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Biodiversity Condition Assessment for Grazing Lands

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Abstract

The primary purpose of the project was to develop and test a prototype procedure for the assessment of biodiversity condition of grazing lands. This would then complement the grazing land condition assessment framework used by the Grazing Land Management education package, which promotes sustainable management of grazed lands in northern Australia. To do this, comprehensive sampling of fauna, flora, habitat features and grazing land condition indicators was conducted at 171 sites. The sample sites were stratified across three different land types of southern Queensland (soft mulga, poplar box on alluvial and brigalow belah scrub), and broad condition states. The project culminated in a stand-alone product with three linked components including (1) a technical manual on the assessment of biodiversity condition '*BioCondition' (*This publication has already been widely accepted is currently used by professionals in the public and private sector); (2) *a Biodiversity in Grazed Lands Toolkit*, which is comprised of seven 'sub-kits' including a simplified version of the technical *BioCondition* manual designed for rapid assessment of condition for biodiversity in grazed lands; and (3) a set of educational presentations that reflect the information and messages provided in the Toolkit. Other products that have been submitted as part of the final report include two publications, one for a book on Temperate Woodland Ecology, and papers on indicators important for assessment of condition for biodiversity, monitoring biodiversity in the rangelands, and extension of known distributions for particular native species.

Executive Summary

There is a strong demand for robust and practical approaches to assess resource condition, particularly in extensive grazing landscapes. A simple, rapid assessment approach is highly desirable as compared with a time-consuming and complicated, if thorough, approach, as it facilitates uptake of use by managers. The grazing land condition 'ABCD' framework of the EDGE*network* Grazing Land Management education package is an example of an assessment approach that has had widespread uptake by grazing land managers and is now a well established procedure in northern Australia. It uses a simple 'ABCD' rating, which is consistent with grazing land ecology concepts and sustainable livestock production. However, the framework currently does not address the assessment of condition relevant for biodiversity values.

The primary purpose of the Biodiversity Condition for Grazing Lands project was to develop and test a prototype procedure for the assessment of biodiversity condition that was complimentary to the ABCD grazing land condition assessment framework. To achieve this, a set of surrogate indicators of condition for biodiversity were selected and tested for three extensive, but ecologically different, land types in the Southern Brigalow Bioregion and Mulga Lands bioregion of southern Queensland. Testing involved the comprehensive sampling of fauna, flora, habitat features and grazing land condition indicators at 171 sample sites. The sample sites were stratified across three different land types of southern Queensland (soft mulga, poplar box on alluvial and brigalow belah scrub), and broad condition states.

For the majority of sites – across land types, landscape types and broad condition (i.e. remnant versus non remnant), there was close alignment between land condition and biodiversity condition classification. The assessment frameworks differed in their assessment of 'good' or functional condition (A or B grazing land condition; 1 or 2 BioCondition) predominantly in pasture and regrowth sites. That is, a site assessed as 'A' or 'B' grazing land condition was likely to be assessed in '3' or '4' BioCondition if the site had previously been cleared. At sites where remnant vegetation had been retained, 'A' or 'B' condition was mostly aligned with '1' or '2' condition. The response of biodiversity to classes representing grazing land condition (ABCD) and the prototype biodiversity condition approach (BioCondition; 1234) was determined using measures of species composition and species richness within broad taxonomic groups. As expected, the BioCondition framework did reflect variation in biodiversity values, albeit there was little discernible difference between classes 1 and 2. However, the ABCD framework did not reflect variation in species composition within tested fauna taxonomic groups (birds and reptiles), but did have some capacity to account for variation in perennial grass species composition.

Key attributes of the ABCD and BioCondition frameworks were tested against species richness and abundance of individual species indentified as increasers or decreasers. Those attributes which were both uncorrelated with other attributes and contributed to explaining much of the variation in species richness or individual abundance were selected as the key features for a rapid biodiversity condition assessment procedure, relevant to the brigalow and mulga lands bioregions. Acknowledgement by managers on the importance of these key features to biodiversity will greatly assist the conservation of species in grazing landscapes. We were able to show that the biodiversity in paddocks of open pasture, which are in A or B grazing land condition, can be greatly enhanced through the retention and maintenance of scattered keystone habitat features such as clumps of shrubs/regrowth, large trees and fallen woody material.

The primary output from the Biodiversity Condition for Grazing Lands project was a Toolkit, made up of seven interlinked kits that can be used together or separately to inform on biodiversity in southern Queensland, guide paddock-scale assessment and monitoring of

grazing land condition for biodiversity, reveal where condition for biodiversity and land management are similar and where they differ, and provide some insights on how to maintain or improve condition for biodiversity in the paddock and across the property. Components of the Toolkit can be used to demonstrate sustainable management for biodiversity to benefit grazing land managers in the marketplace and when competing for relevant funding. The toolkit was produced to support facilitators, extension officers and Natural Resource Management groups who work with grazing land managers involved in the management of grazing land production and biodiversity conservation. The toolkit can also be used directly by grazing land managers interested in biodiversity conservation, particularly those familiar with the concepts used in the EDGE*network* Grazing Land Management and Stocktake education and training packages.

The toolkit will provide capacity for land managers to build on existing knowledge of sustainable grazing land management, and in doing so encourage proactive conservation of biodiversity on their properties. The toolkit also aims to provide some knowledge and insights on what we learnt about biodiversity in grazed landscapes in southern Queensland. Local examples from research and managers' own experiences were used in the Toolkit to ensure relevance to the southern Queensland region, particularly in the brigalow and mulga lands bioregions.

Contents

1 Background

1.1 Introduction

The management of native vegetation to produce services such as food and fibre has meant that an estimated 62% of Australia's native vegetation has been modified by agricultural and grazing enterprises (Thackway and Lesslie 2006). Knowledge of the extent of native vegetation by broad structural and floristic type is therefore considered integral for natural resource planning, management and environmental reporting. Consequently, vegetation-mapping programs to describe structural and floristic type have been conducted across the majority of the states and territories of Australia. This has been broadly captured and described at a national scale by the National Vegetation Information System (NVIS) framework (ESCAVI 2003). However, vegetation description and mapping at the regional scales is much less consistent between Australian state and territory boundaries, as well as within. An exception is Queensland, which is unique in that it is the only Australian jurisdiction to have a statewide ecosystem mapping program[1] at a regional scale (1:100 000). This is regularly updated to monitor change in extent (Accad *et al.* 2006) using the Statewide Land and Tree Study[2] (Kuhnell *et al.* 1998) as a primary input. In Queensland, the regional ecosystem mapping is now being used to underpin the mapping of land types – an important information component of grazing land management.

Compared with vegetation *extent*, the assessment of vegetation *condition* is considerably less well documented in Queensland, and indeed most of Australia. It has only been relatively recently that policy demands and expectations have conceptualized vegetation condition as a major component of native vegetation management, primarily to assist decision-making for developmental approvals, incentive payments and market-based investments (Keith and Gorrod 2006). Regional Natural Resource Management groups are also interested in vegetation condition, given its recent identification as a national environmental indicator for reporting targets (MEWG 2004). At the property scale, land managers are increasingly becoming aware of the challenge to demonstrate duty of care (Bates 2001; Neldner 2006), and indeed the assessment of condition for the purpose of lease renewal is now undertaken in Queensland under the Delbessie Agreement (DERM 2010).

A procedure to effectively assess vegetation condition is paramount to the implementation of these decision-making and reporting schemes, including implementation of off-sets and biobanking schemes and comprehensive environmental accounts (Hawke 2009). The ability to assess and monitor vegetation condition is also essential for governments to administer legislation relating to the landscapes and biodiversity covered by their jurisdiction. In Queensland, this legislation includes the *Nature Conservation Act 1992, Land Act 1994, Environmental Protection Act 1994, Coastal Protection and Management Act 1995* and *Vegetation Management Act 1999*. In addition, premium markets are likely to develop in the future for properties demonstrating sustainable production (Neldner 2006).

The use of the term 'condition' as it is generally used by policy and management, is underpinned by the assumption that its assessment will represent a measure of ecological composition, structure and function (*sensu* Noss 1990) along a continuum of 'poor' to 'good', relative to some desired state or potential. However, what the condition measure

[1] www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/regional_ecosystems/introduction_and_status/index.html
[2] www.derm.qld.gov.au/slats

represents is context dependent. One of the earliest definitions of condition was developed relative to grazing land management of rangelands, as the "health or productivity of both soil and forage of a given range, in terms of what it could or should be under normal climate and best practicable management" (Society of American Foresters 1944). Since then, the development of conceptual frameworks to better reflect ecological complexity and thinking, as well as the expansion of applications to which the concept of condition is often attached (e.g., Westoby *et al.*, 1989), has led to much current confusion and ambiguity regarding what is meant by 'condition' (Keith and Gorrod, 2006).

It is therefore important to be clear regarding the definition of 'condition' and the objective of any assessment as the approach used, the attributes to measure, and the outcome of the assessment will vary between contexts as a matter of necessity (Oliver *et al*. 2002). That is, the measure will depend upon whether the objective for the condition assessment is for production, biodiversity or aesthetic purposes (Keith and Gorrod 2006; Gibbons and Freudenberger 2006). For instance, recent work in the savanna rangelands has shown that the concept of condition for productive grazing land only partially represents condition for biodiversity values (Fisher and Kutt 2007).

Ecology is complex, with many drivers and interactions and variable responses. Consequently, many indicators, surrogates and attributes have been suggested for use in rangeland assessment and monitoring (Smyth and James, 2004). However, a simple, rapid assessment approach is highly desirable as compared with a time-consuming and complicated, if thorough, approach, as it facilitates uptake of use by managers (Andreasen *et al.* 2001). Accordingly, a number of recently developed condition assessment tools have utilised a key set of attributes or surrogates of that can be rapidly measured in the field (Gibbons and Freudenberger 2006). From a grazing land management perspective, the ABCD framework is one, and from a biodiversity perspective, the BioCondition framework - developed for this project - is another.

1.2 Grazing land condition (ABCD framework)

Grazing Land Management (GLM) education packages define grazing land condition as "the capacity of land to respond to rain and produce useful forage" (Pickup *et al.* 1994; Chilcott *et al.* 2003). The concept underpinning the definition is that ecological processes, such as nutrient cycling, are maintained through variable rainfall periods to ensure stable responses by pasture species relative to livestock carrying capacity (Karfs *et al.* 2009a). The associated ABCD grazing land condition framework (Chilcott *et al.* 2003), developed from existing knowledge and long term grazing trial data (e.g. Ash *et al.* 2002), allows the differentiation between four grazing land condition classes, relative to a particular land type (Table 1). Indicators used in the ABCD framework include:

- soil condition: the capacity of the soil to absorb and store rainfall, store and cycle nutrients, provide habitat for seed germination and plant growth, and to resist erosion. It is measured by the condition of the soil surface, which is influenced by the amount of ground cover over time, and the signs and extent of erosion.

- ground cover per se is not an indicator of land condition as its presence or absence can fluctuate with season and events such as fire.

- pasture condition: the capacity of the pasture to capture solar energy and convert it into green leaf, use rainfall efficiently, conserve soil condition, and to recycle nutrients. It is measured by the types of perennial grasses present, their density and vigour and the presence or absence of weeds.

- It is the combination of these two factors (soil and pasture condition) that determines a land condition rating. Woodland condition (see below) is measured by measuring tree basal area (TBA).
- woodland condition: the capacity of the woodland to grow pasture, cycle nutrients and regulate groundwater. It is measured by measuring the density and trunk size of trees and shrubs present using a variation of the Bitterlich technique.

Table 1: Features of ABCD grazing land condition classes. A condition has all the features listed, while other condition classes exhibit one or more of the listed features.

Grazing land condition class	Features
A	▪ High density and good cover of perennial grasses dominated by 3P species (perennial, productive and palatable) for a particular land type ▪ Little bare ground (usually <30%) ▪ Few or no weeds ▪ Good soil condition; no erosion and good surface condition ▪ High organic matter ▪ Little woody thickening
B	▪ Some decline in the health and/or density of 3P grasses; an increase in other less favoured or weed species ▪ Some decline in soil condition; some signs of previous erosion and/or increased bare ground (usually >30% but <60%)
C	▪ Moderate to low density of preferred grasses or moderate density of intermediate grasses ▪ High numbers of annual grasses and forbs, ▪ Many weeds ▪ Some erosion ▪ Often poor ground cover (<60%) ▪ Some woody thickening
D	▪ General lack of any perennial grasses or palatable forbs ▪ Severe erosion or scalding, resulting in restricted plant growth ▪ High numbers of weeds and annuals ▪ Thickets of woody plants or weeds cover most of the area ▪ Restoration to a better condition is reliant on high inputs of time, energy and money. D condition land will not recover in the short term by excluding grazing.

