with heavy grazing and loss of pasture condition as described in a grazing trial in the Burnett region (MLA Project CS195; McIntyre 1996). The change in sward structure is also significant for the diversity of plants and animals that can persist in pastures.

Patch formation

We hypothesized that both short patch types resulted from high grazing pressure and that lawns developed when there were also increases in soil fertility. These were tested in an experiment which measured the response of tall tussock patches to mowing (representing grazing pressure) and fertiliser application (soil fertility) over three years. We transplanted short patch species to all treatments to ensure the possibility of patch transition. Methods and results are presented in Appendix 8, Part A.

The changes in abundance supported our initial hypothesis to some extent - the lightly defoliated plots remained dominated by the tall grasses and stoloniferous grasses were increasing on the heavy defoliation-high fertility plots. However, there was little change in the heavy defoliation-low fertility plots. This probably reflects a lack of seed of the low tussock grasses and slow rates of increase in size of these plants even if they are able to colonise new areas.

The experiment provided information that could not be generated from field observations, for example, fertiliser application reduced species density (richness). In the survey of different habitats in the study area, fertilization was always coupled with cultivation and it was not possible to separate the effects of the two disturbances. The experimental results suggest that applications of fertilizer onto native pastures could present problems for grassland conservation.

Management to alter patch type

Can short tussock or lawn patches be managed to encourage transition to tall tussocks? While short patches can provide areas of high quality grazing, they represent a problem for natural resource conservation if they are too extensive. Local producers have expressed an interest in restoring their pastures to *Themeda* and other palatable tall grasses. Resting from grazing and the use of fire are possible management tools and their effects were tested in two experiments. Cages were used to exclude grazing and some plots were burnt. Changes in species density and abundance were recorded for four years. Methods and results are presented in Appendix 8, Part B.

Overall, there were only small changes in the pasture composition during the four years of exclosure from grazing, and no responses to burning. In the lawn patches (dominated by *Cynodon* spp.) and short tussock patches (dominated by *Eremochloa*) these dominants were maintained where grazing continued, indicating the stability of these patches. When cattle were excluded, the dominants declined; in the short tussock patches, the dominant *Eremechloa* was replaced by tall grasses. In the lawn patches a variety of types of plant (but not tall grasses) replaced the stoloniferous grasses.

Our interpretation is that there were established, but suppressed tall grasses in the short tussock patches (e.g. *Themeda*). Once grazing was excluded, existing plants grew larger, but new plants did not establish in significant numbers. In the lawn patches, tall grasses appear to have been completely eliminated and establishment from seed did not occur. Perennial grass seeds do not persist in the soil (unpublished data) so once the adults are eliminated, seed dispersal must be combined with seed establishment to restore perennial grasses. Lawn and short tussock patches (with no tall tussock species present), therefore, represent a very stable state in the sense of conventional state-and-transition models.

Overall, our results confirm the stability of the native pastures under present management. The advantage of this is that these native grasslands are resistant to degradation - a fact reflected in their extremely good condition when assessed in the district (Martin *et al.* 2000; Appendix 3). A disadvantage is that, once composition is altered by grazing, the pastures are difficult to rehabilitate i.e. their resilience is low. Four years of pasture resting is a long spelling period, especially if changes don't occur.

Our observations of grazed patches and the high resistance, but low resilience, of the pastures is similar to that observed in the Glenwood grazing trial (McIntyre 1996). The Crows Nest observations were made on sandstone and metamorphic substrates, while Glenwood results are for granite. Thus the generality of the results is boosted by considering both studies.

However, the argument for pasture resting is still strong, as many pastures do support tall tussock species that are grazed down and not apparent to the manager. In this case, one or two seasons of resting should be enough to see whether tall tussock species are present. A second season of resting may be needed to enable these species to recover sufficiently to set seed.

Landscape patterns of grassland diversity

Our experimental results have confirmed that while manipulations are necessary to understand dynamics of vegetation, field observations of the landscape are also important to detect the effects of long-term management. Sampling over larger areas than plots is also needed to capture a realistic amount of variation in the vegetation at landscape scales. Our survey of habitats throughout the district (Fig. 2) enabled us to do this.

The aims of this survey were:

1. To make a comprehensive record of the understorey species occurring on the Crows Nest case study properties and surrounds.
2. To document how the patterns of plant diversity vary according to the environment (e.g. landscape position, soil type) and management variables (e.g. grazing, soil disturbance) that operate in the grassy woodlands.

The methods, results and interpretation of the data are detailed in Appendix 1 [McIntyre (2000), McIntyre, Martin & McIvor (2000), McIntyre & Martin (2001), McIntyre, Best & Martin (submitted), McIntyre & Martin (submitted)]. Key conclusions arising from this study are:

- Low intensity cattle grazing is compatible with maintenance of grassland diversity and function. The grasslands in the district, including the native pastures, were found to be amongst the most species-rich in the world (at the spatial scale measured) and contained many species of conservation significance.
- Although commercial native pastures can support a diversity grassland plants, there are a group of grazing-sensitive species that are restricted to roadsides, reserves and stock routes. These habitats are limited in area and are vulnerable to non-intentional destruction e.g. through roadworks, earthworks, fertilizer run-off and subsequent weed invasion.
- On properties, vulnerable grazing-sensitive species are likely to persist in areas with a light grazing history. As these areas are very restricted in grassy woodlands, they should be given high conservation priority in farm planning, and their development and heavy grazing should be avoided.
- The most significant threat to the native grasslands is further expansion of intensive land uses. Cropping, cultivation and fertilization would pose a major threat to grassland vegetation and would threaten 69 of the 121 native species analysed.
- Exotic pasture grasses are an invasive element of native grasslands. *Paspalum dilatatum* is invasive of all habitats and becomes dominant with any level of soil disturbance or enrichment. Rhodes grass (*Chloris gayana*) is absent from native pastures but becomes dominant in disturbed roadsides. When dominant, grasses such as green panic (*Panicum maximum*) can virtually eliminate other grassland species.

The development of principles and thresholds

In the previous section, we have described recent findings on the relationships between the grasslands, grazing, and other management. However, it is also necessary to consider the impacts of beef property management on the wider range of natural resources in grazed landscapes including soils, trees, water and native animals.

These management impacts should be viewed in terms of landscape scale ecological processes. It is increasingly evident that issues such as dryland salinity, water quality decline, eucalypt dieback and biodiversity losses have arisen through our failure to understand management impacts as they progressively accumulate across the landscape. This is where the concept of thresholds becomes important. Thresholds indicate a point above (or below) which a small change in a management factor will produce a large change in an ecological process. For example, tree clearing may have no observable impact on bird life until so much habitat is cleared, that birds can no longer move around in the landscape to eat, breed and avoid adverse weather conditions. Species then disappear from the landscape. The maximum point of clearing before abrupt changes to the bird community are observed is an example of a threshold.

Figure 2. Part of the survey area in the Crows Nest district showing the habitats that are typical of eucalypt grassy woodland that have been altered to become a variegated landscape as a result of clearing and habitat modification. From foreground: crops, sown pasture, grazed woodland, native pasture, roadside.

The concept of thresholds, the set of principles and thresholds developed, and their scientific rationale are presented in Appendix 1 (McIntyre, McIvor & MacLeod 2000) and Appendix 2. The principles are summarized in Table 1. A detailed description of the rationale and management issues associated with each point are given in Appendix 4.

The significance of the principles

Developing the principles and thresholds was the first stage of the project and they have been pivotal to the economic modelling as well as the communication activities of the project.

To our knowledge, this is the first serious attempt to fully synthesize the range of land management issues relevant to a production landscape and to quantify limits to resource exploitation from a landscape perspective. For this reason, the principles and thresholds have attracted considerable interest from researchers, extension officers, agency personnel and land managers. This interest has been intensified by the high level of activity generated by the Natural Heritage Trust program, and the numerous national state and regional planning activities with an interest in vegetation retention targets. Added to this is the growing recognition of salinity and biodiversity loss and various activities related to vegetation protection legislation.

Despite intense scrutiny, the scientific community has strongly endorsed the principles as being scientifically sound within the limits of the information available. It is important to note that our scientific knowledge is still incomplete and the thresholds in particular need further investigation. There have been some non-scientific concerns raised which can generally be related to one of the following:

1. Philosophical disagreement that quantified limits to development should be proposed at all. This concern can be shared by some people having a pro-development or pro-conservation perspective, as a limit to vegetation clearing also implies an allowance for vegetation clearing.
2. A perception that if the principles were implemented, all landscapes would be cleared down to 30%, regardless of their development current status.

Regarding point 1 we can only acknowledge that this is a difference of opinion. We understand the thresholds to be real, and that there can be frightening consequences to exceeding them (e.g. the loss of productive land to dryland salinity). Therefore, it important to formally recognize them.

Point 2 is more complex. It is true that if there were no other limits to development, that the thresholds specify a minimum of 30% woodland cover. However, this threshold is a minimum, and there is a hierarchy of other factors that affect the amount of woodland that may need to be retained or restored in a specific landscape. The principles take into account that it is not advisable to develop land beyond its capability, including retaining trees on steep slopes, water recharge areas and riparian buffer areas. The total retention (or restoration) rate could therefore be anywhere between 30 and 100% depending on the landscape (see Chapter 10, Appendix 4). There may be good reasons not to clear a landscape that has potential to be developed, but this would be based on other land-use objectives. The principles are identified as the ecological limits to development, given that this is the land use objective for the landscape.

Landscapes or properties

Another criticism that has been levelled at the principles and thresholds is that they have been developed for properties and are, therefore, not relevant to broader catchment or regional planning. The reality is that the information used to develop the principles is mostly related to landscape-scale evidence, or evidence that is scale-independent (e.g. neutral landscape models). We are not aware of emergent ecological processes that have been reported at the property scale, with the exception of Walpole's (1999) study of tree cover and property-scale production. The principles are therefore most relevant to catchment and regional planning. Our application to the problem of property planning has been based on the principle of equity (all landholders have a duty of care to manage and protect natural resources). We also believe that there will be some aggregative effect of good management at the property level that will reflect on the wider landscape. The context in which the principles were developed was that broader-scale planning was also proceeding, particularly in the requirement for a national network of conservation reserves (in addition to the environmental reserves on properties).