1.3 Biodiversity condition (1234 BioCondition framework)

The use of the reference condition approach underpins most procedures developed in Australia for vegetation condition assessment for biodiversity. The referential approach compares an indicator or attribute at the assessable site with a value, or range of values expected for that site if it was in a state of the desired condition – usually a pristine state free from threatening factors – known as the ‘reference condition’ (Karr and Chu 1999; Bailey *et al.* 2004). The use of reference conditions has also been widely used for assessment of water quality (Negus and Marsh 2006), and is rapidly being embraced by terrestrial assessment systems as it provides an objective means of comparison within and between vegetation ecosystems.

The reference approach can potentially be criticized as being the construct of another Clementsian-based successional model, but this will depend on what state is used as the ‘desired’ state of condition for comparison (Gibbons and Freudenberger 2006). The BioMetric approach (Gibbons *et al.* 2008) aims to avoid this criticism by providing a range of values as the benchmark for vegetation communities, representing the natural alternative states that the community may display as a consequence of environmental variation or natural disturbance. However, in general, the ‘historical’ pristine natural state, with absence of post-European human disturbance is usually used as the reference state (e.g. Parkes *et al.* 2003). The use of sites in a ‘pristine’ state is unrealistic, given that impacts from post-European settlement management are widespread. Furthermore, it is extremely unlikely that a given patch of vegetation could be restored to historical states (Hobbs and Norton 1996; Oliver *et al.* 2002). Sites that have been least impacted by local threats should be of increased value for aspects of biodiversity, thus should constitute the best available benchmarks, or ‘best-on-offer’ (Landsberg and Crowley 2004). This is the approach that has been adopted for this project, and used in BioCondition (Eyre *et al.* 2011).

BioCondition is broadly constructed of three components:

1. **A set of site-based and landscape-scaled attributes** – which act as surrogates of biodiversity values. These attributes were selected based on their known or perceived surrogacy for aspects of biodiversity and representation of ecological processes relative to composition, structure and function, their relevance and applicability for a range of ecosystem types and condition states, the relative ease with which they can be assessed and their educational appeal (Table 2).

2. **Benchmarks** – are quantitative values for each attribute obtained from a set of Best-on-Offer (BOO) ‘reference’ sites for a particular regional ecosystem or land type. For this project, benchmark data were derived from six to seven BOO sites located in each of the three target land types (brigalow-belah woodlands on sedimentary; soft mulga woodlands; and poplar box woodlands on alluvial; see Appendix 1).

3. **Rating system** – based on the relative value of an attribute to the benchmark values. Scores are then categorised into a ‘1234’ rating system to match the ABCD framework of grazed land condition assessment, relative to a particular land type or regional ecosystem (see Figure 1 for an example).

Table 2: Assessable indicators used in BioCondition to derive 1234 condition ratings

	Attribute	
Site-based indicators	**Regeneration**	Recruitment of dominant tree species
	Diversity	Native plant species richness for four life forms
	Cover and complexity	Tree canopy cover and canopy health (%) Tree height (m) Shrub layer cover (%) Native perennial 'decreaser' grass species basal area Native perennial forb and non-grass cover (%) Native annual grass, forb and non-grass cover (%) Cryptogram cover
	Habitat	Large trees and hollows Fallen woody material Litter cover
	Weeds	Weed cover
Landscape indicators		Size of patch Context Connectivity Distance to artificial water

2 Project Objectives

The primary purpose of the project was to develop and test a prototype procedure for the assessment of biodiversity condition of grazing lands, to complement the land assessment framework used by the Grazing Land Management education package, which promotes sustainable management of grazed lands in northern Australia. The specific objectives of the project were to:

1. Provide a prototype toolkit (and corresponding set of presentations in powerpoint format), for the rapid assessment of biodiversity condition on grazing lands that is compatible with the grazing land condition (ABCD) assessment framework used in the GLM education package, and which includes materials for;
    a. The rapid assessment of biodiversity condition (BioCondition);
    b. Understanding biodiversity condition and its relationship to grazing land condition;
    c. The significance of the BioCondition ratings for property and regional biodiversity, and;
    d. Management options for maintaining or improving biodiversity in the grazed lands of southern Queensland.

2. Specify a set of surrogate indicators of condition for biodiversity on grazing lands, and their benchmark values, for a range of regional ecosystems occurring on grazing properties in the Southern Brigalow and Mulga regions of southern Queensland.

3. Establish relationships between the surrogate indicators and selected elements of biodiversity (e.g. persistence of identified decreaser species or species groups, for a range of flora and fauna) in the study regions.

4. Produce a technical BioCondition Manual relevant for the assessment of terrestrial biodiversity in Queensland.

AT A GLANCE: *BRIGALOW BELAH SCRUB*

Land type: BRIGALOW AND BELAH SCRUB

Regional Ecosystem 11.9.5

RATING 1:

- 3 or more tree species and high canopy cover (more than 35 %)
- More than 4 shrub species and cover (more than 10 % but not more than 45%)
- More than 11 trees larger than 30 cm DBH* (or 90 cm circumference)#
- More than 6 fallen logs in a 10m radius from a given point
- More than 30 % of the ground covered by native intermediate and pre-ferred grass species
- More than 25 % of the ground covered by litter
- Is well connected with other remnant vegetation
- More than 75 % of the surrounding landscape contains remnant and/or high value regrowth vegetation

RATING 2:

- 2 tree species with medium canopy cover (20-35 %)
- 2-4 shrub species with medium cover (5-10 %)
- 6 to 10 trees larger than 30 cm DBH (or 90 cm circumference)
- 3-5 fallen logs in a 10m radius from a given point
- 16-29 % of the ground covered by native intermediate and preferred grass species
- 10 –25 % of the ground covered by litter
- Well connected with other remnant and/or high value regrowth vegetation
- More than 30 % of the surrounding landscape contains remnant and/or regrowth vegetation

RATING 3:

- 1 tree species and low tree canopy cover (5 –20 %)
- 1 shrub species and low shrub cover (3-5 %)
- 1-5 trees larger than 30 cm DBH (or 90 cm circumference)
- 2 fallen logs in a 10m radius from a given point
- 5 -15% of the ground covered by native or more than 10% non native intermediate and preferred grass species
- 5 -10% of the ground covered by litter
- Not well connected with other remnant vegetation
- 10-30% of the surrounding landscape contains remnant and/or high value regrowth vegetation

RATING 4:

- Very few trees (< 5 % cover), if any, none large.
- Few shrubs of same species (less than 2 % cover) OR an over-abundance of shrubs (more than 45 %)
- None or 1 fallen log in a 10m radius from a given point
- Less than 5 % of the ground covered by native intermediate and preferred grass species
- Less than 5 % of the ground covered by litter
- Less than 10 % of the surrounding landscape contains remnant Or less than 30 % of the surrounding landscape contains remnant and high value regrowth vegetation

*dbh—Diameter at breast height (measured at 1.3m above the ground) #Count within a 50 x 50m area

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'1234' Biodiversity Condition Framework

mla Queensland Government

Figure 1: Example of '1234' BioCondition ratings for brigalow belah scrub land type

3 Methodology

3.1 Study region

This project was conducted within two Interim Biogeographic Regionalisation of Australia (IBRA) bioregions within Queensland, the Mulga Lands and Brigalow Belt South bioregions. Within the two bioregions, sites were restricted to the Soft Mulga land types which are broadly distributed to the east of the bioregion, and the Brigalow-belah on sedimentary and poplar box on alluvial land types distributed towards the west of the Brigalow Belt South bioregion (Figure 2).

3.1.1 The Mulga Lands

The Mulga Lands bioregion covers approximately 18.1 million hectares, and constitutes 12.5% of Queensland. The Mulga Lands bioregion is dominated by flat to undulating plains and low ranges supporting a range of mulga *Acacia aneura* woodlands. Poplar box *Eucalyptus populnea* and other eucalypt species codominate with mulga in the more easterly parts of the bioregion, which receive higher rainfall (Wilson, 1999). The bioregion is subject to extremely variable rainfall patterns and relatively frequent droughts.

The primary land use in the Mulga Lands bioregion is grazing by sheep, cattle and increasingly, goats. Mulga provides a significant reserve of forage for sheep and cattle particularly during drought, although supplement feeding is required to maintain animal condition during prolonged feeding. The landscape in the Mulga Lands is predominantly intact, except towards the east where intensive land clearing has occurred prior to cessation of broadscale land clearing at the end of 2006. The majority of remnant vegetation clearing in Queensland between 2001 and 2003 occurred in the Mulga Lands bioregion (55% of clearing in Queensland; Accad *et al.* 2006). Land resource surveys conducted in the region indicated that 20% of the area has substantial cover of unpalatable woody perennials in the understorey, and close to 30% of the areas has been affected by sheet erosion (Beale, 1994).

3.1.2 Brigalow Belt South

The Brigalow Belt South covers approximately 22.7 million hectares, comprising approximately 15% of Queensland. The bioregion has a subtropical climate although droughts are common. Rainfall tends to decrease from the eastern to western areas of the bioregion, but is summer dominant and highly variable. The bioregion is characterized by brigalow *Acacia harpopylla* which occurs in forest and woodland formations on clay soils. Eucalypt forests and woodlands and cypress pine *Callitris glaucophylla* forests are also dominant ecosystems in the bioregion (Young *et al.* 1999).

Broadscale clearing of brigalow communities occurred as part of grazing land development schemes initiated in the 1960's (Young *et al.* 1999). By 1990, 86% of the original extent of brigalow and belah *Casuarina cristata* scrub had been cleared. In the Dalby, Chinchilla and Goondiwindi areas, brigalow/belah communities had decreased by 96% (Smyth 1997). The other ecosystem that has been extensively cleared in the bioregion has been poplar box *Eucalyptus populnea* dominant communities. Approximately 70% of the pre-clear poplar box woodlands have been cleared for stock grazing, and much of the remaining 30% is also grazed. are now grazed pasture land. The establishment of buffel grass *Pennisetum ciliare* pasture through aerial or on-ground sowing accompanied the majority of vegetation clearing in the region (Cavaye 1991).

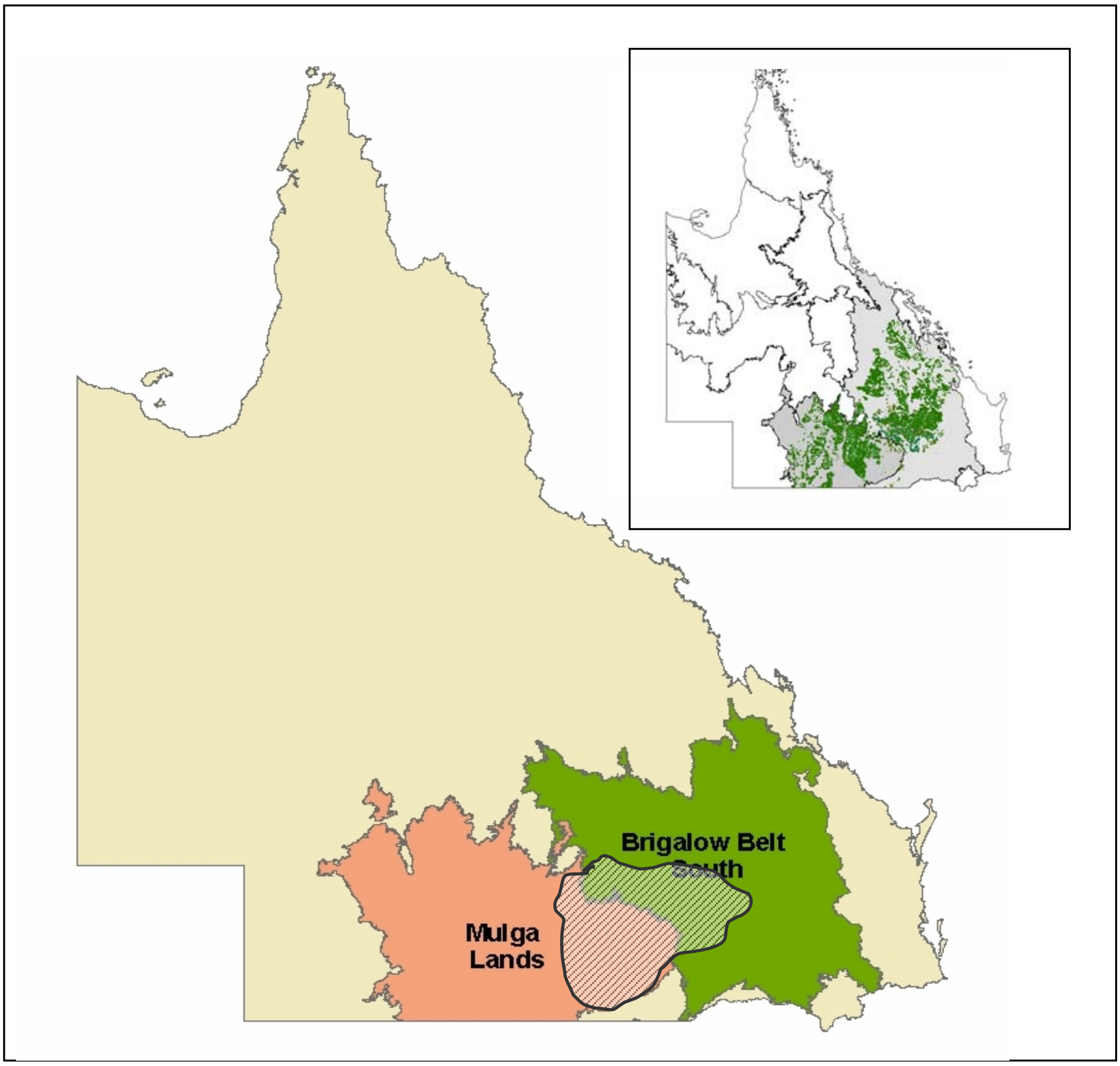


Figure 2: Broad study area showing delineation of the Mulga Lands and Brigalow Belt South bioregions. Hatched area shows the area within which sample sites were located. Inset shows the distribution of the three target landtypes across southern Queensland.

3.2 Site Selection

Across the two bioregions, three distinct land types were targeted to sample across high and low productivity for grazing; soft mulga in the Mulga Lands bioregion; and poplar box on alluvials and brigalow/belah scrub land types in the Brigalow Belt South bioregion. Eleven land types have been identified in the Mulga Lands bioregion (Whish (Ed.) 2010). In the region the most widely referred to land types include “soft” mulga, “hard” mulga and “sandplain” mulga. Soft mulga generally occurs to the east of the Warrego River, and hard mulga is distributed to the west. For the purposes of this project, soft mulga land types were targeted for survey. We aligned the soft mulga land type with relevant regional ecosystems, which have been described and mapped by the Queensland Herbarium (EPA 2005). Eleven regional ecosystems were identified as representing soft mulga land types. These were then mapped to demonstrate distribution in the bioregion for property selection.

In the Brigalow Belt South and Balonne-Maranoa region, 18 land types have been described (Whish (Ed.) 2010). Of these, the two most predominant land types were targeted for sampling; poplar box on alluvials land type and the brigalow/belah scrub landtype. These were selected due to their significant pre-clear and remnant extent and value as productive grazing land. A description of the regional ecosystems targeted to sample the soft mulga, brigalow belah scrub and poplar box land types is provided in Appendix 1.

The design used for site selection in the study area was based on a stratification of land type by landscape type by management type and by grazing land condition plus BOO condition for biodiversity (see Table 3 for definitions of the stratification variables used). A landscape was defined as a circular spatial extent encompassing 314 ha, centred on the sample site. Four landscape management types were selected for sampling in each land type; the *conservation landscape*, sampling 1) **remnant vegetation** in an intact landscape; the *mixed landscape* sampling 2) a **patch of remnant vegetation** in a fragmented landscape (e.g. Figure 3); and the *production landscape*, sampling both 3) **pasture** and 4) **regrowth** vegetation in a fragmented landscape. In the soft mulga fodder harvesting is another form of pastoral management. Therefore, in this land type the production landscape sampled included 3) **regrowth and/or pasture** and 4) **stump cut** (lopped or thinned for fodder).

We used the 1:100 000 remnant and pre-clear regional ecosystem mapping to delineate remnant and pre-clearing extent of the regional ecosystems selected to represent the three land types of interest. We also used a combination of the pre-clear regional ecosystem mapping and the Statewide Land and Tree Study (SLATS) woody cover mapping to delineate areas of potential regrowth or disturbed woody component for each of the three land types.

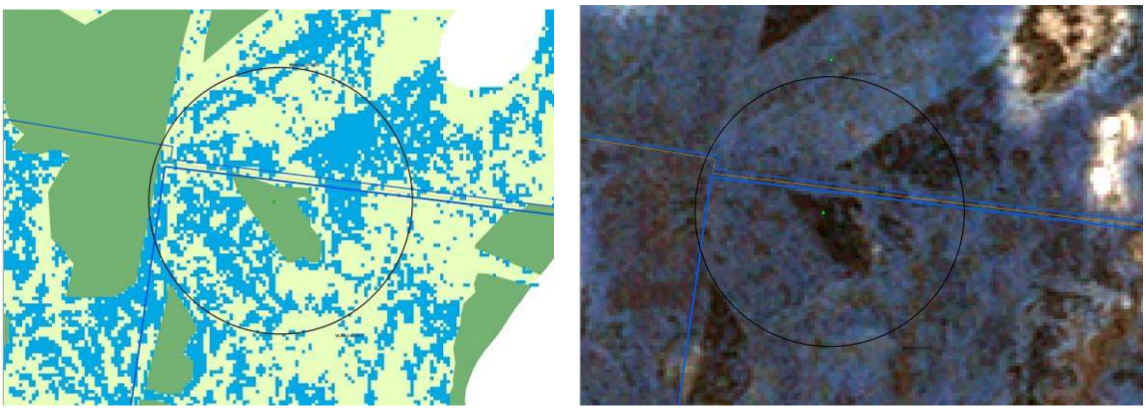


Figure 3: Example of the remnant vegetation in regrowth/cleared landscape. Dark green = mapped remnant vegetation, light green = pre-cleared vegetation, blue = potential regrowth / woody component from SLATS mapping.

Within each of these landscapes we further stratified by good to fair (AB) and poor to very poor (CD) land condition. Sites representing BOO vegetation for biodiversity values were selected only within the intact conservation landscapes. Thus for each land type a possible nine treatment classes or strata were identified for sampling. In the Mulga Lands, seven replicates were sampled per treatment, whereas in the Brigalow Bioregion, six replicates per treatment were sampled. This meant that a total of 171 sites were selected for sampling (i.e. one land type by nine treatments by seven replicates plus two land types by nine treatments by six replicates, Table 4). Sites were distributed across twenty grazing properties.

In selecting and locating sites in the field, the following rules were followed;

a. Sites were located a minimum of 1 km apart, to avoid spatial autocorrelation issues associated with far-ranging taxa (birds);
b. Sites were located, as much as practicable, > 100 m from the edge of pasture / regrowth / remnant boundaries;
c. Sites were located wholly within paddocks i.e. sites did not cross fencelines;
d. Sites were located > 200m from waterpoints.

Table 3: Definitions of stratification variables used

Stratification	Definition
Land type	
Soft mulga	Regional ecosystems: 6.5.1, 6.5.7, 6.5.9, 6.5.10, 6.5.11, 6.5.14, 6.5.18 (see Appendix 1 for description)
Brigalow/Belah Scrub	Regional ecosystem 11.9.5 (see Appendix 1 for description)
Poplar Box on alluvials	Regional ecosystem 11.3.2 (see Appendix 1 for description)
Landscape scale	
Fragmented	Remnant vegetation incorporates 10 to 30% of area within a 1-km radius landscape
Intact	Remnant vegetation incorporates > 70% of the area within a 1-km radius landscape
Management (site scale)	
Remnant vegetation	Overstorey canopy cover is > 50% of the benchmark value for that regional ecosystem and median overstorey canopy height is > 70% of the benchmark value for that regional ecosystem.
Pasture	Cleared for pasture growth. No (or minimal) regrowth or woody component (except in the mulga lands), and can be sowed to exotic species.
Regrowth	Woody cover of appropriate ecosystem is present either in regeneration/regrowth phase, or has been disturbed through thinning (selective lop fodder feeding in mulga, thinning in brigalow and poplar box).
Condition	
BOO	Best-on-offer vegetation condition for biodiversity. Best available reference condition where attributes of the vegetation are within the range of natural variability and with relatively little evidence of modification by humans since European settlement.
AB	AB Grazing Land Condition defined as good to fair ability of land to respond to rain and produce useful forage (Chilcott *et al.* 2003)
CD	CD Grazing Land Condition is poor to very poor ability of land to respond to rain and produce useful forage.

Table 4: Stratification table showing the treatments and number of sites selected for each

Land type	Landscape	Management	Condition state	Strata unit	No. sites
Brigalow-belah on sedimentary	intact remnant ***Conservation landscape***	Preferably ungrazed / light	BOO	**1**	6
			AB	**2**	6
			CD	**3**	6
	fragmented landscape sampling remnant ***Mixed landscape***	Remnant can be grazed	AB	**4**	6
			CD	**5**	6
	fragmented landscape sampling non-remnant ***Production landscape***	Pasture (native or sown to buffel)	AB	**6**	6
			CD	**7**	6
		Brigalow regrowth or disturbed (e.g. heavy thinning)	AB	**8**	6
			CD	**9**	6
Soft Mulga	intact remnant ***Conservation landscape***	Preferably ungrazed/light	BOO	**10**	7
			AB	**11**	7
			CD	**12**	7
	fragmented remnant ***Mixed landscape***		AB	**13**	7
			CD	**14**	7
	fragmented non-remnant ***Production landscape***	Previously pushed (mulga regrowth)	AB	**15**	7
			CD	**16**	7
		Disturbed/thinned (lopped/ axe cut / chainsaw)	AB	**17**	7
			CD	**18**	7
Poplar box (alluvial)	intact remnant ***Conservation landscape***	Preferably ungrazed/light	BOO	**19**	6
			AB	**20**	6
			CD	**21**	6
	fragmented remnant ***Mixed landscape***		AB	**22**	6
			CD	**23**	6
	fragmented non-remnant ***Production landscape***	Pasture (native or sown to buffel)	AB	**24**	6
			CD	**25**	6
		Poplar box regrowth or disturbed (e.g. heavy thinning)	AB	**26**	6
			CD	**27**	6
	Total number of sites				**171**

3.3 Fauna surveys

Quantitative data on diurnal birds and reptiles was collected over two sampling periods, during spring and again during autumn. Repeated surveys for each taxonomic group were conducted at the same sites, to increase the probability of detection.

For this project diurnal birds and reptiles were targeted for survey because these taxa:

1. are known to be sensitive to variation in floristic and structural change in the mulgalands and brigalow belt bioregions
2. have broad distributions and are more likely to be detected relative to other taxonomic groups in the region (e.g. arboreal marsupials are naturally uncommon in the region; small ground-dwelling mammals tend to occur in pulses).
3. can be surveyed using relatively standardised and time efficient methods, which allows more sites to be surveyed.

All fauna survey techniques used in this study was endorsed by the Queensland Department of Environment and Resource Management Animal Ethics Committee (Approval number SRAEC0014).

All fauna sampling was based on a 1 ha (100 m x100 m) site (Figure 2). BioCondition and floristic sampling occurred on a randomly chosen 100 m x 50 m plot (A or B), located either side of the central N-S transect.

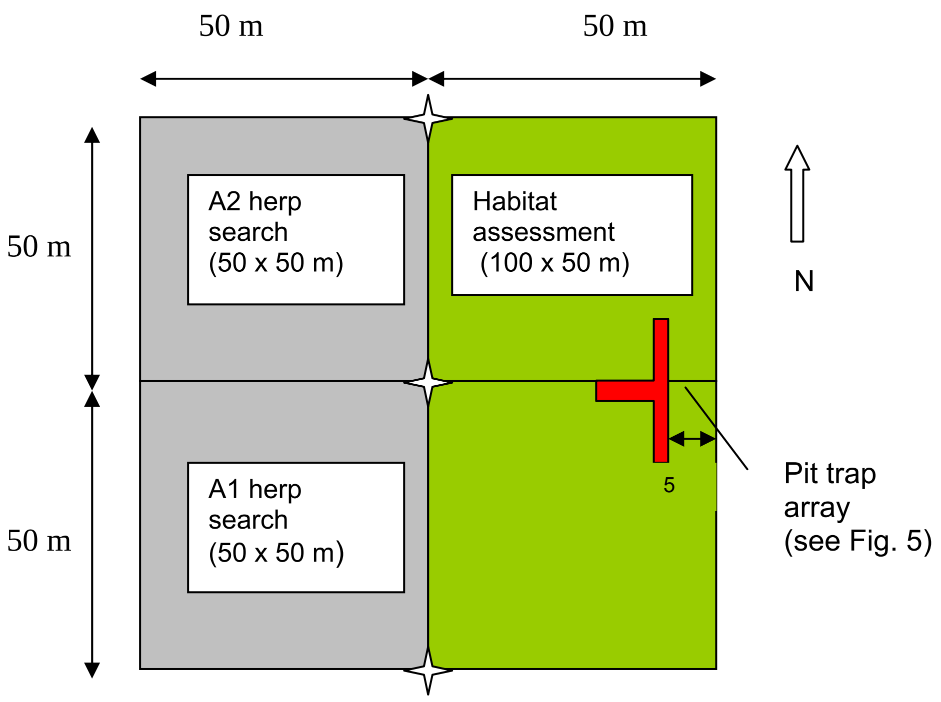


Figure 4: Fauna sampling site layout

3.3.1 Birds

At each site, diurnal bird surveys were conducted within a 100 m x 100 m quadrat. The bird survey methodology was based on extensively used protocols developed for the Australian rangelands (Woinarski and Ash, 2002; Hannah et al., 2007; Kutt and Woinarski, 2007). Birds were sampled over two six-day survey periods, one during 'spring/summer' (September to December) and again during 'summer/autumn' (February to May) during 2007 and 2008. During each survey period, birds were sampled in six, 10-min counts per quadrat, twice during the 'early morning' (<2 h after sunrise), twice during the 'late morning' (between 2- and 4-h after sunrise) and twice during 'other' times of the day (between 4-h after sunrise and 2-h before sunset). All surveys were conducted on different days by one of two observers on fine, calm days. Only birds seen or heard within the quadrat were counted. Birds flying over the quadrat were excluded, unless they were observed to be actively hawking or foraging within the quadrat.