We do not know the range of scales at which all the principles apply, or could most profitably be applied. We are aware that collective and broader scale regional and catchment planning has the potential to produce good management outcomes. However, widescale collective action was not a reality in the study regions at the time the project commenced. Producers were largely acting individually on a daily basis, and will continue to.

Table 1. General ecological principles for the sustainable management of grazed woodlands. There are six main principles for sustainable management of grazed woodlands (sub-tropical grassy eucalypt woodlands). Further principles are defined under the main principles. The principles which are in italics are those that include thresholds (recommended upper or lower limits). These principles were first published in McIntyre, McIvor & MacLeod (2000). The wording, but not the intent, of Principle 5 has been revised in this version.

1. Property planning and management should include a long-term vision which considers the whole of the property and its place in the catchment.

1.1. Manage to the potential and limitations of the land, based on an understanding of ecological processes.

1.2. The precautionary principle of conservative or delayed development should apply.

1.3. Land uses of high intensity need to be balanced with significant areas of low intensity use across landscapes.

1.4. Land uses can have influences that spread beyond their boundaries so their arrangement across landscapes is important.

1.5. Vegetation representative of all the land types occurring on a property needs to be retained and managed.

2. Manage soils to prevent erosion and to maintain productive capacity and water quality.

2.1. *Keep the amount of bare ground exposed to no more than 30-40% of the ground surface in pastures.*

2.2. Place infrastructure in stable locations on the landscape to avoid erosion.

2.3. Some soil types require particular attention to avoid erosion and salt problems.

3. Manage pastures for production and to maintain the variety of plants and animals.

3.1. *Graze conservatively to maintain dominance of tall and medium tussock grasses over 60-70% of the native pastures.*

3.2. *Limit the extent of intensive land use (grain and forage cropping, sown pastures) to a maximum of 30% of the property area.*

3.3. Vary the management of pastures to provide for a variety of species and a diverse range of fodder sources.

4. Maintain local native trees for the long-term ecological health of the property and catchment.

4.1. *There should be a minimum of 30% woodland or forest cover on properties.*

4.2. Always favour natural regeneration of existing trees to planting and re-creating habitat.

4.3. *To be viable in the long term, woodland patches should be a minimum of 5-10 ha.*

4.4. Retain trees of different ages within stands to retain the long-term viability of tree populations.

4.5. Maintain or regenerate trees in appropriate places to minimize degradation, enhance livestock production and enhance diversity.

5. All properties require an environmental reserve for species that are sensitive to agricultural land uses.

5.1. Where possible choose the areas with existing flora and fauna values for ongoing management and include areas on good quality soils.

5.2. Retain critical habitat elements such as mature trees, understorey vegetation and standing dead and fallen timber for fauna.

5.3. Environmental reserves need protection from heavy or continuous grazing.

5.4. Ongoing weed control and fire may be required in environmental reserves.

5.5. Environmental reserves should be connected to others on the property or in the district.

5.6. *Manage at least 10% of the property as an environmental reserve*.

6. Watercourses are particularly important to the ecosystem and grazing enterprise, and require special management.

6.1. Vegetation should not be cleared up to the edges of watercourses.

6.2. As a general principle, livestock should be excluded from watercourses to reduce soil erosion and maintain the quality of water.

6.3. Control of exotic species in riparian zones is important.

2. Quantifying the relationships

Objective: Quantify these relationships for at least one ecosystem that is economically important to the northern beef industry.

Our experimental work and the data synthesis described above have enabled us to specify for a particular landscape a best-bet estimate of management and property layout that is ecologically sustainable. The thresholds listed in Table 1 represent the quantified assessment of ecological sustainability in grassy eucalypt woodlands, using the best available scientific information. By comparing these with the status of the four case study properties we were able to identify the extent to which the properties were within, or exceeded the thresholds. These are detailed in Appendix 3 and summarized in Table 2.

Our overall assessment is that the soil and pasture resources have been maintained in good condition on all four properties, particularly those in the Crows Nest district. With one exception, the properties had not been over-developed in terms of tree clearing and intensive land use was generally within the recommended threshold. In Queensland, intensive land use has been associated with increased levels of insect-mediated eucalypt dieback (Wylie *et al.* 1993), and therefore, increasing pressure is placed on remaining tree populations. If tree regeneration potential is lost under these circumstances, the long-term future of existing populations is at risk. The property with the fewest trees (10%) and the most pasture development (32%), also had the lowest level of tree regeneration. Significant tree dieback was recorded in the blue gum and narrow-leafed ironbark populations on this property, indicating that it had entered a downward spiral of tree decline and accelerated tree death.

While the tree and pasture resource was in good condition for three of the properties, there were issues associated with the types and location of the retained vegetation and the management of riparian areas on all four properties (Table 2). Specifically, these concerned:

- *The high level of clearing of vegetation types on the most fertile land types*. This pattern is consistent with that of the rest of Queensland (Sattler & Williams 1999). It is an issue because of the loss of specific plants and animals that are associated with particular vegetation and soils. The fact that these vegetation types are poorly represented in the formal reserve system intensifies the problem.
- *Livestock access to riparian zones and watercourses*. The general recommendation from a wide range of sources is for stock to be excluded from these areas (Appendix 4, Ch. 7).
- *The high level of clearing in riparian zones.* This is related to the fertile land issue as fertile soils are often associated with the lower parts of the landscape and therefore to watercourses. These areas have a high level of importance to producers (for the level of production obtained), livestock (for access to water, shade and high quality forage) and wildlife (access to particular types of habitat and a stable food resource). Water quality and other pollutants are a concern to urban dwellers and downstream water users.

Table 2. Summary of condition of case study properties in relation to selected management principles and thresholds.

Principle or threshold	Status of case study properties
1.5. Vegetation representative of all the land types occurring on a property needs to be retained and managed.	All properties had at least two land types that had retention rates of <10% of original extent.
2.1. Keep the amount of bare ground exposed to no more than 30-40% of the ground surface in pastures.	The two Crows Nest properties easily conformed to this threshold and the Burnett properties less so.
3.1. Graze conservatively to maintain dominance of tall and medium tussock grasses over 60-70% of the native pastures.	All properties conformed to this threshold and had adequate densities of tall and medium tussock grass species.
3.2. Limit the extent of intensive land use (grain and forage cropping, sown pastures) to a maximum of 30% of the property area.	All properties conformed to this threshold with intensive development ranging from 0 - 32%.
4.1. There should be a minimum of 30% woodland or forest cover on properties.	This threshold was met for three of the properties (range: 29 - 49% woodland cover). One property had only 10% retention.
5.6. Manage at least 10% of the property as an environmental reserve.	Only one of the four properties had any land managed specifically for sensitive species and this property had a fenced off rugged area representing 1% of the property.
6.1. Vegetation should not be cleared up to the edges of watercourses.	Riparian vegetation was less than the buffer areas recommended from regional tree clearing guidelines (ranging from 34 - 56% of the suggested area).
6.2. As a general principle, livestock should be excluded from watercourses to reduce soil erosion and maintain the quality of water.	Livestock was not excluded from any watercourse on any property.

3. Linking quantified relationships to enterprise returns

Objective: Link these quantified relationships to measures of productivity, and thence to economic indicators of enterprise returns, and assess alternative management strategies for both economic and biodiversity costs and benefits.

Management actions to apply the principles involve controlling grazing by livestock, regeneration or retention of trees, planting trees, use of fire, and locating infrastructure such as fences and water. The most direct economic effect on grazing enterprises of pursuing these strategies will be a reduction in the available supply of forage for stock. This follows restrictions to grazing in certain parts of the landscape such as riparian areas and dedicated environmental reserves. Also, stocking rates must be reduced as timber density increases in the areas identified, as we considered the current grazing pressure appropriate under the guidelines and maintained it in the scenarios. The application of the forage and economic models to predict economic performance under the scenarios are detailed in Appendix 4 (Ch. 8). The results are summarized in Tables 3, 4 and 5.

Table 3. Area (ha) of additional woodland required under the scenarios in which the principles and thresholds are applied to the four case-study properties.

	Case property			
	A	B	C	D
Salinity risk recharge area without woodland cover	145	1707	0	0
Additional woodland area needed for riparian buffers	41	333	59	112
Additional woodland area needed to ensure viable patches of all vegetation types	1	0	0	1
Additional area to provide overall 30% woodland	25	0	0	0
Total additional woodland	212	2040	59	113
Regenerate	48	895	38	72
Plant	164	1145	21	41

As Table 3 indicates, the greatest requirement for woodland was to restore cover to recharge areas and riparian areas. Once this was done there was virtually no requirement to provide additional woodland to represent all vegetation types. This reflects the close proximity of fertile soils and watercourses. Only one property required additional woodland simply to meet the 30% minimum woodland threshold. The most heavily impacted property under the scenario was one that had cleared over 1700 ha of woodland for sown pastures on soil considered to represent a salinity hazard. Adjustment of the amount of pasture production available over the properties with the projected areas of woodland is detailed in Table 4. Reductions in forage production ranged from 8-23%.

Table 4. Estimated total pasture production (tonnes of dry plant material per property) on four case-study properties under existing management and under scenarios in which the principles and thresholds were applied.

	Case property			
	A	B	C	D
Existing	3,900	28,000	2,400	5,000
Scenario	3,000	21,500	2,100	4,600
% decrease	22	23	12	8

By maintaining current utilization rates and adjusting herd size, it was possible to model impacts on gross margin and net profit for each property. Reductions in profit were $21K, $83K, $6K and $10K for properties A-D respectively (Table 5). These estimates of the impact on enterprise profitability of fully adopting the principles paint a bleak prospect for wide-scale action in the short term. The longer-term economic climate for extensive livestock production on grassy woodlands places limits on managers' scarce financial and labour resources. For example, ABARE (2000) surveys consistently reveal a significant proportion of specialist livestock enterprises are earning low net incomes and carrying substantial levels of debt. Some enterprises will struggle to persist in the medium to longer term. The ongoing and deteriorating cost-price squeeze is making conditions progressively worse. These are not encouraging signs for sacrificing present income for future and uncertain gains.