Counts for each species were summed across the 12 quadrat samples to give a relative abundance for each site. Species richness was recorded as the number of species detected at least once at each site.

3.3.2 Reptiles

Two general techniques were used to survey for reptiles – pit trapping and active herpetofauna searches. Pit trapping involved using an array of four pit traps and six funnel traps on the sample plot in a T-shape pattern, as per the plot layout in Figure 2. Twenty-litre plastic buckets were used as pit traps, which were connected via drift-fence at 7.5 m intervals.

Active searches for herpetofauna were conducted over two survey periods (spring and autumn), on the 100 m x 50 m plot not selected for floristic measurements. The plot chosen for active herpetofauna searches was divided into two 50 m x 50 m quadrats – with A1 searched during the first period and A2 searched during the second survey period (Figure 4). This is done to eliminate the effect of the destructive active searches on the microhabitat used by the reptiles (e.g. logs, burrows, leaf litter etc).

Each quadrat is actively searched five times for herpetofauna (reptiles and frogs). Three active diurnal searches (approximately two in the morning and one in the late afternoon) along with two nocturnal searches (conducted at night using headtorches and, to a lesser extent, spotlights). Each search is conducted for 20 person-minutes (generally 2 persons x 10 minutes). The active diurnal searches involve scanning for active reptiles as well as turning rocks and logs, raking through leaf litter, looking under bark and in crevices looking for more cryptic reptile species. Nocturnal searches are, however, predominantly observational with little destructive searching. Nocturnal searches involve scanning for active reptiles, looking for eyeshine, and listening for signs of activity.

The number of individuals of each reptile species seen while searching is recorded along with any mammals or other fauna, scats, bones and other signs where these can confidently be attributed to species. A total abundance score for each species was derived from the sum of all counts from trapping and searches.

3.3.3 Incidental vertebrate records

Species that were seen, heard or caught and reliable signs of species in the vicinity of a site and in the same habitat were recorded as incidental for that site. Incidental records were not used in the analyses but did contribute to overall species lists and general distribution data collated and distributed to the landholders. Other species seen or trapped (e.g. using harp traps for microbats) on the properties, that were not attributable to a site, were also recorded and listed for the general area.

3.4 Flora surveys

Ground floristics and attributes of ground cover were assessed within ten 1 x 1 m subplots located along the centre transect. The number and cover (%) of each flora species located within the subplot was recorded. The broad cover categories followed that described in BioCondition; native grass; native non-grass; native shrubs < 1 m height; non-native grass; non-native non-grass; fine litter < 10 cm diameter; rock; bare ground; cryptograms and other. Shrubs and small trees 2–20 cm DBH and > 1 m height are recorded in the 50 x 10 m subplot, and counted by species. Shrub canopy cover and Tree canopy cover is estimated along the 100m transect. All trees > 20 cm DBH are recorded in the 100 x 50 m area. The following characteristics are noted for each tree measured; species, diameter, whether it is dead or living, size and number of hollows.

Life forms discussed in this report included trees, shrubs (woody species usually 1.5-4 m in height and generally multi-stemmed, also including mistletoe), vines (woody), forbs (all herbaceous species including rushes, creepers, trailers and non-woody climbers), grasses (Poaceae), sedges (Cyperaceae) and ferns. The tallest and mid layers were composed of tree, vine and shrub species while the ground layer consisted of forb, grass, fern, sedge and shrub species. The assemblages of all species at each site were collated. Nomenclature used follows that of Bostock and Holland (2007). When identification to species or genus level was not possible, the specimen was identified to genus or family level.

3.5 Site-based habitat features

Field assessment of site based indicators selected for testing, as well as other attributes not selected but likely to provide habitat value for biodiversity (e.g. rock cover) or quantify disturbance levels (e.g. stumps) were conducted on one occasion at each site. The habitat assessment plot coincided with the fauna assessment plots. The habitat assessment site constituted a 100 m x 50 m fixed area plot, within which were nested a series of sub-plots required for specific habitat assessments (Figure 5). A total of five sub-plots were used to assess the habitat characteristics of each site, and are summarised as follows:

1. 100 x 50 m area: recorded all trees > 20 cm Diameter at Breast Height (DBH), all stumps > 5 cm diameter (plot size can vary depending on the density of stumps), and site information and disturbance;

2. 100 x 25 m area: recorded all coarse woody debris > 10 cm diameter (plot size can vary depending on the density of logs);

3. 100 m transect: recorded tree canopy cover, shrub canopy cover.

4. 50 x 10 m area: recorded all trees and shrubs 2 – 20 cm DBH.

5. 10 1x1 m plots, located 10 m apart along the centre transect: floristics (cover and frequency by species), ground cover, litter, rock cover, and proportion of bare ground.

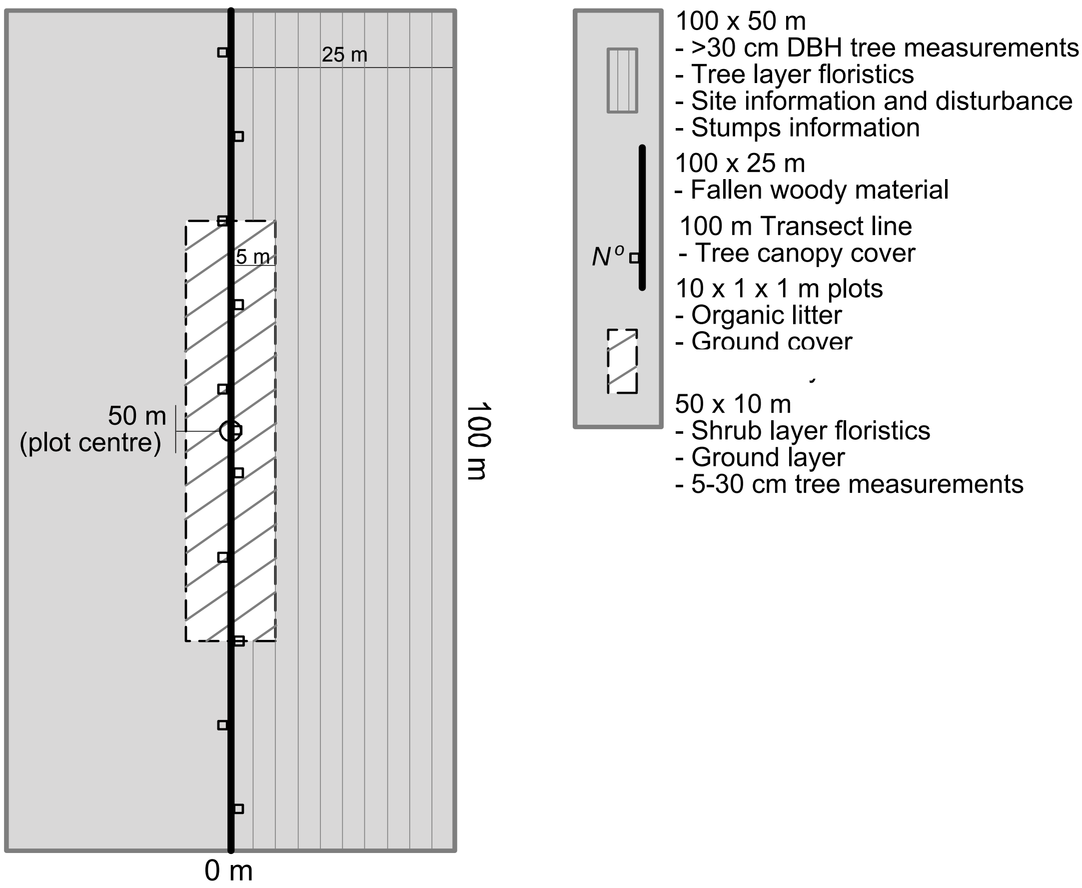


Figure 5: Habitat assessment area and layout

3.5.1 Trees and shrubs

All trees > 20 cm DBH were recorded in the 100 x 50 m area. The following characteristics were recorded for each tree measures; species, diameter, whether it is dead or living, size and number of hollows. Tree canopy cover was assessed as the percent canopy cover of each tree whose projected canopy intersects the 100 m transect. The approach uses the line intercept method and treats each canopy as solid, i.e. continuous leaves with no light gaps) (Greig-Smith 1964). The vertical projection of the tree canopy and the height of each tree intercepted along the 100 m transect was recorded. The total length of the projected canopy was then divided by the total length of the tape to give an estimate of percent canopy cover for the tree layer. The health of the canopy of each tree intercepting the transect was assessed on a 1 to 4 scale (Eyre *et al.* 2011). The average height of the tree canopy was also estimated. Shrubs and small trees 2 to 20 cm DBH and > 1 m height were recorded in the 50 x 10 m subplot, and counted by species. Shrub canopy cover was estimated as described for tree canopy cover.

3.5.2 Native perennial grass basal area - preferred and intermediate species

This feature refers to the average crown or basal cover of native perennial ‘decreaser’ grasses, and was assessed within five 1 x 1 m quadrats. The crown cover of a perennial grass tussock is the cross-section through the tussock base in contact with the ground (Figure 6). Crown cover is measured in preference to grass herbage cover as it provides a much more reliable estimate, particularly during times of drought. It is also the standard experimental measure used to assess grazing land pasture condition (DPI&F 2006). The preferred approach focuses on the assessment of "decreaser species" or preferred and intermediate species (which decline under heavy grazing), as opposed to “increaser species” and non-preferred species (which increase under heavy grazing). Each grass species encountered was identified as a preferred or intermediate species based on the respective land type documents.

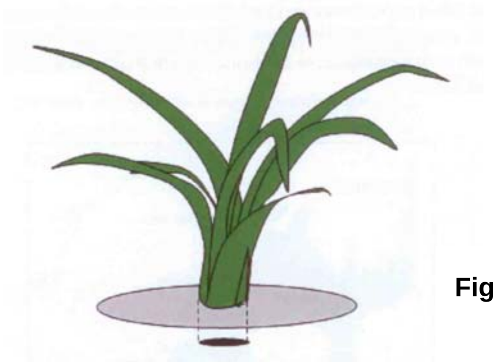


Figure 6: Crown cover of grass tussock (from DPI&F 2006).

Two methods were used to assess grass basal area, a detailed method and a rapid method. The detailed method involved the assessment of the number, basal area size, via measurement of diameter of the tussock base and species of all grass tussocks within each of 10 quadrats (whose size was determined by the spatial arrangement of tussocks e.g. how spread out they are – quadrat sizes were either $1m^2$, $2m^2$ or $4m^2$). From this sample the Basal area of perennial decreaser grass species was determined. The second, more rapid method involved assessors literally “walking the transect line”. At each metre point along the 100m transect line, assessors recorded whether the point on the tape had struck the base of a grass species tussock. Grasses were identified to species.

3.5.3 Litter cover

Litter is a key habitat component for wildlife and woodland functioning. Leaf and woody litter protects the soil from erosion and its decomposition provides continual nutrient supply into the ecosystem. It supports a diverse range of invertebrates which in turn provide a food source for vertebrate species. Litter cover is considered one of an important minimum set of indicators to be included in a patch-scale, species-level biodiversity assessment (Oliver *et al.* 2007).

For the field assessment, litter was defined as including both fine and coarse organic material such as fallen leaves, twigs and branches < 10 cm diameter. Litter cover was assessed in each of the 10, 1x1m quadrats. An overall value of litter cover for each site was the average value of the 10 quadrat assessments.

3.5.4 Cryptogram cover

A cryptogram is a broad term for a plant which reproduces by spores, and includes groups such as algae, lichens, mosses, ferns and liverworts. They occur on stable surfaces and are considered to assist with the stabilization and protection of the soil surface (Tongway and Hindey 1995). Cryptograms have been shown to decrease with increasing grazing pressure (e.g. Yates *et al*. 2000) and typically decrease in close proximity of artificial waterpoints (Harrington 2002). Other than the fact that cryptograms themselves contribute to the floral biodiversity, there are few direct links with biodiversity and the presence of cryptograms (even though they are frequently measured in studies of ground-dwelling fauna). A couple of exceptions are the association of the endangered black-eared miner (*Manorina melanotis*) with increased grass diversity and cryptogrammic crust cover and lower bare-ground cover (Harrington 2002); and the importance of biological soil crusts for lizard burrows (Zaady and Bouskila 2002). Cryptogram cover was assessed in each of the 10, 1x1 m quadrats, and averaged to give an overall value for each site.

3.5.5 Fallen woody material

Fallen woody material constituted all branches and logs >10 cm diameter and >0.5m in length which fell wholly or partly within the 100 x 25 m area. The diameter of each log was measured at both ends, recorded down to the point in the log where the small end reaches 10cm and above. In addition, the length of the log was measured within the bounds of the diameter measures or where the log intersected with the plot boundary. Smalian's Formula was used to generate volume per hectare of fallen woody material (Woldendorp *et al.* 2004). A number of attributes were recorded for each piece of fallen woody material measured, so that a description on the quantity, age and decay status of fallen woody material could be obtained for the site.

3.5.6 Landscape Function Indicators (LFI) of soil and pasture condition

Ground cover data was collated to provide the following quantitative indicators of soil and pasture condition relevant to the ABCD grazing land condition framework:

- Crust – % of crusted, bare soil surface;
- Crust-dist - % of crusted and disturbed soil surface;
- Organic cover - % of ground cover comprised of litter, grasses, forbs and cryptogams;
- Perennial grass - % of ground covered by perennial grasses – either dead or alive;
- Perennial forbs - % of ground covered by perennial forbs – either dead or alive;
- Annual grass - % of ground covered by annual grasses – either dead or alive;
- Annual forbs - % of ground covered by annual forbs – either dead or alive;
- Grass tussock - % of ground covered by grass tussocks.

3.5.7 Landscape Function Zones (LFZ)

Along the 100m north-south and east-west transects landscape organisation data was collected. These assessments, a modification of the Landscape Function Analysis (LFA) methodology (Tongway 2003, Tongway and Hindley 2004), used a simple patch rating system similar to that used in the 'Patchkey' technique of Corfield *et al*. 2007 and successfully adopted in the Fitzroy basin (Karfs and Beutel 2008). Lengths of zones, being measured distances between obstructions, were recorded as per Tongway (2003) along transects. Obstructions delineating patches included any long-lived feature such as perennial grasses and logs. These obstructions may be a single entity or as part of a larger patch. The area of ground between long-lived obstructions could include rock, bare ground, litter and cryptogams. The following Landscape Function Zones (LFZ) were identified, and their average length (m) and proportion (%) of each 100m transect calculated:

- 0 = interpatch or runoff zone dominated by bare ground, and/or litter and/or annual ground species;
- 1 = runon zone dominated by perennial forbs, and/or shrub, and/or permanent log;
- 2 = runon zone dominated by non-3P grasses (perennial grasses other than those that are also considered palatable and productive (3P) or sparse patch) and/or shrub, and/or permanent log; and
- 3 = runon zone dominated by dense perennial grass (3P) and/or grass tussock.

3.6 Landscape-scale features

Four landscape-scale measures were derived, relative to each of the assessment sites. These included Patch Size, Context, Connectivity and Distance to water.

3.6.1 Patch size

Patch size is used as an indication of patch viability and is one of the most commonly used landscape metrics in ecological research. Research suggests that fauna groups vary in their utilization of different size patches within the landscape (Catterall *et al.* 1991; Lindenmayer *et al.* 1999). Studies within central Queensland (Hannah *et al.* 2007) have revealed that bird species richness generally declines in smaller remnants. In cases where the assessable patch (if remnant or regrowth vegetation) was connected to larger areas of remnant vegetation, but through narrow corridors (< 200 m in width) within 1 km radius of the site, then these areas were treated as different patches and not included in the calculation of patch size. Patch size was measured using ArcGIS 9.1 (ESRI 2005) for the sites located in mapped remnant vegetation or regrowth only (
Figure 7).

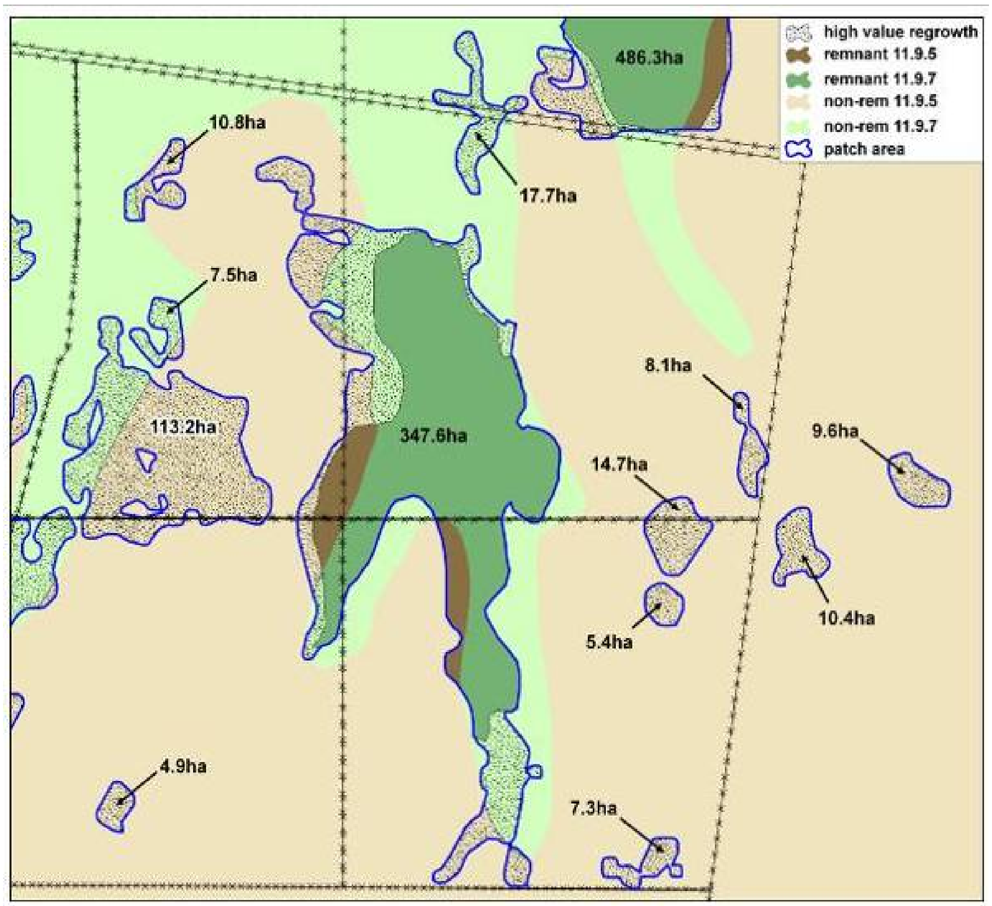


Figure 7: Example of the delineation of the patch area for calculating patch size, where mapped regrowth is present in the landscape.

3.6.2 Connectivity

Connectivity relates to the capacity that species have to disperse through the landscape between suitable patches of habitat, and therefore has important implications for species persistence (With 2004). A landscape with high connectivity is one in which a particular fauna species can readily move between suitable areas of habitat. A landscape with low connectivity means populations become largely isolated (Bennett *et al.* 2000). Immigration by a species into a single patch of habitat is related to connectivity at the landscape scale. However, other aspects such as the size of the patch (landscape attribute 1) and the amount of habitat in the landscape (landscape attribute 3), as well as the dispersal behaviour of species all contribute to the strength of the relationship (Tischendorf and Fahrig 2000).

This landscape-scale attribute was assessed using ArcGIS 9.1 (ESRI 2005) based on the length of the perimeter by which the sampled strata unit was directly connected with other remnant and/or regrowth vegetation (Figure 8).

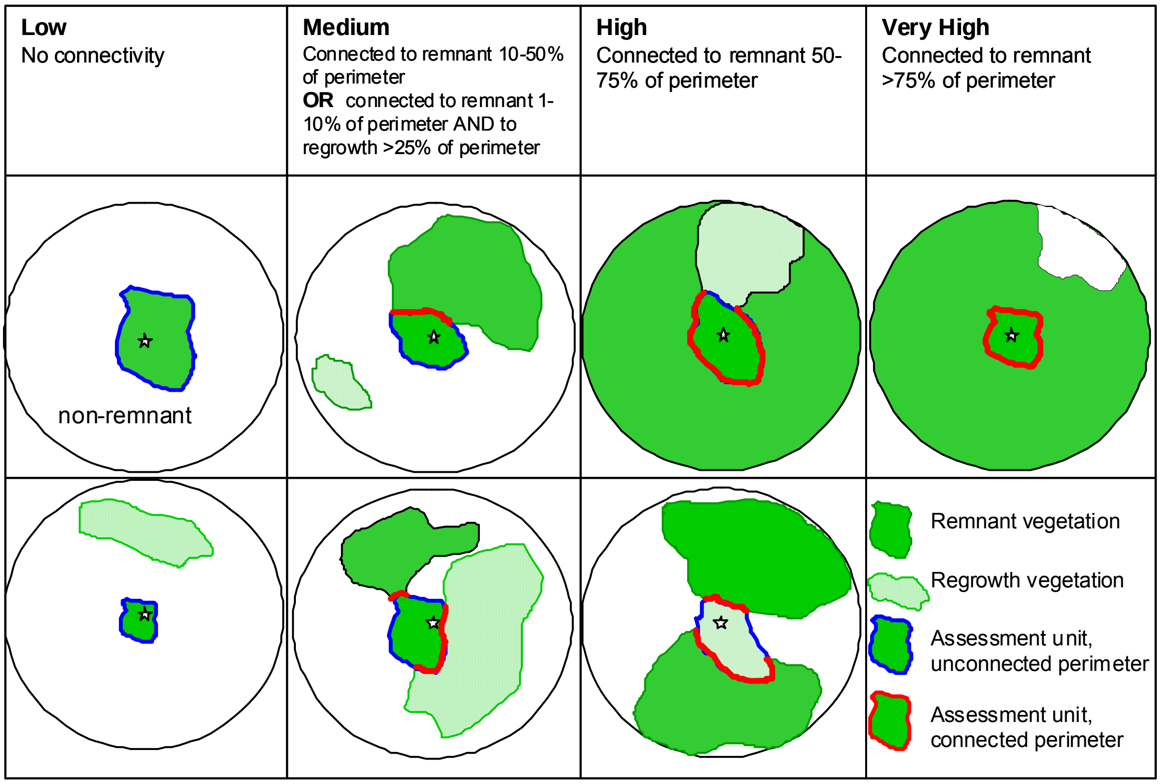


Figure 8: Examples of how connectivity in the landscape was assessed. The Assessment Unit refers to the Strata Unit, within which the assessment site is located.

3.6.3 Context

The Landscape-scale attribute "context" refers to the amount of native remnant vegetation that is retained proximal to the site being assessed. The amount of remnant vegetation retained in the landscape proximal to the area of interest has a notable influence upon the species composition and abundance of sensitive species. For example, local bird abundance patterns in the fragmented landscapes of Victoria are influenced not only by local processes operating within the assessment area, but also by the dynamics of regional populations elsewhere in the species' range relative to the amount of remnant vegetation retained in the landscape (Radford *et al.* 2005).

This attribute was measured using a 1 km radius buffer using ArcGIS 9.1 (ESRI 2005), which was positioned at the centre (50 m mark) of the site transect. The proportion of native vegetation, regrowth vegetation and cleared vegetation within each 1-km spatial extent was calculated for each site (Figure 9).

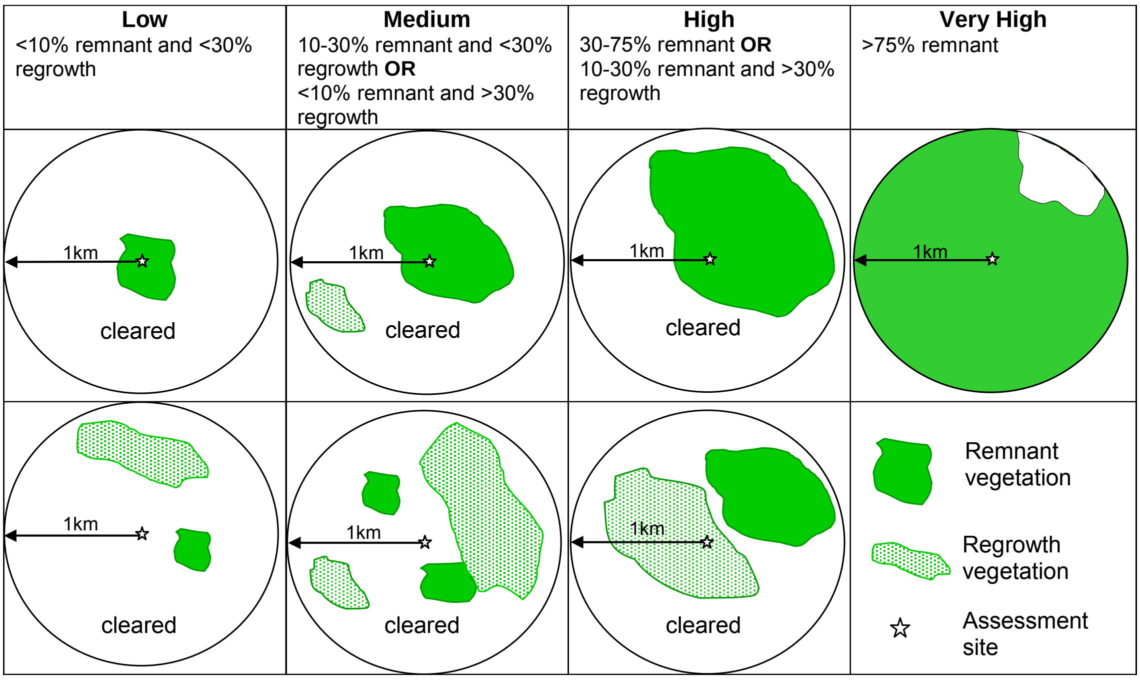


Figure 9: Examples of context in the landscape relative to the assessment site.