However, there is also an ecological imperative that underlies the need to implement the principles. Positive action needs to be taken. Moreover, this action will need to start with generally limited public support until the necessary institutions are in place to more appropriately balance private and public shares in the costs of the necessary ecological investment (Young *et al.* 1996; Binning 1997).

Table 5. Financial performance of the four case-study properties under current management and under scenarios in which the principles and thresholds were applied.

	Case Property			
	A	B	C	D
Total Herd Size (adult equivalents)				
Present	388	1998	429	771
Scenario	304	1545	379	711
% decrease herd size	22	23	12	8
Total gross margin ($'000)				
Present	100	363	70	91
Scenario	79	280	64	81
% decrease gross margin	21	22	9	11
Overhead costs ($'000)	64	249	49	64
Net profit ($'000)				
Present	36	114	21	27
Scenario	15	31	15	17
% decrease net profit	58	73	29	37

The above reflections on levels of woodland cover to offset salinity hazards and to rehabilitate riparian buffers provide something of a clue for making the breakout and making some partial steps towards the ideal future landscape balance. We suggest that the costs of augmenting woodland cover to avoid salinity hazard might be reduced if we knew more, so that we could target planting to strategic parts of the recharge zone. Similarly, if we could reach a reasonable consensus on 'duty of care' for riparian vegetation, it might be possible to make some steps to achieving much of the gain that might come with full adoption. This is consistent with the notion of the Pareto 80:20 rule in which 80 percent of the gain might accrue to the first 20 percent of commitment, if this is strategically planned. In a major sense, this requires a re-framing of the question on adoption from "why?" to "why not?" and "how?".

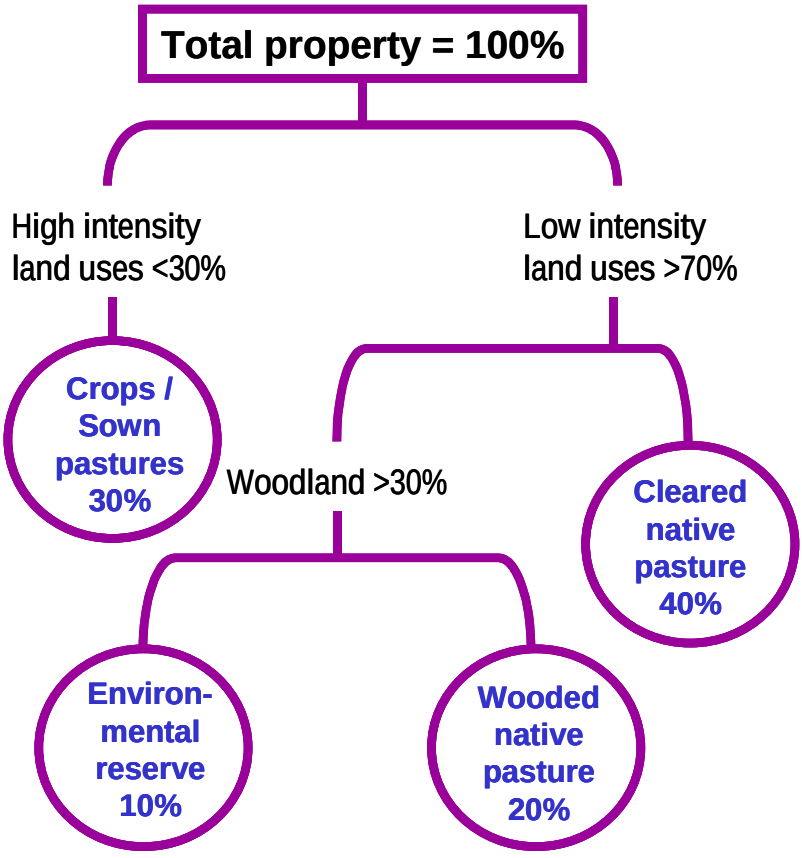
4. Practical measures to conserve biodiversity

Objective: Identify practical measures to conserve biodiversity that producers can incorporate within their sustainable management practices, together with simple indicators they can use to assess results and continue to adapt and improve management.

Indicators

Our principles and thresholds provide a comprehensive framework of indicators to cover all major natural resource issues on grazing lands. Our approach differs from others in that we have used types and extent of land uses or landscape elements as key indicators. This is innovative in that we have developed indicators incorporating landscape-scale processes that are increasingly important. Land use is a deceptively simple but effective indicator of ecological sustainability. Given their simplicity, and ease of recording at the property scale, the main challenge is gaining acceptance of land-use indicators. We also need a stronger technical basis for justifying these indicators and their relevant thresholds. Current information is significant, but rudimentary. The broad land use indicators and their thresholds are illustrated in Fig. 3.

Figure 3. Three broad land-use indicators and their thresholds for maximum development on a grassy woodland landscape, that would be considered ecologically sustainable. With combinations of grazing and clearing, four land uses are derived.



Indicators that relate to the location or extent of woodland include the following:

- Vegetation representative of each land type retained (≥10% of each regional ecosystems type is the legal minimum at the bioregional scale and would ideally be applied at the property scale. Patches of vegetation should be a minimum size of 5-10 ha, depending on the surrounding land use)
- Extent of woodland cover on recharge zones (100% revegetation of recharge areas above salt sources used in scenarios)
- Riparian zones supporting native vegetation (using existing tree clearing guidelines)

The following indicators of pasture condition within land uses are relevant to cleared native pasture and grazed grassy woodland:

- Tall and medium tussock grasses dominate native pastures (Threshold: 60-70% of pasture area has these grasses dominant).
- Bare ground (Threshold: ≤30-40%)

Indicators of condition within environmental reserves include the presence of mature trees, understorey vegetation and standing and fallen dead timber. Thresholds have not been set for these indicators.

Some of the indicators are easy to monitor with tools as simple as a property map (intensive land use, areas grazed), aerial photos (woodland cover) and visual observations may be sufficient for informal monitoring (see Appendix 4, Ch. 10 for further discussion about the use of indicators and principles).

Practical issues associated with implementation of the principles are discussed in each of the chapters of the technical information manual (Appendix 4). Full implementation of the principles requires all the natural resource information that would be required to develop a farm plan. In some cases, accessing this technical information will make some indicators technically difficult to apply. For example, with salinity hazard mapping incomplete for northern Australia, the identification of recharge areas and potential salinity problems is difficult and requires on-site assessment by experts. Even then, hazards may not be identified reliably enough to justify major remedial works to managers.

Riparian management

Perceptions of practicality are affected by the motivations of the managers and the extent to which they might see conservation measures as being desirable. For example, the desirability of fencing riparian zones from livestock is widely accepted in southern Australia, and techniques are well developed (e.g. see Lovett & Price 1999). In contrast, the fencing of riparian zones was identified amongst the Management Panels as the most problematic and least practical of the potential management changes. Differences in perceptions of practicality may arise from:

- The issue is relatively new in Queensland; water quality issues have been subjected to longer and more intensive debate in southern Australia.
- The more extensive land use in the Queensland study area may make actual and/or perceived impacts of livestock on watercourses and water quality less evident. Most streams are dry for most of the year and they are generally stable.

On individual case properties, there are up to 70 km of watercourses identified for protection and the capital costs of implementation are extremely high (Table 6). Managers have argued that good grass cover is better for soil protection than trees. However, the role of trees in providing structural stability to banks and habitat for wildlife needs to be considered. The project team did not have the resources to adequately explore this issue, or provide solutions, and our observations are at odds with activity in northern Qld where extensive fencing of riparian areas is supported by National Heritage Trust funding. Because riparian areas and

watercourses are of such great ecological and financial significance, an important area to explore is the trade-offs associated with riparian protection. The technical underpinnings of riparian management under the scenarios needs critical review and practical responses need to be identified. This is particularly important given pressures on northern Australia's wildlife and water resources will inevitably increase.

Table 6. Capital costs required to implement protection of riparian areas from livestock on four case-study properties. Details are provided in Appendix 4 (Ch. 8).

	Case Property			
	A	B	C	D
Fencing riparian areas				
Length of riparian boundary (km)	22	140	21	43
Fencing cost ($)	45,000	490,000	42,000	130,000
Off-water watering points				
Number of points	5	16	6	11
Cost of watering points ($)	20,000	64,000	24,000	33,000
Tree planting				
Area planted (ha)	164	1,145	21	41
Cost of tree planting ($)	165,000	1,145,000	21,000	41,000
Total Capital Outlays ($)	230,000	1,699,000	87,000	204,000
Capital/ha of holding ($/ha)	219	168	88	116

5. Determining generality of the results

Objective: Assess whether the results of this project can be used to assist management for conservation of biodiversity in other ecosystems within northern Australia.

Through our numerous interactions with researchers and land managers Australia-wide, we have been able to consider the relevance of the principles and thresholds to other ecosystems (see following section on communication) and have discussed the topic in Appendix 4 (Ch. 10). There are three issues that are pertinent to the discussion of generality: the sources of evidence, the relevance of the land uses and existing landscape condition.

Sources of evidence

One objective of the project was to identify a minimum ecologically sustainable state for eucalypt grassy woodlands in south-east Queensland in landscapes that were variegated (i.e. intensive land use over 10-40% of the landscape, McIntyre & Hobbs 1999). We used specific ecological information on Australian grassy woodlands throughout their latitudinal range (tropical to temperate). Much of the information was drawn from temperate studies, but there were also significant observations from the tropics and sub-tropics (e.g. Wylie *et al.* 1993 on eucalypt dieback). The feedback that we have received indicates that, from an ecological perspective, the principles are highly relevant to all eucalypt grassy woodland systems throughout Australia, and can be directly applied.

Other significant evidence was drawn from theoretical landscape ecology (neutral landscape models) and empirical observations of ecosystems worldwide (McIntyre, McIvor & MacLeod 2000). Both sources of evidence informed the 30% woodland threshold (therefore the term woodland can be substituted for any major vegetation or habitat type relevant to any

landscape). The 10% environmental reserve threshold is drawn from observations of representativeness of grassy woodland habitat and neutral landscape models. The notion of 70% habitat retention for organisms with low mobility is also related to neutral landscape models, but is complementary to empirical observation of eucalypt dieback in Queensland that support limitations of intensive land use to around 30%. Thus the landscape scale land-use thresholds have a fundamental biological relevance to all ecosystems. Where there is empirical evidence, it has turned out to be complementary to the theoretical predictions.