3.6.4 Distance to permanent waterpoint

The intact landscapes of Queensland's arid and semi-arid rangelands include a diversity of relatively unfragmented ecosystems of tropical savannas, woodlands, shrublands and grasslands (James *et al.* 1999, Woinarski and Fisher 2003). The dominant landuse is grazing by domestic livestock with minimal deliberate habitat modification in terms of vegetation clearing (Freudenberger and Landsberg, 2000). However, natural permanent water is rare in the landscape and to support the pastoral industry there has been an ongoing program of artificial waterpoint development since the late 1800's (Fensham and Fairfax 2008). This creates a pattern of grazing pressure, from stock as well as feral and native herbivores, that tends to radiate in intensity with distance from permanent water, known as a piosphere (James *et al.* 1999). Consequently, with increased densities of artificial waterpoints in the rangelands, areas of water remoteness for grazing relief are becoming increasingly rare. The issue with piospheres is that species assemblages can change in response to variation in grazing intensities, with the loss of “decreaser” species, or species sensitive to grazing pressure, closer to waterpoints (Landsberg et al. 1999; Pringle and Landsberg 2004).

Two measures were calculated for the distance to permanent water attribute. The first was based on the shortest distance from the centre of the assessment site to the nearest permanent water point within the one fenced area, and the second was to the nearest permanent water point regardless of fencing (Figure 10). The location of all waterpoints on each of the project properties were mapped using SPOT 5 imagery, which was then validated with the property managers. Permanent waterpoints were typically dams (earth tanks), raised ring tanks and troughs on pipelines.

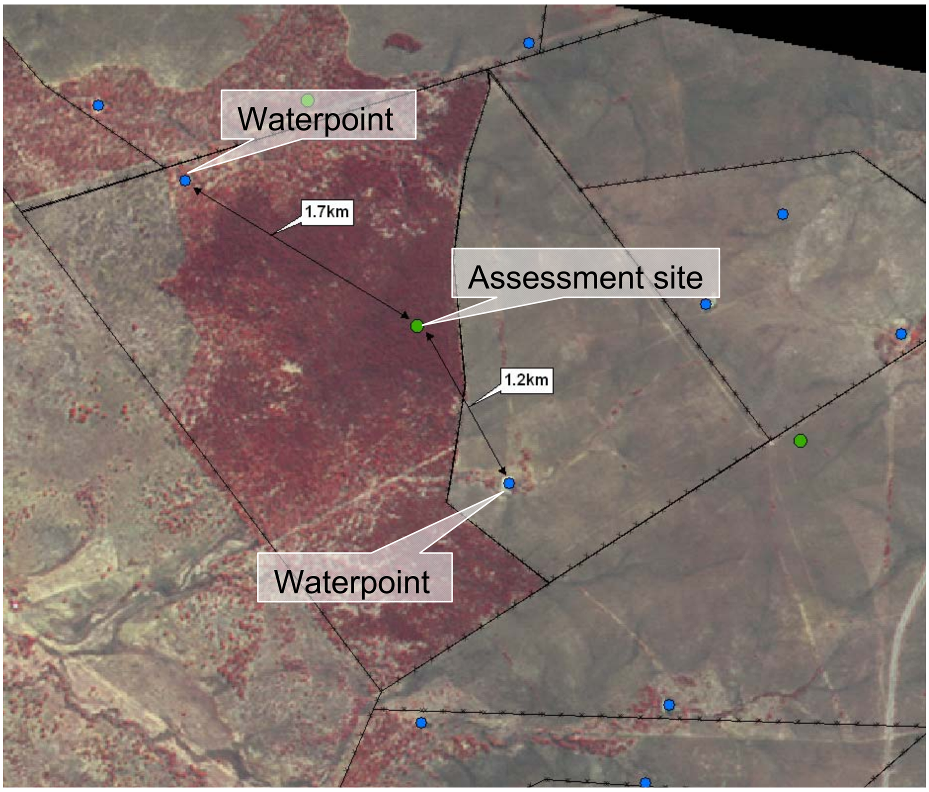


Figure 10: Calculation of distance to nearest permanent waterpoint within and across paddock boundaries

3.7 Grazing land condition assessment

Since its development by Chilcott *et al.* (2003), the ABCD land condition framework has gained wide acceptance and application in Queensland (Karfs *et al.* 2009b). The ABCD grazing land condition of each of sample site was assessed using the Stocktake method (Aisthorpe and Paton 2004). Sites were assessed towards the end of the growing season following above average rainfall. One experienced observer assessed land condition at all sites to ensure consistency. Both land condition and forage standing crop (kg of dry matter per hectare) were assessed.

Condition classes were assessed according to the criteria given in Table 1. Importantly, soil condition and pasture condition were assessed independently and their combined scores contributed to the overall land condition rating. Pasture condition was assessed by checking the density, health and relative yield of 3P pasture species. These are gauged relative to tree density. Woodland condition was measured using a tree dendrometer that returns a measure of tree basal area in m^2/ha. This measure did not contribute to the land condition rating.

3.8 Biodiversity condition assessment

The biodiversity condition of each site was assessed using the BioCondition framework (Eyre et al. 2011). This framework uses a standardised and systematic approach based on a fixed sample plot to assess the relevant attributes listed in Table 2. The value sampled for each site-based attribute is then compared with the benchmark value for the relevant regional ecosystem or land type, and scored. The scores for each attribute are then added together to give an overall BioCondition score for that site, as standardised against the BOO sites. The overall score then be categorised as '1234', for comparison with the ABCD framework. The score for each site was classified as 1, 2, 3 or 4 by using the summary statistics (mean + standard deviation) of all the BioCondition scores generated for the 171 sample sites (Table 5).

Table 5: Rules used to delineate the BioCondition '1234' classes

BioCondition Class	Lower cut-off of site score for classification
1	Mean + 1 standard deviation
2	Mean
3	Mean – 1 standard deviation
4	All scores > Mean – 1 standard deviation

3.9 Landholder or land manager surveys

Qualitative and some quantitative data were collected by interviewing participating landholders about their property's current and historical management. Locations of permanent stock watering points were verified using a property map so that distances to monitoring sites could be checked. Other historical management and infrastructure data collected included:

- Location of existing fences and any recent changes
- Number and classes of stock in each paddock
- Types of grazing systems and whether paddocks were rested from grazing as part of routine management, and when this might have occurred
- The use of fire, its intended purpose, time of the year and when burnt.
- Control of wild dogs and methods used.
- Timber clearing history and methods
- Whether paddocks had been previously cropped and, if so, when this occurred and the use of any fertilisers
- Whether exotic pasture species had been sown and when.

The data obtained from the land managers was used to validate location of fencelines and waterpoints, and to inform on recent management strategies relevant to grazing land management and biodiversity.

3.10 Analyses

The raw biodiversity data collected from the standardised flora and fauna surveys provided species abundance values for each site. For birds and reptiles, the abundance value was based on the total number of animals of each species that were counted during the surveys.

For plants, the abundance value was the count of individuals of each species detected during the survey. For the ground cover life forms (grass and forbs), a cover-abundance value was derived for each species for each site. Species richness was represented by the total number of species within each taxon (i.e. grasses, forbs, reptiles and diurnal birds) that were detected during the standardised surveys.

3.10.1 The relative importance of key habitat features

The aim of this analysis was to reduce the number of site-based and landscape-scale key features selected for the technical version of BioCondition for use in the rapid assessment. Indicators of condition used by the ABCD framework were also incorporated in to this analysis. This meant there was a total number of four landscape scale features tested, and 26 site-based features tested (Table 6). We also included abundance of miner birds, given their known impact upon small, declining woodland birds (Grey *et al.* 1998; Eyre *et al.* 2009). The combination of the key features can be thought of as a crude model, which gives an overall indication of a condition state. However, it is important to ensure no highly correlated explanatory variables exist with a model, as a lack of independence between the explanatory variables within a multivariate model means that extra weighting is inadvertently given to the correlated features, and this can lead to unreliable selection of the most appropriate features to include in the assessment (Mac Nally 2000).

Table 6: The suite of key features tested for correlation and relative importance

	Attribute	
Site-based features	**Diversity**	Tree species richness Shrub species richness Grass species richness Forb species richness Other species richness
	Cover and function	Tree canopy cover (%) Tree canopy health Tree canopy height (m) Shrub canopy cover (%) Native perennial forb and non-grass cover (%) Native annual grass, forb and non-grass cover (%) Cryptogram cover Density of miner birds
	Habitat	Large live trees Large dead trees Large live trees with hollows Fallen woody material Litter cover
	ABCD	3P native grass species cover/yield* Landscape Funcition Analysis categories (4) Soil condition 3P grass basal area
Landscape features		Size of patch Context Connectivity Distance to artificial water

Hierarchical partitioning provides a mechanism to identify those explanatory variables that explain most variance independently of the others, thus overcoming issues of multi-collinearity between explanatory variables (Mac Nally 2002). Therefore, for each key site-based and landscape-scale habitat feature (

Table 2), hierarchical partitioning was used to determine the independent contribution made by each in explaining bird species richness and reptile species richness. The hierarchical partitioning procedure was conducted using the heir.part package in R (Walsh and Mac Nally, 2007).

3.10.2 Species richness and ABCD and 1234 condition classes

Grass, forb, reptile and bird species richness, defined as the number of species within each taxon for each site, were each compared among the ABCD or 1234 condition classes and land type treatment classes using a two-way analysis of variance (ANOVA). Prior to the analyses species richness data was transformed using a log(x+1) transformation. Post hoc Tukey pairwise comparison tests were used to identify significant variation between the treatment classes.

3.10.3 Species composition and ABCD and 1234 condition classes

Community composition, defined as the relative abundance of each grass, forb, reptile or bird species per site, was compared between the ABCD land condition classes or the 1234 BioCondition classes and land type (3 classes; soft mulga, poplar box and brigalow belah) treatments, and their interaction, using a balanced two-way crossed design PERMANOVA in the PRIMER program (Anderson et al., 2008). PERMANOVA is a distance-based, non-parametric, multivariate analysis of variance that calculates a pseudo F-statistic and associated P-value by means of permutations, rather than relying on normal-theory tables (Anderson 2001; Anderson et al., 2008). We used the Bray-Curtis dissimilarity measure and 9999 permutations on square-root transformed data. Post-hoc pair-wise comparisons were used to examine differences in grass or bird assemblages between the treatments. Species observed in less than 10 sites were not included in the analysis.

To visualise multivariate patterns in species assemblages between the treatments, we used a non-metric multidimensional scaling ordination. The ordination was undertaken using the similarity matrix derived for the PERMANOVA in PRIMER (Clarke and Gorley, 2006). To allow identification of the grass or bird species characterising assemblages across the mulga, poplar box and brigalow belah land types, we used the average percentage procedure (SIMPER) in PRIMER to identify the percentage contribution each species made to the measures of the Bray-Curtis similarity within treatments.

3.11 Trial to map condition using remotely sensed imagery

The main aim of this trial mapping project was to assess the utility of remotely sensed data in the mapping of each of the field assessable attributes measured using the BioCondition field methodology. The premise being that these field assessable attributes can act as surrogates or indicators of biodiversity values, which can then be mapped.

The study area for the mapping trial was defined by the subregions Langlo and Nebine Plains within the Mulga Lands Bioregion. Remotely sensed data available for the study area included: ALOS PALSAR radar imagery, Landsat derived Foliage Projective Cover (FPC) time series data, and Landsat derived ground cover data. Site based attributes from 67 of the field sites visited throughout the MLA project were used to assess the remotely sensed imagery.

4 Results and Discussion

4.1 General fauna results

During the project information was collected on more than 55,000 animals, comprising 376 vertebrate species. Roughly 43,000 of these animals were recorded from our 171 study sites and comprised of 175 bird, 77 reptile, 38 mammal (7 introduced) and 17 amphibian (frog) (1 introduced) species. Figure 11 shows this species richness across the three land types we examined. Whilst the species richness appears to be similar across the three land types for each of the animal classes, the species composition is very different (Appendix 3). It is changes in this species composition within the land types that forms the basis for analysing the influence of changes in habitat, land condition and biodiversity condition.

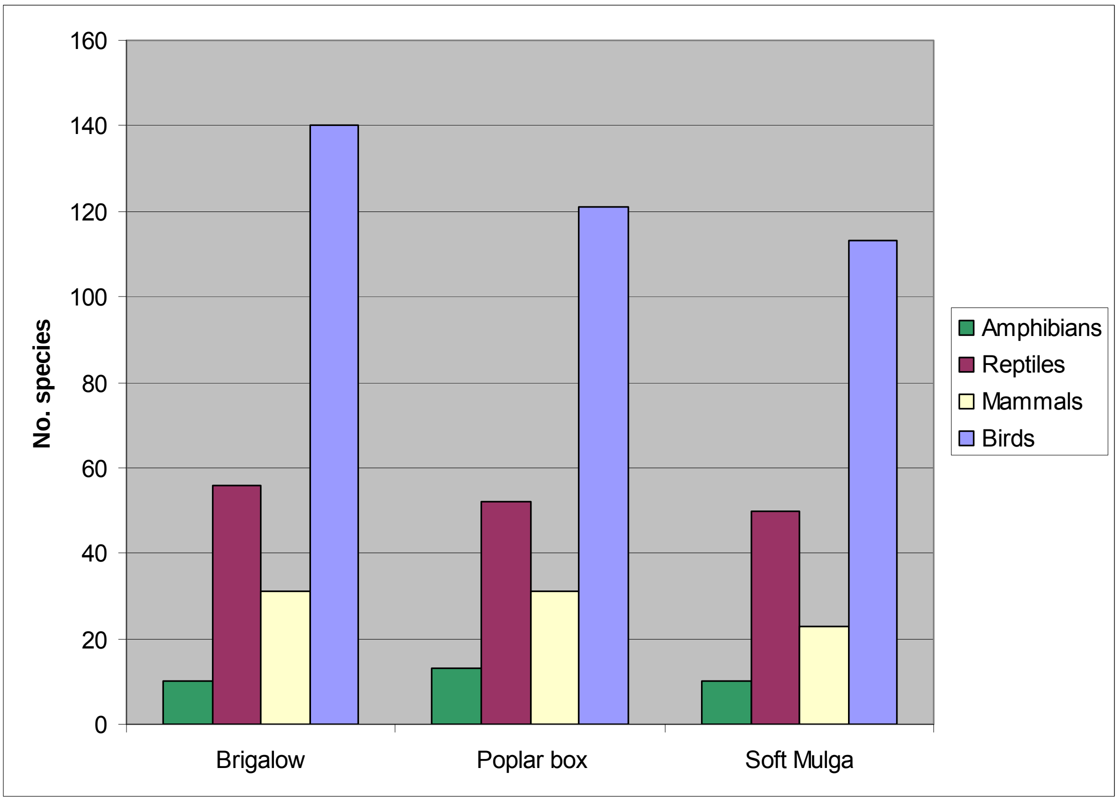


Figure 11: Species richness of all vertebrate species classes across the three land types of interest, brigalow, poplar box and mulga.

This extensive fauna data not only provides us with a basis to meet the project objectives but also allows us to gain valuable ecological information on individual species and species groups. The survey work has added significantly to the knowledge of biodiversity on grazing lands, which is often under surveyed. Within the Mulga lands this work also represents some of the first extensive systematic biodiversity surveys undertaken within the bioregion.

The following section will summarise some of the ecological knowledge gains we have made by undertaking this work by looking at the animal classes (groups).

4.1.1 Amphibians (Frogs)

Amphibians were not specifically targeted for the purpose of this project due to their highly variable detectability within these semi-arid landscapes. Essentially many of the species found within the brigalow belt and the mulga lands burrow, and can remain concealed deep underground for many years without emerging, until good rains fall. This makes them a difficult species group to utilise in researching how changes in habitat and land condition influence their occurrence.

As some of our field trips were quite wet, we did collect information on 17 species across the three land types - 10 in brigalow, 13 in poplar box and 10 in soft mulga, with a further 2 species collected incidentally (Appendix 3). Of the total the cane toad (*Bufo marinus*) was the only introduced species being detected on sites in the brigalow and poplar box communities. The knowledge gained from the burrowing frogs (e.g. holy cross frog, *Notaden bennettii* and the meeowing frog, *Neobatrachus sudelli*), in particular, is very valuable, slowly adding to our ecological knowledge of the individual species, where they occur and how weather conditions influence when the species emerge to breed.

4.1.2 Reptiles

A large amount of effort was invested in detecting reptile species on our study sites. We undertook across the 171 sites some 6300 pit trapping nights; 9400 funnel trapping nights; 400 hours actively searching through the day, and a further 260 hours searching at night. This effort resulted in 77 reptile species being detected, with appendix 3 showing the species found in each of the land types, as well as an additional 10 species found incidentally across the study area. Figure 12, below, shows how many species of reptile, by broad species group were found in each land type (a), and the abundance of each of these species groups (b). As can be seen from Figure 12b, the smaller more conspicuous reptile groups (geckoes and skinks) dominate all the land types with the larger, often more obvious species groups being far less abundant.

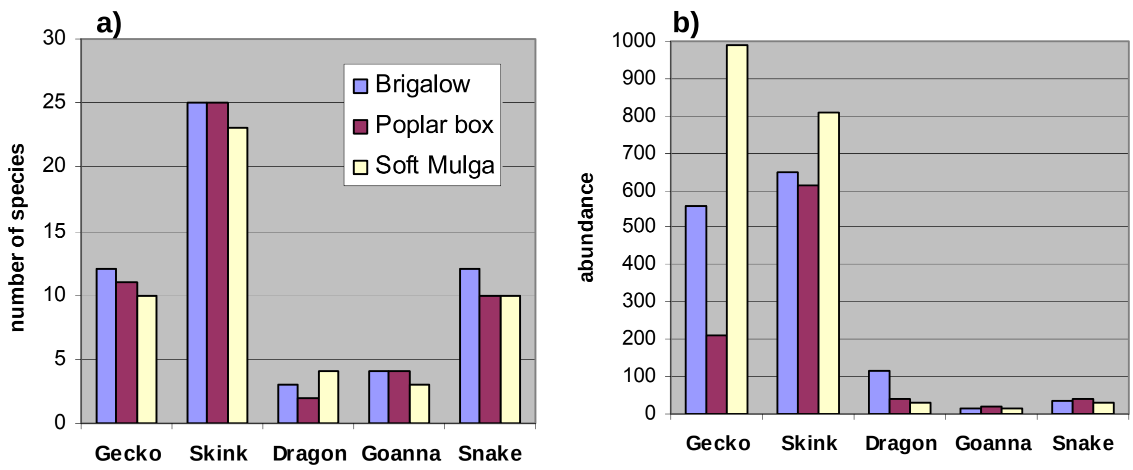


Figure 12: The distribution of reptile species groups across a) number of species or species richness, and b) the abundance of each reptile group.

Two vulnerable species *Egernia rugosa* (yakka skink) and *Paradelma orientalis* (brigalow scaly-foot lizard), and two near threatened species *Furina barnardi* (yellow-naped snake) and *Aspidites ramsayi* (woma python), as listed by the Nature Conservation Act 1992, were found during the surveys. The yakka skink was recorded from 14 sites (36 records) across our study area – seven poplar box sites, five mulga sites and two brigalow sites. They were also recorded incidentally at a number of other places across our study properties. The yakka skink is a large (up to 40cm long), communal burrowing skink that is sparsely scattered across a large part of semi-arid Queensland. Yakka's often utilise large logs to stabilise the entrances of their burrows and to provide additional shelter. It appears they persist in paddocks where fallen timber is retained.

The brigalow scaly-foot lizard was detected at five of our remnant brigalow sites (11 records). This harmless species that superficially resembles a snake is endemic to the Brigalow Belt in Queensland. Recent work, including the records from this project, suggest that the species is probably more secure within its range than previously thought and its status is currently undergoing a reassessment under the *Nature Conservation Act 1992*.

The yellow-naped snake is a very poorly known, relatively small nocturnal snake that until this project was only known from scattered records in the northern half of Queensland. One specimen was collected from near Charleville, on a remnant mulga site that had recently been cleared. Because this site changed treatments during the course of the project we have excluded it from the project analyses but will use the data for other purposes. The yellow-naped snake is the subject of a range extension paper in the process of being published in the Memoirs of the Queensland Museum.

Liopholis modesta (Eastern rock skink) is also worth noting here, even though it is currently not a listed species. This species is particularly interesting as it is a locally common species in a small area of Southeast Queensland and Northern New South Wales. In the Brigalow Belt, where we conducted our study, it is known from only 3 or 4 isolated localities. As we'd expect with a common name of Eastern rock skink, it predominantly lives in granite outcrops throughout the main part of its distribution; this is not however the case in the Brigalow belt, where it seems to have a preference for fallen timber, often building burrows in and around large logs. Like the yakka skink (which the Eastern rock skink is related to), the Eastern rock skink is also a communal species, forming colonies or families of presumably related individuals.

Like the Eastern rock skink, we also found a number of other noteworthy species. Noteworthy reptile species detected during the fauna surveys are listed in Table 7, with comments outlining why each of the species is of interest.

Table 7: Significant reptile species recorded during fauna survey work, with comments on why they are significant.

Scientific Name	Common name	Comment
Egernia rugosa	Yakka skink	Listed as vulnerable, with a sparse, scattered population.
Aspidities ramsayi	Woma (python)	A 'near threatened' python species that can feed on venomous snakes. Rarely encountered in the Brigalow belt and Mulga lands bioregions.
Furina barnardi	Yellow-naped snake	Significant range extension of a poorly known species, listed as 'near threatened'.
Liopholis modesta	Eastern rock skink	Isolated, disjunct population in Brigalow Belt that has different habitat preferences.
Ctenotus brachyonyx	Striped skink	Edge of range.
Strophurus krisalys	Spiny-tailed gecko	A recently described species probably at the edge of their range.
Delma plebia	Flap-footed lizard	Appears to be an isolated, disjunct population in the Brigalow Belt, with very few records.
Brachyurophis incinctus	Unbanded shovel-nosed snake	A rarely encountered, burrowing species at the eastern edge of its known range.
Ramphotyphlops sp.	Blind snake	Most likely a species found in southern parts of Australia. Requires further work to confirm ID of Qld Museum specimen.

4.1.3 Birds

From more than 200 hours of bird surveys we recorded a total of 175 species on the 171 study sites across all three land types (appendix 3 provides the bird list by land type). All these bird species are native. In addition to the birds we recorded on our study sites we recorded further 45 species incidentally across the study area, these are also listed in appendix 3 with abundance in the 'incidental' column.

During the surveys we detected two vulnerable species, the painted honeyeater (*Grantiella picta*), and the southern subspecies of squatter pigeon (*Geophaps scripta scripta*), as listed by the Nature Conservation Act 1992. The painted honeyeaters were recorded in low numbers in both soft mulga and brigalow land types, while the squatter pigeons were recorded only in the Brigalow belt in both poplar box and brigalow land types. We did record over 200 squatter pigeons during the project, however as they are a target species, we often recorded this species incidentally whenever we encountered them. This southern subspecies of squatter pigeon has declined throughout the southern part of their range, including in southern Queensland.

Other significant, listed species include the freckled duck, square-tailed kite and black-chinned honeyeater, all species listed in the Nature Conservation Act as 'near threatened' (see Table 8 for comments).

Table 8: Significant bird species recorded during fauna survey work, with comments on why they are significant

Scientific Name	Common name	Comment
Grantiella picta	Painted honeyeater	A vulnerable nomadic and migratory species, following fruiting of mistletoes.
Geophaps scripta scripta	Squatter pigeon (sthern subspecies)	A vulnerable species that was once common and widespread, now rare and patchily distributed.
Stictonetta naevosa	Freckled duck	A 'near threatened' highly nomadic duck that irregularly appears on freshwater swamps and lakes in southern Qld.
Lophoictinia isura	Square-tailed kite	An uncommon to rare raptor (near threatened), with widely scattered breeding in eastern Qld.
Melithreptus gularis	Black-chinned honeyeater	A 'near threatened', uncommon and seasonally nomadic honeyeater species.
Climacteris picumnus	Brown treecreeper	One of the declining woodland bird species in southern states. Relatively common in suitable habitat.
Climacteris affinis	White-browed treecreeper	One of the declining woodland bird species in southern states. Relatively common in suitable habitat, especially remnant mulga.
Chthonicola sagittata	Speckled warbler	Locally common (patchy) small passerine that has declined in southern states.
Petroica goodenovii	Red-capped robin	A relatively common robin in woodland in drier areas. This species is suspected to be declining in southern states.
Melanodryas cucullata	Hooded robin	Again a relatively common robin in drier woodland areas that is declining in settled areas, especially in southern states.
Pomatostomus temporalis	Grey-crowned babbler	Relatively common in woodlands and open forest but becoming rarer in settled area's.
Pachycephala rufiventris	Rufous whistler	Appears to be a relatively common species in brigalow and mulga land types, but has declined in southern states.
Phaps histrionica	Flock bronzewing pigeon	Significant, potentially breeding records of this species in the Charleville area. This species is highly nomadic and has declined significantly over the years.