However, it should be noted that the empirical evidence is very limited and as more landscape-scale observations are made, the variation in landscape response (and methodological approaches) will become evident. If the theoretical predictions that we have used are sound, it will take many, rather than a few observations to confirm them.

Relevance of the land uses and vegetation types

This is one of the most easily identifiable 'objections' to generalizing. If a landscape does not support a grassland layer, then thresholds pertaining to grassland extent or condition are irrelevant. Similarly, if cropping is not practised on a particular landscape, the thresholds relating to this land use may appear irrelevant (although land use change can be rapid and the possibility of future intensive use should always be kept in mind). On other landscapes, shrub layers may occur instead of tree layers.

In some cases functional equivalents to vegetation layers and modified habitats can be identified. However, the principles would still need to be tailored to reflect the types of vegetation, the types and amount of land-uses or vegetation states, and the indicators of condition. This would involve reviewing the fundamentals of what the thresholds mean and how the land uses affect the biota. At the coarse scale, this may not be particularly difficult, but relies on a reasonable knowledge of the effects of management on the biota. Some 'top of the head' examples are given in Table 7.

Table 7. Examples of levels of land use relevant to different landscapes. The types and amounts of the suggested land uses are derived from interpreting the principles in the context of existing development and vegetation types. The high intensity land uses represent a maximum, assuming there are no other limits relating to land use capability, riparian protection, salinity etc. Percentages are the extent of the land use across the landscape. Apart from the eucalypt woodland figures that are justified in McIntyre, McIvor & MacLeod (2000), these represent examples rather than recommendations.

	Intensity of land use or management			
Landscape type (alteration state)	**High**	**Medium**	**Low**	**Very low**
Grassy eucalypt woodlands - temperate to tropical (variegated)	Cropping, sown pasture (30%)	Cleared native pasture (40%)	Grazed grassy woodland (20%)	Environmental reserve (10%)
Tropical eucalypt woodlands (intact)	-	Heavily grazed in areas of high use (10%)	Grazed but uncleared (80%)	Environmental reserve (10%)
Woodlands (fragmented)	Cropping (60%)	-	-	Environmental reserve (40%)
Brigalow (fragmented)	Cropping, sown pasture (50%)	-	Grazed brigalow regrowth in rotation with cropping (20%)	Environmental reserve (30%)
Semi-arid rangelands (intact)	Heavily grazed, close to watering points (10%)	Grazed, intermediate distance from water (40%)	Grazed, large distance from water (40%)	Far from water, beyond the reach of livestock (10%)

Existing landscape condition and land use

A fundamental barrier to generalization is that of existing landscape alteration state. An important example is that of intensive land use. A 30% upper limit to intensive land use is likely to be relevant to all grassy eucalypt woodlands owing to their susceptibility to insect mediated tree dieback. If development exceeds this threshold, we predict that there will be increased incidence of eucalypt dieback and, with increasing extent of intensive use, progressive local extinctions of plants and animals. However, in a predominantly (90%) cropped landscape, it would neither be economically feasible, or socially acceptable to suggest reducing intensive land use to one third of current. The discrepancy between the ideal and actual levels of land use points to severe ecological problems for these landscapes. Nonetheless, it is not necessarily constructive to present biodiversity ideals as management recommendations in the first instance, particularly when we need to better quantify the trade-offs between conservation and production on fragmented and relictual landscapes. Maintaining biodiversity is a different process to restoring it.

It is possible for principles and thresholds to reflect either ideal states, or pragmatic targets, as long as these are stated, and acknowledgement of potential compromises are made evident. For example in the principles and thresholds publication (McIntyre, McIvor & MacLeod 2000) we point out that under the scenarios, organisms with various combinations of tree-dependency, low mobility and grazing sensitivity will experience the landscape as fragmented and may therefore be at risk. This is probably the most difficult challenge to generalizing, as it is easy for important contextual information to be lost in the process of communication.

In Table 7, the scenarios for fragmented woodlands and brigalow reflect achievable rather than 'ideal' targets for these already highly developed landscapes. Because we know the viability of habitats can be enhanced by locating habitats in such a way as to maintain connectivity for organisms, this becomes an important strategy in landscapes where habitats are fragmented, and revegetation is only going to be undertaken to a limited extent. Within these less conservative management levels, intelligent landscape planning can do much to enhance the outcome for plant and animal conservation.

6. Communication of results

Objective: Proactively publicise and disseminate project results to the industry and others concerned with natural resource management in northern Australia, including providing assistance to producer-led management within NAP3.

In our communication plan (see Appendix 1), we identified seven areas of planned communication activity and have focused our activities in these areas. In addition to the these outputs (detailed below), we have produced six refereed scientific articles and seven conference papers (Appendix 1).

Learning module, the landscape game and associated workshops

The learning module 'Balancing Conservation and Production' is a presentation of the principles and thresholds in a non-technical format, with explanation of the ecological terms and concepts that underpinned the principles (see Appendix 2). The material was developed into a resource book for people working in extension and community learning areas. The module, and its introduction to stakeholders in a workshop environment, has been at the centre of the project's success. The draft module was presented at three one-day workshops in Bundaberg and Toowoomba in November 1999. In this phase, 75 people, mainly extension, catchment and landcare co-ordinators attended.

Successful strategies were the careful design of the workshops and the use of a professional facilitator. The habitat connectivity game was developed as an exercise in the workshops and was a great success, being scored on average 9/10 while the rating for the three workshops averaged 8/10 (see Appendix 5).

An edited version of the module was introduced in a second round of two workshops in Toowoomba and Bundaberg in March, 2000. These workshops were also very well received by the great majority of attendees. The learning module was finalised in April 2000 and is being distributed in booklet form. An electronic pdf version is also available on the web. A total of 114 people attended the five workshops and the process was very successful in providing feedback to the module and eliciting interest in the project's outputs. We have subsequently distributed approximately 500 copies of the module and are still receiving requests from across the country and overseas.

Technical information manual

A draft technical information manual to provide the technical background for the module was completed in February 2001 and is appended (Appendix 4).

Field days and workshops

Field days and meetings were initiated and organized to involve the case study producers and the Management Panels in the review and assessment of the scenarios as follows:

- Field days in Auburn (July 1998), Mundubbera (September 1998) and Crows Nest regions (November 1998).
- A second round of meetings for the Management Panels was held to consider the economic implications of applying the principles on the case study properties (Auburn and Mundubbera - April 1999, Crows Nest - August 1999).

We wanted to more systematically explore the issues associated with adoption of sustainable management, with the three Management Reference Panels, particularly in relation to the principles and thresholds that have been the focus of our previous discussions. To achieve this, interviews were held with 26 individual panel members in February 2000 (Auburn, Mundubbera) and May 2000 (Crows Nest).

Open field days were held at:

- Crows Nest, November 1998.
- "Stanley House" near Esk, in association with Beef Improvement Association, November 1999.
- "Yerilla" Auburn River, near Mundubbera, September 2000.

Spoken presentations

The following presentations were made to meetings and workshops. Only those not resulting in subsequent publications are listed.

MacLeod N.D. *Sustainable management of variegated landscapes for livestock production and nature conservation – Balancing ecology, economics and human preferences.* Paper presented at Nature Conservation in Production Environments conference at Taupo, N.Z. (December 1997).

McIntyre, S. *Human impacts on landscape*s. Seminar, CSIRO Wildlife and Ecology, Canberra (May 1998).

McIntyre, S. *Principles for sustainable grazing in eucalypt woodlands*. Presentation to extension officers, Brian Pastures (November 1998).

McIntyre, S. Presentation on landscape design principles at workshop for MLA, UGA and pastoral industry representatives 'Biodiversity and grazing management', Brisbane (November 1998).

McIntyre, S. *Principles for landscape design and management.* Regional landcare and catchment forum, Mary, Burnett and Baffle Catchment areas at Brian Pastures, Gayndah (June, 1999).

McIntyre, S. *Functional role of biodiversity.* CSIRO Component meeting. Adelaide (June, 1999).

McIntyre, S. Co-convened (with Sandra Díaz, Universidad Nacional de Córdoba, Córdoba, Argentina) a symposium at the VI International Rangelands Congress on the theme 'Range Management and Plant Functional Types (July 1999).

McIntyre, S. Landscape game presented to Crows Nest Catchment Landcare Group (November 1999).

McIntyre, S. Presentation describing the principles and thresholds at a Nature Conservation Council workshop on setting targets for vegetation retention and revegetation in Sydney (March 2000).

Green, J. Landscape Game demonstration at Get Active Day, Tallebudgera (April 2000).

McIntyre, S. *Sub-tropical grasslands.* Seminar at Department of Ecosystem Management, University of New England, Armidale (May 2000).

McIntyre, S. Workshop to advise NSW National Parks on the identification of targets for bioregional conservation, Sydney (July 2000).

Green, J. Landscape Game Demonstration at Northern Grassy Landscapes Conference, Katherine (August 2000).

MacLeod, N. Presented information to the House of Representatives Standing Committee on Environment and Heritage Inquiry into impact of public good conservation measures on private landholders, Brisbane (September 2000).

McIntyre, S. *Dr Pangloss visits south-east Queensland in 2010*. Greening Australia's 2000 Conference at Gatton, (September 2000).

Martin, T. G. *Data needs for planning for sustainable grazing*. DPI workshop: Data needs and data integration for regional vegetation management, Brisbane (October 2000).

McIntyre, S. *What is biodiversity?* CSIRO Long Pocket Laboratory, Seminar (March 2001).

McIntyre,S. *Setting vegetation targets to meet multiple objectives.* Land and Water Australia Stakeholders' Forum, Barossa Valley, (May 2001).

McIvor, J. *Identifying production-conservation tradeoff: the economics of beef cattle grazing with active conservation management in S.E. Queensland.* Land and Water Australia Stakeholders' Forum, Barossa Valley, (May 2001).

McIntyre, S. *Principles and thresholds for sustainable management of grazing lands.* Talk at Southeast Queensland Nature Refuge Field Day, Esk (July 2001).

Project newsletter

A project newsletter has been produced on a six-monthly basis (Appendix 1) between 1998 and 2001. Our mailing list has grown from 220 (Issue 3) to over 400 (Issues 4-6). Although it provides a useful way of maintaining contact with a large number of people, and we have had positive feedback, we think that the cost-benefit of producing a newsletter should be considered.

Media activities - radio and television

A Media Release "Playing CSIRO's environment game" was released in March 2000. This attracted media activity including: Channel 10 evening news ; Good News Week on Saturday evening; ABC regional radio (including Queensland Country Hour); Indigenous Radio (4K1G); Radio Australia.

A major interview relating to landscape thresholds on Radio National (Earthbeat) was broadcast in March 2000, but was initiated through scientific connections rather than the media release. Other activities included a 'Totally Wild' TV segment on sustainable landscapes filmed on a case study property in May 2001 and an interview for CSIRO Awareness for Sci-Files on i) Landholder perceptions of the landscape principles; ii) Grazing and conservation. A CD-ROM containing the material was distributed to radio stations, October 2000.

Success in achieving objectives

1. Learning module

Develop a learning module introducing concepts of ecological sustainability and biodiversity conservation in a whole property context. Milestone 10 was the submission of a draft to MLA by July 2000.

The learning module was submitted nine months prior to the milestone deadline and the draft was piloted at a series of workshops.

The module 'Balancing Conservation and Production' is a presentation of the principles and thresholds in a non-technical format, with explanation of the ecological terms and concepts that underpinned the principles (see Appendix 2). The material was developed into a source book for people working in extension and community learning areas. The module, and its introduction to stakeholders in a workshop environment, has been pivotal to the project's impact. The draft module was presented at three one-day workshops in Bundaberg and Toowoomba in November 1999. In this phase, 75 people, mainly extension, catchment and landcare co-ordinators attended.

Successful strategies were the careful design of the workshops and the use of professional facilitator. The habitat connectivity game was developed for an exercise within the workshop program and was a great success being scored on average 9/10 while the rating for the whole workshops averaged 8/10.

An edited version of the module was introduced at second round of two workshops in Toowoomba and Bundaberg in March, 2000. These workshops were also very well received by the great majority of attendees. The learning module was finalised in April 2000 and is available in booklet form. An electronic pdf version is available on the web. A total of 114 people attended the five workshops and the process was very successful in providing feedback to the module and eliciting interest in the projects outputs. We have subsequently distributed approximately 500 copies of the module and are still receiving requests from all over the country.

"*I read your paper this morning and was extremely impressed with your presentation of the issues. The paper would have to be the most relevant, succinct, easily digested I have come across. I congratulate you on presenting a paper which all farmers must have as compulsory reading.*" Gavin Wall, NSW Farmers Association.

2. Technical information manual

Develop a manual providing appropriate technical information for producers and other resource managers wishing to implement sustainable management.

Milestone 13 was the submission of a draft to MLA by October 2000. This milestone was renegotiated for February 2001.

The draft manual was submitted in February 2001 and a copy is presented in Appendix 4. The manual consists of contributions from seven members of the research team and contains ten chapters explaining the technical detail behind the management principles, as well as sections on financial issue, adoption and implementation. The chapters have been sent to reviewers in relevant fields and most reports have been received. CSIRO publishing has expressed interest in the publication of this manual as a book and negotiations are being conducted.

3. Implementation

One hundred beef producers in northern Australia implementing management strategies on their properties to maintain biodiversity and sustainability.

As a result of the usage of the learning module, the content relating to the principles and thresholds reached 1543 landholders. The information contained in the module changed perceptions of conservation management in 942 landholders. This means that these landholders have a better understanding and greater awareness of the issues of conservation management in terms of their own properties. Of these 942 landholders, 418 (44%) have changed their property management practices to incorporate some conservation measures. The majority of landholders were involved in beef cattle grazing (81%), the others were dairy farmers or involved in cropping or farm forestry. The method of evaluation is presented in Appendix 7.

"*I have found your work to date very interesting and as you know we constantly write your findings into our landholder management agreements because they (your findings) make a lot of sense.*" Steve Cupitt, Regional Extension Coordinator, Greening Australia QLD Inc.

4. Creating awareness

At least 500 producers demonstrating awareness of the role of biodiversity on their properties.

As described above, our evaluation had indicated that as a result of usage of the concepts presented in the learning module, the material has reached 1543 landholders and has changed perceptions of conservation management in 942 landholders. This substantially exceeds the set objective of 500.

5. Communication

Communication activities aimed at building the capacity of extension personnel to promote practices to maintain biodiversity and sustainability.

Our evaluation has shown that through communications with extension networks, we have been effective in reaching producers and promoting awareness of issues relating to biodiversity and sustainability. As described above, the use of the project outputs by Queensland extension officers have resulted in the material reaching over 1500 producers, has produced considerable changes in perceptions and has influenced management actions amongst producers. A specific example of usage of the material by an extension officer is given in Appendix 6. This activity was a contribution to NAP3.213.

A major strength behind our communications has been the timely publication of the technical underpinning of our work in scientific papers. This has provided a strong supporting base for the material amongst our specialist stakeholders and has added considerably to the credibility of our work.

We have been innovative in our translation of technically difficult material into easily understood text, graphics and spoken presentations. The development of a board game to demonstrate a key aspect of landscape ecological theory is another example of innovation. This game was incorporated into our workshops and was crucial in demonstrating the importance of thresholds in land use and the impacts of vegetation clearing.

In addition to the communication activities targeted specifically to extension networks in Queensland, our work has appeared in 29 press and popular articles and we have presented material in 19 invited oral presentations. These communications have attracted interest from all over Australia.

The learning module and landscape game were selected by Land & Water Australia in June 2001 to be included in their Innovations Database, which describes the "Top 50" innovations in natural resource management.

Impact on the industry

Our project has substantially raised awareness of ecological sustainability and biodiversity conservation issues in northern Australia. The project has been timely in that it has been able to provide a sound scientific basis for a dialogue on these issues at a time when investment via the Natural Heritage Trust was substantial, and when legislative changes were occurring. It has been effective due to the team's ability to translate ecological concepts into easily understood language and learning tools. In the 2000 peer review (Lambert 2000), the project was described as "..influencing industry management guidelines and practices." and "…(having) major industry implications".

Although our project team was not directly involved in the establishment of tree clearing legislation, we are aware that the landscape principles and thresholds were one of the few relevant sources of scientific information available to those considering Duty of Care Provisions and vegetation management legislation in Queensland, and that the project outputs are currently of interest in relation to the development of targets for natural resource management planning at the catchment and regional scale. While we realize that the legislative approach has not been widely accepted by stakeholders in the beef industry, the Queensland Vegetation Management Act (1999) is not overly restrictive in terms of seeking ecological sustainability. For example, there are no limits to intensive land use (e.g. sown pastures), despite indications that this can impact on water quality and the viability of remnant vegetation. Also, although the policy code states that remnant vegetation should not be reduced to less than 30% of its pre-clearing extent, this applies at the scale of bioregions (Queensland has 13 bioregions), leaving the possibility of over-clearing in individual catchments and on properties. The legislation can therefore only be seen as a bottom line for biodiversity protection, and best practice will only be achieved by conscientious development and implementation of Regional Vegetation Management Plans.

The project has had influence beyond northern Australia. Our work has stimulated the MLA Sustainable Grazing Systems key program to take a similar approach in temperate Australia. We have also been frequently consulted to contribute to processes associated with catchment and landscape planning in southern Australia, while the Land and Water Australia Native Vegetation Program is now explicitly addressing the question of landscape thresholds in its new R & D program. Commissioned projects are to test aspects of the principles and thresholds in Queensland, Western Australia and Tasmania.

We have identified that while producers generally have a positive view of ecologically sustainable management, they face substantial barriers to implementation e.g.

1. The economic penalties of restoring landscapes to adequate tree cover and appropriate patterns of grazing are substantial. When farm profitability is low, the impacts can be very high. Attempts to increase profitability by raising stocking rates, or expanding areas of crops and improved pasture will only accelerate damage to natural resources and further contribute to losses of biodiversity.

2. The areas that have the greatest need for conservation management are the riparian areas and fertile land types. These are the areas that are most desirable for production and for which there are both attitudinal and financial obstructions to change.

3. The benefits of improved landscape management are long-term, while the costs of implementation are immediate. In addition, the benefits may not always be directed towards producers, or at least be perceived as beneficial to them. For example, fencing and regenerating riparian areas appear to offer considerable advantages for biodiversity conservation and water quality improvement, but these may be valued more by downstream and off-site users than by producers.

We consider the major **threats to sustainability** in grazing lands in Queensland to be:

1. **Lack of long-term protection of native grasslands and pastures.** Technical difficulties have meant that as a vegetation type, grasslands and the grassy layer of eucalypt woodlands are not protected under the *Vegetation Management Act 1999, QLD*. This is a problem as most of the diversity in grassy woodlands is in the grassy layer, and its condition determines the health of tree and wildlife populations. Sown pastures and fertilizer, rather than grazing, are the major threats to grassland. Protection is currently afforded only by economic conditions; it is not perceived to be profitable to expand these technologies on a significant scale. Changes in commodity prices and new technologies could turn this situation around overnight.

2. **Loss of tree regeneration capacity**. Tree control is a major management input for producers, and there is a prevailing view that this burden should be eliminated. However, the loss of tree regeneration processes on the landscape means the beginning of a tree decline process. Initially this might provide relief to producers, but decades later, biodiversity losses will be felt and salinity hazards will become salinity problems. From a practical management perspective, is far easier to kill trees than it is to establish them.

3. **Failure to protect riparian areas.** Our findings have supported other evidence that watercourses and their adjoining lands represent key parts of the landscape that need protection. Functionally, watercourses integrate management impacts from all over the catchment. Dysfunctional landscapes leak soil, excess water, nutrient and organic matter which leave the catchments via the watercourses. As well as reducing the quality of the water, this results in a loss of resources from the catchment. Riparian vegetation assists in the retention of resources and provides a keystone habitat for wildlife.

Conclusions and recommendations

1. Native pastures have provided the production base for viable beef enterprises over a long period and will continue to do so. While production peaks are lower relative to sown pastures, they have proven to be a stable source of production that is resistant to the vagaries of climate and degradation. Maintaining native pastures has been shown in our research to be compatible with a high level of native plant diversity and underpins ecologically sustainable management of grazed woodlands. **In the light of this knowledge, we recommend that new or proposed technologies that may be associated with the expansion of areas of intensively used land be reviewed in relation to their impact on natural resources**.

2. The landscape management principles developed and the thresholds identified form a basis for the development of an Environmental Management System for the beef industry. Our principles as they are expressed are most relevant for tropical and temperate grassy woodland landscapes with some areas of cropping or improved pastures. Where the main vegetation type differs, and/or intensive land use is either absent or widespread, the wording of the principles would need to be adapted, although most of the principles and associated thresholds are still of general relevance.

3. Our project has only started to address the science behind landscape planning which we have advanced by synthesizing existing information. **Continued learning through scientific observations of landscape function is important.** Our work has structured current knowledge so as to identify some important questions that require research *viz*:

   a. What are the limits to intensive land uses at the landscape scale in terms of vegetation health and the condition of riparian zones?

   b. What ecological attributes are maintained by providing riparian vegetation of different widths and different combinations of structural attributes (e.g. grazed sward, ungrazed sward, shrubs, trees)?

   c. What birds and mammals are adversely affected by different levels of vegetation clearing in the landscape?

   d. What are appropriate spatial scales to apply the different land-use thresholds (property, sub-catchment, catchment)?

4. The financial and practical barriers to adoption of ecologically sustainable management need to be further explored in terms of:

   a. **Defining the duty of care** of producers, which involves determining the limits of private responsibility for natural resource management, and the point at which it is replaced by public responsibility.

   b. **Cost-sharing arrangements** as a way of balancing private and public contribution to the cost of achieving sustainability.

   c. Applying improved understanding to **further refine the boundaries of the thresholds**, how they vary, and what are the trade offs under different levels of management. This will provide a more accurate assessment of landscape and a way of better identifying acceptable solutions.

   d. Continued exploration of the practical issues of applying the principles and **providing opportunities for producers to identify their own practical solutions**.

   e. **The availability of technical support** for farm planning and decision making. Salinity hazard mapping, soil maps, topographical maps and vegetation maps are examples of information that is required at specific scales, which may not be accessible.

5. It is important to acknowledge that addressing biodiversity and natural resource issues is a long-term activity, and in northern Australia, the dialogue has only just commenced:

   a. Although there may be similar use of the language, the concepts of sustainability and biodiversity conservation often vary greatly between stakeholder groups. We should be aiming for a more seamless use of concepts as an indicator of improved communication.

   b. Producers need to be provided with the relevant technical understanding to make informed decisions about natural resource management. An example is the recognition of tree regeneration potential as an ecosystem service, that can be a cost to maintain,

but which producers need to weigh against future permanent losses of biodiversity and high tree planting costs

c. Defining duty of care is a legal decision, that is only informed by technical information, not determined by it.

6. We note the importance of scientific publication as a means of making project outputs accessible, credible and durable. Peer-reviewed publications need to be fostered as a reliable way of adding to the industry's technical intellectual capital in the long-term. They provide a firm technical footing from which other communication outputs can be sourced.

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Appendix 1 (presented as a separate volume)

Publications associated with the project

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Appendix 2 (presented as a separate volume)

The learning module

Grazed Landscapes Management Project (2000) *Balancing Conservation and Production. Understanding and Using Landscape Thresholds in Property Planning.* CSIRO Tropical Agriculture.

Available on: http://www.cse.csiro.au/research/srs or to go straight to the pdf file: http://www.cse.csiro.au/research/srs/Learning%20Module.PDF

Appendix 3 (presented as a separate volume)

Assessment of the properties

Martin, T. G., Best, K. M., McIntyre, S., McIvor, J. G. & MacLeod N. D. (2000) *Four grazing properties in southeast Queensland: patterns of land use and ecological status.* CSIRO Tropical Agriculture Technical Memorandum, No. 5, 2000. 111 pp.

Appendix 4 (presented as a separate volume)

Technical information manual

McIntyre, S, McIvor, J. G. and Best, K. M. (eds) *Landscapes for the Future: Conservation Management of Grazed Woodlands*. Ten chapters by various authors. Book draft, submitted to MLA in February 2001 as Milestone 13.

Appendix 5

The following report was submitted to MLA in January 2000.

Learning module pilot workshop report and game description

Background

A major objective of Project NAP3.222 is to identify practical measures to conserve biodiversity, and to develop simple indicators that producers can use to continue to adapt and improve management. The need to proactively publicise and disseminate results to the industry and others concerned with natural resource management is also recognized in the goals. Milestone #10 of the project requires the completion of a draft learning module by 31/7/2000. At the annual peer review meeting, in October 1999, copies of the draft learning module 'Balancing Conservation and Production: Understanding and Using Landscape Thresholds in Property Planning' were distributed to Peter Loneragan, Judy Lambert, Phil Price and Annemarie Watt. Bringing forward this milestone has been the result of strong positive response to the material produced jointly with the Technical Reference Panel to identify appropriate land management practices for natural resource conservation, including biodiversity conservation.

The material in the module covers some fundamental ecological concepts and the broad property planning and management principles are described in a forthcoming publication produced by the University of Queensland. The manuscript has been widely distributed (in the order of 150-200 copies) and received favourable comment from scientific and extension networks alike. The material has also been piloted extensively amongst producers at six management panel meetings and several other field days and has had a generally positive reception. There has also been particularly strong interest from the extension community, driven by the lack of material on this topic, and the extra demand for it generated by the large number of Natural Heritage Trust projects in southern Queensland.

Evidence of the impact and relevance of the principles to the cattle industry are:

1. Adoption by other programs of our concept of identifying land-use thresholds, and best-bet practices for landscape design and management. Warren Mason, co-ordinator of the temperate Sustainable Grazing Systems key program in MLA, is planning a one year exercise in which researchers and producers both engage in the process of pulling together and synthesising best-bet information for temperate grazing lands. This exercise has been inspired by the outputs of LWRRDC/EA CTC9 and MLA NAP3.222.

2. The principles and thresholds (as articulated in the Learning Module and paper1) are currently being used to define the principles of 'Duty of Care' requirements for holders of leasehold land in Queensland under the Land Act 1994. They have been incorporated into the internally distributed State Land Practice Manual of the Department of Natural Resources.

In an environment where there has been a flush of resources for on-ground works (stimulated by the National Heritage Trust) and much debate and activity relating to vegetation clearing legislation, it is not surprising that information of the type generated by this project has attracted so much interest. Because if this, we have directed our priorities to making the information as widely available as possible, but at the same time trying to ensure that the material is delivered in an interactive environment, where there are opportunities to interpret and discuss issues with the potential users of the information.

Learning module scope and rationale

The Learning Module was designed to assist extension officers and others to communicate what is currently understood to be needed to maintain ecosystem health in grazing lands. The Module is intended to work at two levels, firstly as a direct source of visual aids and packaged concepts that are judged to be of relevance to landholders. Second, the Module is intended to speak to the deliverers of this material and provide a context for the delivery. The scientific rationale for the Module is described in McIntyre *et al.* in press. The technical content in this paper can be used to provide technical back up for users of the Module. At the workshops, the Module was presented in draft form to the participants. It comprised a 33 page black and white booklet and was accompanied by a set of 8 colour overheads depicting some of the key graphics from the draft Module.

The Workshops

Workshop aims

The aims of the one-day workshops were to:

- Receive feedback on the draft module;
- Introduce the module in a learning environment;
- Discuss issues related to the communication of sustainability and biodiversity concepts;
- Consider future actions and how the project might interact with other groups in the future.

Workshop interest

Interest in the workshops was overwhelming. We mailed out open invitations to 150 people on September 10th. Within three working days we had filled all the 50 planned places. We added a third workshop, and the final schedule was one in Bundaberg (Nov. 3rd) and two in Toowoomba (Nov. 4 and 5th). The third workshop was oversubscribed within a week and by the closing date, there were 117 people seeking 75 places. Workshops were filled strictly on a first-come-first-served basis. We understand the interest was even wider, but the knowledge that the sessions were already filled stopped some people approaching us. The workshop was aimed at extension officers, and others involved in the communication of natural resource management concepts e.g. catchment and landcare coordinators.

Workshop conduct

Participants were sent the Module booklets and feedback sheets for assessment several weeks prior to the meetings. At the workshop, these assessment sheets were collected, the information collated and a summary presented to the group at the end of the day, giving them the chance to further discuss or reinforce points.

The other major aim of the workshop was to present key elements of the module material and provide opportunities for discussion and questions. Material was presented by different members of the CSIRO team. A board game was devised for one session, as a means to illustrate the effects of habitat destruction on landscapes and to demonstrate the thresholds. By simulating the ability of different organisms to move across the landscape, the game is able to illustrate the rationale for setting the various minimum thresholds in the principles e.g. minimum 30% woodland cover, maximum 30% cropping or sown pasture. The results are clear cut, and similar results are obtained consistently within and between sessions.

The board-game session involved a presentation discussing why organisms need to move across landscapes and an explanation of the board-game rules. The participants then played

the game, recording the effects of different amounts of habitats on landscape permeability. The results were then collated for the whole group, and discussed.

A further element of the workshop was to consider 'where to from here?' We wanted to determine what kinds of future activities might be most useful to assist the participants develop their understanding of landscape planning.

Workshop costs

The direct costs of running the three workshops (not including the development of the Module) were recorded and these included: the provision of workshop materials, travel for workshop presenters, catering for the three days and the costs of materials for the game. All up, the costs were approximately $8,500. However, about half of this total covered the costs of a professional facilitator, Geoff Watson (Orange Agricultural College, University of Sydney). We did not charge participants for registration, catering or workshop materials. We believe that providing a cost-free day was a major positive factor in encouraging attendance, as budgets are limited for many people, or need to be planned for in previous financial years.

The cost of printing 90 copies of the draft module (including a set of 8 overheads) was $1,685, or $18.70 per copy ($4.50 for booklet and $14.20 for overheads).

Feedback

The Workshops

Ninety percent of the seventy-five participants filled out feedback sheets. The overall rating they gave the workshops was 8 out of a possible 10 points. Most respondents (86%) thought that there was an appropriate balance of discussions and presentations. There were suggestions for improvements, but few points were consistently iterated. There was some feeling that use of photographs in the presentations and/or a field component might have been useful.

The Game

The board game attracted particular interest and positive response, and was clearly successful in demonstrating some of the dramatic effects that vegetation clearing has on the animals and plants that depend on it for habitat. Participants rated the game, on average, 4.5 out of a possible 5. There were many suggestions that the game be further developed and made accessible to a wider audience, particularly producers, and a number of people have requested borrowing/making games for their own use.

In response to this positive feedback, a week later the game was subsequently introduced by Sue McIntyre to producers at a landcare meeting and was similarly well received. Game boards were also made available to an extension group in DNR to use in a workshop. However, they felt that they misjudged the timing of the information delivery during the session, and that this reduced the impact. Discussions on the outcome of this DNR trial confirmed our view that although the game can present a very powerful message to producers, it needs to be presented in the right context; some of the biology needs to be explained up front to give the rules meaning, and an interpretation session needs to be reasonably carefully facilitated at the end.

The module

Participants were sent a draft of the Module three weeks prior to the meetings and were asked to fill out feedback sheets prior to the workshop. These were collected and collated at the workshops, and summaries were presented to the participants at the end of the day for further discussion.

The aims as expressed on the Module feedback sheets were:

- To provide a source book of ecological concepts to assist in the planning and preparation of extension activities;

- To provide key words and concepts that are simply expressed, together with short clear explanations;
- To provide material for use in extension activities (not as a full technical explanation of the background research)

We obtained 51 completed feedback sheets (70% return rate) and recorded the following results:

Question relating to the module	Respondents in overall agreement (Yes)
Are the module aims useful?	92%
Does the module achieve it aims?	82%
Is the writing style appropriate?	92%
Is the technical level appropriate?	80%

Positive comments on the Module

The following quotes were taken from the feedback sheets:

"The biggest plus is that you have some workable, on-ground guidelines which are gleaned from research based activities."

"The link has been made between extension staff (landholders) and scientists in an understandable form."

"A good concept and a well presented package."

"This is an exceptionally important and timely document. Congratulations and thank you."

"Excellent to have a whole property coverage of relevant ecological concepts and ideas for how to manage for these."

"A well written, easily understood booklet. A useful reference booklet for Resource Centre and for student research."

"A good basic module. Very well covered."

"Has great potential for use in school activities on resource management."

Suggestions for improvement of the Module

Although response to the module was overwhelmingly positive, a consistent request was for economic figures to support the ideas e.g.

"Apart from the legislation pathway, the only way you are going to sell this to the great majority of grazing land owners is to bring economics into the equation, and I don't think you have the figures to convince anyone."

"Need to incorporate production benefits."

"More examples on production side of the balance – case study examples."

In the final version of the module, we intend to strengthen the economic aspects. However, our interpretation is that the type of economic arguments hoped for, are those that do not exist – i.e. that there are clear medium- and short-term financial benefits from implementation of the management thresholds. If this were the case, producers would not be tempted to over-clear and over-graze. The reality is, that the short-term implementation costs are considerable, and some of the benefits are to the broader society, not specifically to producers. Calculations of the long-term benefits are extremely tenuous and based on long chains of dubious assumption. However, it is intended to provide some additional selected examples of both short-term costs and long-term benefits.

Where to from here?

The team feels that immediacy of the issues makes the rapid availability of project outputs a high priority. There are many on-ground National Heritage Trust projects underway, and the imminence of land-clearing legislation will only increase the demand for information in the form of 'explanations'. This has influenced our views relating to the publication of information. Conventionally, we would expect to negotiate formal publication of a booklet as a next step. However, taking into account the demand for information, tempered by the need for it to be discussed in a learning environment, we suggest that the workshop format, with the module materials supplied as 'notes' will be the most effective one. Without the appropriate context, the information can have little, or negative impact, whether the clients are producers or extension personnel.

However, demand for the booklet far outstrips the number of places available in workshops, and will continue to do so. We feel that we cannot restrict its availability only to workshop participants, but that the cost of supplying unlimited numbers of printed copies for free could become a problem. The same issues apply to the provision of overheads.

We believe that we have tested the module sufficiently to justify the development of a final version. The feedback indicated that the module was about the right length and that the overheads supplied were of considerable value. In addition to the economic issues discussed in the previous section, there were specific editing changes provided by participants that will be responded to on a case by case basis. We plan to provide a list of references for background and further reading, at the end of the module. People were happy with the black-and white format, and we hope to improve photo quality through the use of grey-scale images.

There is still a un-met demand for workshops, as many people were turned away from the first round of workshops. Among the groups that did attend workshops, there was interest in follow-up workshops, and the team agrees that reinforcement of the concepts covered will be critical to getting effective outcomes.

1.1..1 Proposed actions

1. The learning module booklet be edited to a final version in January-March 2000 (ahead of our current timeline of July 2000).

2. A fourth and fifth workshop be conducted in March 2000 for participants who missed out in 1999. These workshops would be substantially the same, but using the final module rather than the draft.

3. The module and overheads be made available as a pdf file for people not attending the workshops.

4. A second round of workshops be held in November 2000, drawing from the group who attended the previous round, and further developing learning activities and communication issues.

5. Documentation of the board game, describing biological context, instructions for playing and instructions for making. This would be used as workshop notes and submitted for publication.

6. Further exploration of development possibilities for the board game.

HE LANDSCAPE GAME – HOW IT WORKS, WHAT IT MEANS

"Tell me and I'll forget; show me and I may remember; involve me and I'll understand"

- Adults have a relatively short attention span to a given activity when they are only receiving information. They need to be actively engaged in learning.

- For these reasons the Landscape Game was devised as part of a workshop developed by members of the Grazed Landscape Management Project at CSIRO Tropical Agriculture to assist extension officers and others to communicate current understanding of what is required to maintain ecosystem health in grazing lands.

- The game is about seeing the world from the point of view of the native plants and animals – how are they affected when their habitats are progressively cleared? If plants and animals cannot move across the landscape, they face very serious problems of survival; for them, the key issue is the degree to which habitat is connected.

- The survival of native fauna and the health of native vegetation are linked. The health of native vegetation and the continued productivity of our rural lands are also linked. The issue of landscape connectivity is highly relevant to producers and land managers.

The game demonstrates:

- Whether different organisms can move across the landscape with different amounts of habitat retention. Remember habitat is not always trees, it can be shrubs or grass tussocks. Every plant and animal varies in its ability to cross 'hostile' or cleared environments.

- There are some simple geometrical features of landscapes. Most importantly, with 70% habitat cover, all organisms from that habitat type can cross the landscape without having to move through cleared land.

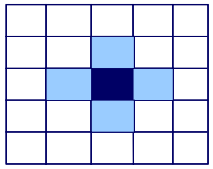
- As habitat is progressively lost, plants and animals find it increasingly difficult to move through the landscape, especially those incapable of moving across cleared land.

- There are thresholds, or critical amounts of habitat below which ecological function is seriously impaired for most plants and animals. There are reasons for setting landscape and property limits to various activities e.g. minimum 30% woodland cover, maximum 30% cropping or sown pasture.

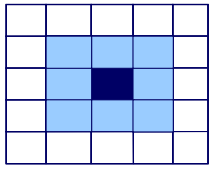
- That whole of landscape planning is important.

The game illustrates one source of evidence that we need to retain minimum amounts of native vegetation on landscapes. There are other sources of evidence, mostly derived from our observations of human effects on landscapes in 'real life' experiments. This knowledge has been brought together by the CSIRO Tropical Agriculture team to develop a package of landscape design principles and management thresholds.

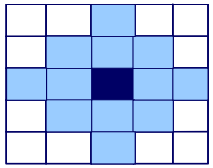
Movement rules



Restricted plants and animals cannot jump spaces and cannot move diagonally



Intermediate plants and animals cannot jump spaces but can move in any direction



Mobile plants and animals can jump one space, only in a cardinal direction (N ,S,W ,E) but can move in any direction

The landscape game

The game board

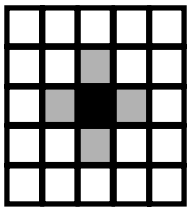
	0	1	2	3	4	5	6	7	8	9	
0											0
1											1
2											2
3											3
4											4
5											5
6											6
7											7
8											8
9											9
	0	1	2	3	4	5	6	7	8	9	

RULES FOR CONNECTIVITY GAME

The aim of the game is to see whether different organisms can move from any side of the board to beyond the opposite side.

1. Start with 10 counters. Generate 10 random co-ordinates using the two dice and place one counter on each co-ordinate.

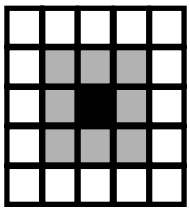
2. Now ask:



(i) Can a ***restricted*** organism move from any side of the board to its opposing side?

Restricted organisms cannot jump spaces and cannot move diagonally.

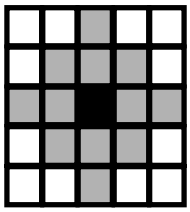
An example of a restricted organism is *Thesium* a parasitic plant which needs to move from one plant to another.



(ii) Can an ***intermediate*** organism move from any side of the board to its opposing side?

Intermediate organisms can not jump spaces but can move in any direction.

An example of an intermediate organism is *Lycosa* a wolf spider which needs to move from one grass tussock to another.



(iii) Can a ***mobile*** organism move from any side of the board to its opposing side?

Mobile organisms can jump one space only in a cardinal direction (i.e. N, S, E, W) but can move in any direction.

An example of a mobile organism is the grey crowned babbler a woodland bird which can fly a short distance in open spaces.

3. Enter result in table supplied. Use **4** for a successful crossing, and **7**if unsuccessful.

4. Add another 10 counters and repeat Step 1 from "…Generate 10 random numbers…".

5. Continue adding 10 counters and placing on 'dice-generated' co-ordinates until all (70) counters are on the board **OR** until all organisms can move across the board.

Make sure to enter results of each increase of 10 into the table.

Note:

If co-ordinate already has a counter in place, roll the dice again to choose a new co-ordinate.

Be consistent in which axis you use. You will have 2 coloured dice. Select one colour to use for the same axis throughout the game.

Appendix 6

Report on the use of the project information and communication resources in extension networks

- detailing the use and impact of a presentation "Ecological Principles for Grazing Land Management" at NAP3 Pasture Monitoring Project workshops, Durong 30,31 March 1988

Report prepared by Benita Darrow[2], July 1998.

Land Monitoring Project and Workshops

An ecological principles presentation based on material from the NAP3 joint CSIRO/DPI/DNR project "Incorporation of practical measures to assist conservation of biodiversity within sustainable beef production" was made by Benita Darrow, Department of Natural Resources Mundubbera at pasture monitoring workshops at Durong on the 30 and 31 March 1998. The workshops were the first part of another NAP3 producer driven project "Determining the productive capacity of your land to develop sustainable management practices" - aimed to increase producers abilities and skills in monitoring pasture resources. The Durong field days were one of six held across Northern Australia involving >120 beef producers. The workshops at Durong aimed to provide an ecological background to pasture resource management and to generate motivation and direction for establishing sites for ongoing monitoring.

Durong Workshop Participants

Twenty four properties were represented by 33 landholders at the two monitoring workshops at Durong and covered a total of over 90000 ha of grazing land. This can be interpreted as over 90000 ha of land is being managed by graziers who have committed themselves to ongoing monitoring from at least one GRASSCheck site established as part of the project. Graziers attended from Kingaroy, Chinchilla, Proston, Durong, Meandarra, Hannaford, Mundubbera, Eidsvold, Hivesville, Monto, and Murgon. The coordinator for this region is Kent Lithgow, "Koala", Chinchilla.

'Ecological Principles Presentation'-Role in Workshop

'Ecological Principle for Grazing Land Management' presented by Benita Darrow was the first of a three part presentation including "The Nuts and Bolts of Pasture Management" presented by Col Paton, Department of Primary Industries (DPI), Brian Pastures Research Station and "Introduction to Pasture Monitoring" presented by Damien O'Sullivan, DPI, Kingaroy. The first principles ecological presentation drew participants thinking above the level of their paddocks, properties and specific problems and encouraged lateral thinking. The 'pyramid approach' began with a broad-brush look at grazing land ecology, then more specifically at pasture management principles and then at pasture monitoring. This pyramid approach was easily followed by attendants and was thoroughly enjoyed.

'Ecological Principles Presentation' - Effectiveness

I felt that this broad ecological presentation greatly enhanced the success of the workshop and of the pasture monitoring that was to follow on individual properties. All but two DPI staff and one producer from approximately 25 on the first day appreciated the approach. The following comments from producers following the 'ecological principles talk' indicated the very positive response to the presentation:

"It is always good to take a step back so you can take a fresh look at the world - at what you're doing" "I wish others could adopt this way of thinking"

[2] Benita Darrow was an extension officer for the Department of Natural Resources in the Burnett region at the time of commencement of the project.

"Starting off broadly and then focussing down on issues allowed for some lateral thinking. We don't get to hear this type of approach very often - we're constantly focussed on our specific problems at a paddock level."

"The overheads were very well done."

"The way the material was presented was simple and unassuming and offered respect to producers."

Likewise on the second day of the workshops participants were similarly impressed.

Background to involvement

In preparation discussions for the workshop Kent Lithgow, area coordinator, expressed interest in starting from a broad ecological viewpoint, and focussing on the role of the plant as the primary producer, and on biodiversity. *The ecological presentation prepared by Sue McIntyre and John McIvor, Tropical Agriculture, CSIRO for the project "Incorporation of practical measures to assist conservation of biodiversity within sustainable beef production" was very appropriate. I had previously witnessed the effectiveness of this presentation at two producer groups at Mundubbera. It is (as far as I am aware) the only concise and effective presentation available to communicate ecological principles for grazing land management at a practical level.*

Appendix 7

Evaluation of communication outputs

Survey conducted and analysed by Jan Green.

Since 1996 the CSIRO Grazed Landscapes Management Project (GLMP) has worked with state agency staff and producers to develop principles for the sustainable management of soils, pastures, trees, wildlife and watercourses in sub-tropical grassy eucalypt woodlands. To assist people involved in the communication of technical information relating to ecological sustainability, GLMP ran a series of one-day workshops in November 1999 and March 2000 in two locations – Bundaberg and Toowoomba.

The aims of the workshops were to:

- Discuss basic ecological principles for sustainable land use;
- Discuss land use thresholds and the ecological consequences of exceeding them;
- Consider the practicalities of applying the thresholds in property and conservation planning;
- Provide an information resource that was relevant and useful for communication.

To this end, a workshop module was produced entitled *Balancing Conservation and Production: Understanding and using landscape thresholds*. Before the first round of workshops, the module was mailed to participants. At the workshop, feedback and comments were collected for use in the final version.

A questionnaire was developed to evaluate the usefulness of the module and its contents. This was to take the form of telephone interviews to all workshop participants (120 people). The questionnaire was structured and consisted of three parts – those who attended a workshop, those who did not, and those who used the module only for their personal use.

Participants included extension personnel, catchment and landcare coordinators, policy makers, researchers and producers. Due to the rate of staff turn-over, about 50% of the participants were no longer employed in their original areas. Consequently 61 people were available for the survey; the results and their comments follow. The survey questions are listed in Appendix 1.

Of the 61 people surveyed, 6 had not attended the workshops. However, they had been referred to and read the module and used it in the course of their work. The majority of those surveyed were extension personnel (69%); 11 % were catchment or landcare coordinators. The rest of the group was comprised of policy makers, producers and researchers. *We interviewed less than half of the workshop participants, which greatly increased the conservativeness of our estimate*.

The module had been used on 290 occasions by the participants, and use included:

- workshops and field days (25%);
- one on one discussion (15%);
- own information (15%); and
- training and communication material (13%).

As a result of this usage, the content reached 1543 landholders. The information contained in the module changed perceptions of conservation management in 942 landholders. This means that these landholders have a better understanding and greater awareness of the issues of conservation management in terms of their own properties. Of these 942 landholders, 418 (44%) have changed their property management practices to incorporate some conservation measures. The majority of landholders were involved in beef cattle grazing (81%), the others were dairy farmers or involved in cropping or farm forestry.

The overall rating on the usefulness of the module in terms of conservation management issues was 4 out of a possible 5. This rating included one score of 0/5 as the respondent does not live in the specific habitat type covered by the thresholds – grassy eucalypt woodlands. In general respondents provided positive comments and feedback on the usefulness of the module and its content. Not all respondents used all the content all the time. The general reaction was that the module was comprehensive and simple and a good resource – all in one book, although some doubted its usefulness at the property level.

Questionnaire used in an evaluation of the workshops and learning module

Hello my name is Jan Green from CSIRO in Brisbane. Our group which, includes Sue McIntyre, Neil MacLeod and John McIvor, produced a booklet called Balancing Conservation and Production, which we used in a series of workshops in November 1999 and March 2000. We want to evaluate the usefulness of the book and its information. Do you have a few minutes to spare?

Yes → 1; **No →** Can I call you at a more convenient time?

1. Have you read the booklet? **Yes → continue**; **No → stop interview**
2. Did you attend a workshop? **Yes → 3**; **No → Section B**.
3. In what capacity did you attend the workshop?
    a. Extension personnel
    b. Catchment/landcare coordinator
    c. Producer
    d. Researcher
    e. Policy
    f. Other
4. Are you using or have you used all or part of the booklet **Yes→ 5; No→ Section C**
5. How have you been using the booklet
    a. For your own information **→ Section C**
    b. In workshops/field days **→ 6.**
    c. Training/communication material **→ 6.**
    d. In property/catchment planning **→ 6.**
    e. Other **→ 6.**
6. How many times have you used the booklet? (e. g. x workshops, x field days)
7. How many people would this have involved? (e. g. x workshops, x field days)
8. Have you used the game in these activities? **Yes → 9**, **No→ 10**
9. How effective was the game as a learning tool:
    1 (no effect) - 5 (highly effective)
10. In your opinion has the material in the booklet had any impact on:
    a. Landholders' perceptions of conservation management **Yes → 12**
    b. Changes in their management practices **Yes → 13**
11. How many have had their perceptions changed?
12. How many have changed their management practices?
13. What sort of agricultural industry were all or most of these people involved in?

Go to Section *C*

Section B – not attended a workshop but seen the booklet

1. How have you been using all or part of the booklet
    - For your own information → **Section C**
    - In workshops/field days → **2.**
    - Training/communication material → **2.**
    - In property/catchment planning → **2.**
    - Other → **2.**
2. How many times have you used the booklet? (e. g. x workshops, x field days)
3. How many people would this have involved? (e. g. x workshops, x field days)
4. Have you used the game in these activities? **Yes → 5**, **No → 6**
5. How effective was the game as a learning tool:
    - 1 (no effect) - 5 (highly effective)
6. Have you evaluated the activities or followed up on people's opinions?
7. In your opinion has the material in the booklet had any impact on:
    - Landholders' perceptions of conservation management → **8**
    - Changes in their management practices → **9**
8. How many have had their perceptions changed?
9. How many have changed their management practices?
10. What sort of agricultural industry were all or most of these people involved in?

Go to Section C

Section C –attended a workshop and use the booklet for their own purposes only

1. How do you rate the usefulness of the booklet in terms of your understanding of the issues of conservation management?
    - 1 (not at all useful) - 5 (Very useful).

Appendix 8

Patch dynamics of grazed pastures near Crows Nest, south-east Queensland

Part A. Patch formation

Part B. Management to alter patch state