In the Mulga lands the presence of species regarded as declining in southern states is also of significance. These include red-capped robin, hooded robin, white-browed treecreeper, grey-crowned babbler and jacky winter. A single record of two slaty-backed thornbills and one of chirruping wedgebill, common species further to the west, represent the very eastern edge of their distributions. Records of the highly nomadic, flock bronzewing pigeon, possibly breeding (eggshell found in area of numerous sightings) in the Charleville area are also worth noting. This species roams across most of inland Australia and has declined dramatically over the last 50 years. In the Brigalow Belt, woodland birds of concern here included red-capped robin, white-browed treecreeper, brown treecreeper, speckled warbler, grey-crowned babbler and jacky winter.

As can be seen from Figure 13, in general the remnant treatments across the land types studied have the highest average diversity of bird species (species richness) while pastures tended to have the lowest diversity. This is particularly true in the more wooded land types of Brigalow and Soft Mulga where we see much higher bird species richness. In poplar box we see less difference in species richness across the broad treatments, probably due to its naturally open structure. These types of graphs can be misleading when showing little difference in species richness, like the poplar box land type, where there are actually significant changes in the species composition, with some species benefiting from disturbance (increasers) and others decreasing due to changes in their environment.

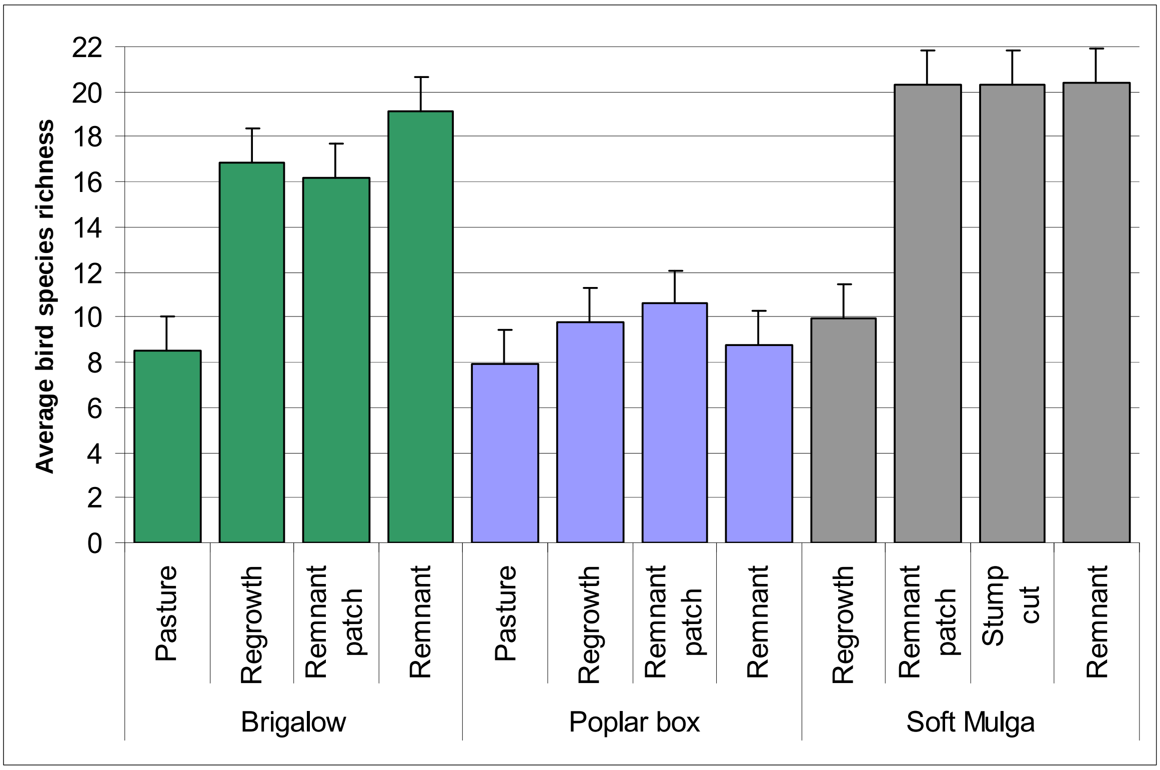


Figure 13: Distribution of bird species richness between treatments in each of the land types targeted (brigalow, poplar box and soft mulga).

4.1.4 Mammals

Like frogs, we were not specifically targeting mammals for the purposes of this project; however we did gain valuable information on a number of small mammal species across the study area, through pit trapping. We also incidentally recorded large mammals (i.e. macropods) using the study sites. The reason we haven't included small mammals in our project analysis is that they tend to have very variable populations based on climatic conditions. For example, during drought their numbers tend to be very low, whereas during good seasons small mammal populations tend to increase dramatically.

We also added on a component to examine how microbats are influenced across our treatments using Anabat detectors and incidental trapping. We have confirmed 16 species of bats across our study properties, 9 from our study sites (Appendix 3). We are still assessing the suitability of the Anabat recordings given detection of a call can vary based on a number of climatic variables, such as humidity. Initially we thought climatic factors, such as humidity, would not be a problem in a semi-arid environment, typically remaining fairly stable but we unfortunately experienced highly variable conditions during the study that have influenced the suitability of our data for the analysis originally planned. The Anabat data combined with the information gained through trapping has still added significantly to aspects of bat biology including distribution, abundance and a call library.

The complete list of the 50 mammal species (42 on study sites, 8 incidental) recorded during the project is in appendix 3. Of these, 7 species are introduced, 6 detected on sites and 1 detected incidentally. We collected information on one vulnerable bat, *Nyctophilus corbeni* (eastern long-eared bat) and one near threatened bat, *Chalinolobus picatus* (little pied bat). We also recorded several other species of significance including *Antechinomys laniger* (Kultarr) and *Chalinolobus morio* (chocolate wattle bat) which are listed in Table 9, with comments on the significance of the records.

Table 9: Significant mammal species recorded during fauna survey work, with comments on why they are significant.

Scientific Name	Common name	Comment
Antechinomys laniger	Kultarr	A rare (near threatened) small mammal in the critical weight range. These mulga records represent the most recent occurrence data for the eastern part of their range since the 90's.
Chalinolobus morio	Chocolate wattle bat	A poorly known, rarely encountered species in the western area's of Queensland. The records around Charleville are therefore significant.
Chalinolobus picatus	Little pied bat	Once listed as rare, this species is now considered "near threatened" thanks to information gained from this and other projects in Qld.
Nyctophilus corbeni	Eastern long-eared bat	Taxonomy of this vulnerable species has only recently been resolved. Possibly due to its behaviour or actual rarity this species is very rarely caught so all additional records add significantly to the knowledge base of this species.

4.2 General flora

A total of 541 vascular plant species (including subspecies, varieties and forms) belonging to 256 genera in 73 families were recorded from all surveyed sites. Of the total, 493 or 91.1% were native species and 48 or 8.9 % were exotic species (Appendix 4).

Of the 493 natives, 235 or 47.7% species were forbs, 119 (24.1%) were grasses, 78 (15.8%) were shrubs, 35 (7.1%) were trees, 13 (2.6%) were vines, 9 (1.8%) were sedges and 4

(0.8%) were ferns. As can be seen from Figure 14, forbs and grasses dominate the species richness across all three land types.

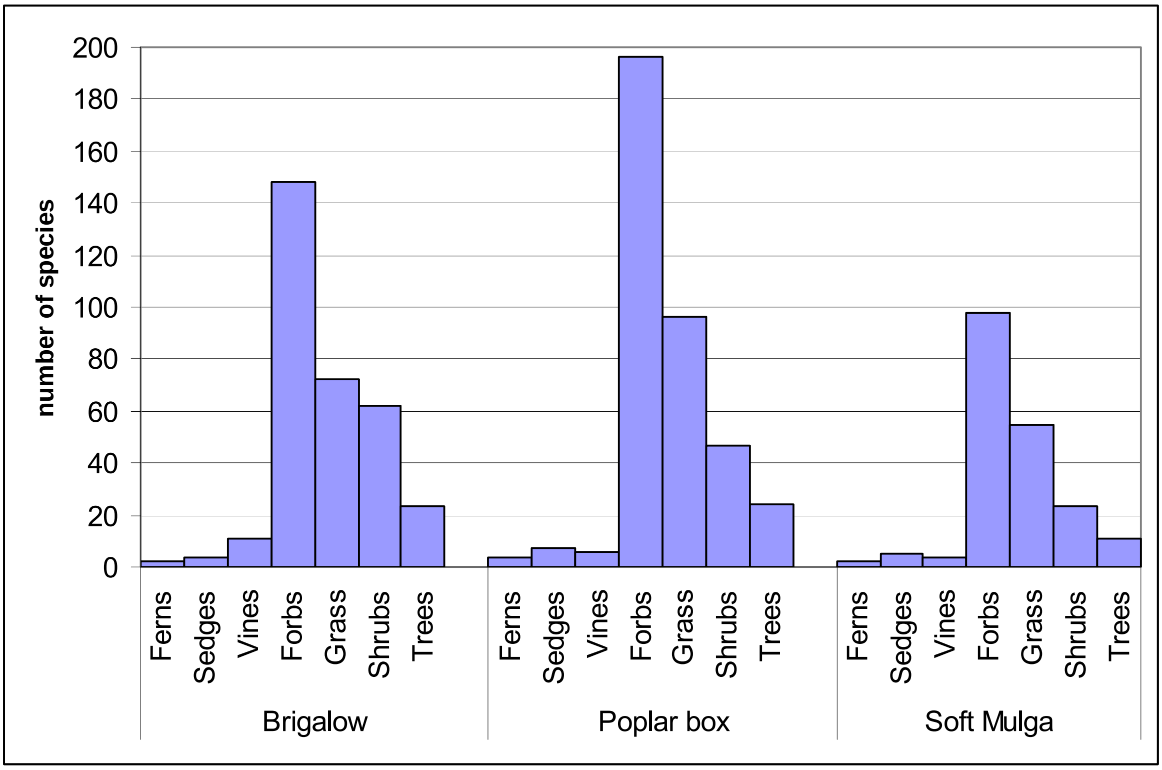


Figure 14: Species richness of each plant life form within the three targeted land types.

No endangered, vulnerable and rare species listed under the Queensland State Legislation (*Nature Conservation Act 1992* and *State Penalties Enforcement Act 1999*) were recorded. However, 22 noteworthy species in the areas were found during the surveys. These species not only have a restricted distribution in Queensland, but are uncommon where they were recorded. Some had distributional significance or were endemic to Queensland (

Table 10).

***Calotis* species**

Table 10: Noteworthy native plant species

Scientific Name	Distribution	Comment
Brachyscome curvicarpa	Qld, NSW	restricted in Qld
Brunoniella acaulis subsp. *ciliata*	endemic to Qld	rare and restricted
Calandrinia stagnensis	Qld, NT	rare and restricted in Qld
Calotis scabiosifolia var. *scabiosifolia*	Qld, NSW	restricted in Qld
Calotis scapigera	Qld, NSW, SA, Vic	restricted in Qld
Galium propinquum	Qld, NSW, Tas, NZA	new record for the area.
Gnephosis tenuissima	Qld, NSW, NT, SA, WA	restricted in Qld
Goodenia havilandii	Qld, NSW, SA	restricted in Qld
Harmsiodoxa brevipes var. *major*	Qld, SA	very rarely collected, restricted in Qld
Harmsiodoxa puberula	Qld, NSW, SA	restricted in Qld
Helichrysum rupicola	endemic to Qld	the most southern distribution
Isoetopsis graminifolia	Qld, NSW, SA, Vic, WA	restricted in Qld
Leiocarpa panaetioides	Qld, NSW	restricted in Qld
Lobelia darlingensis	Qld, NSW	restricted in Qld
Macgregoria racemigera	Qld, NT	rare and restricted in Qld
Micromyrtus hexamera	Qld, NSW	restricted in Qld
Plantago turrifera	Qld, NSW	restricted in Qld
Solanum ammophilum	Qld, NSW	restricted in Qld
Solanum innoxium	endemic to Qld	rare and restricted
Solanum versicolor	endemic to Qld	found in a small area south of Charleville
Stenopetalum lineare var. *lineare*	Qld, NSW, NT, SA, WA	restricted in Qld
Swainsona microphylla	Qld, NSW, NT, SA, WA	restricted in Qld

Micromyrtus hexamera

Swainsona
species

The numbers of tree, shrub, grass and forb species in each treatment type is shown in Figure 15. From these graphs we can look in slightly more detail at the species richness variability between the treatments, within each of the land types. For example, the highest grass species richness across all three land types is in the remnant treatments, while forb species richness is more even across all treatments. The largest differences between remnant treatments and pasture treatments appears to be in the brigalow land type, with tree, shrub and grass species richness all being much higher in remnant brigalow than in pasture.

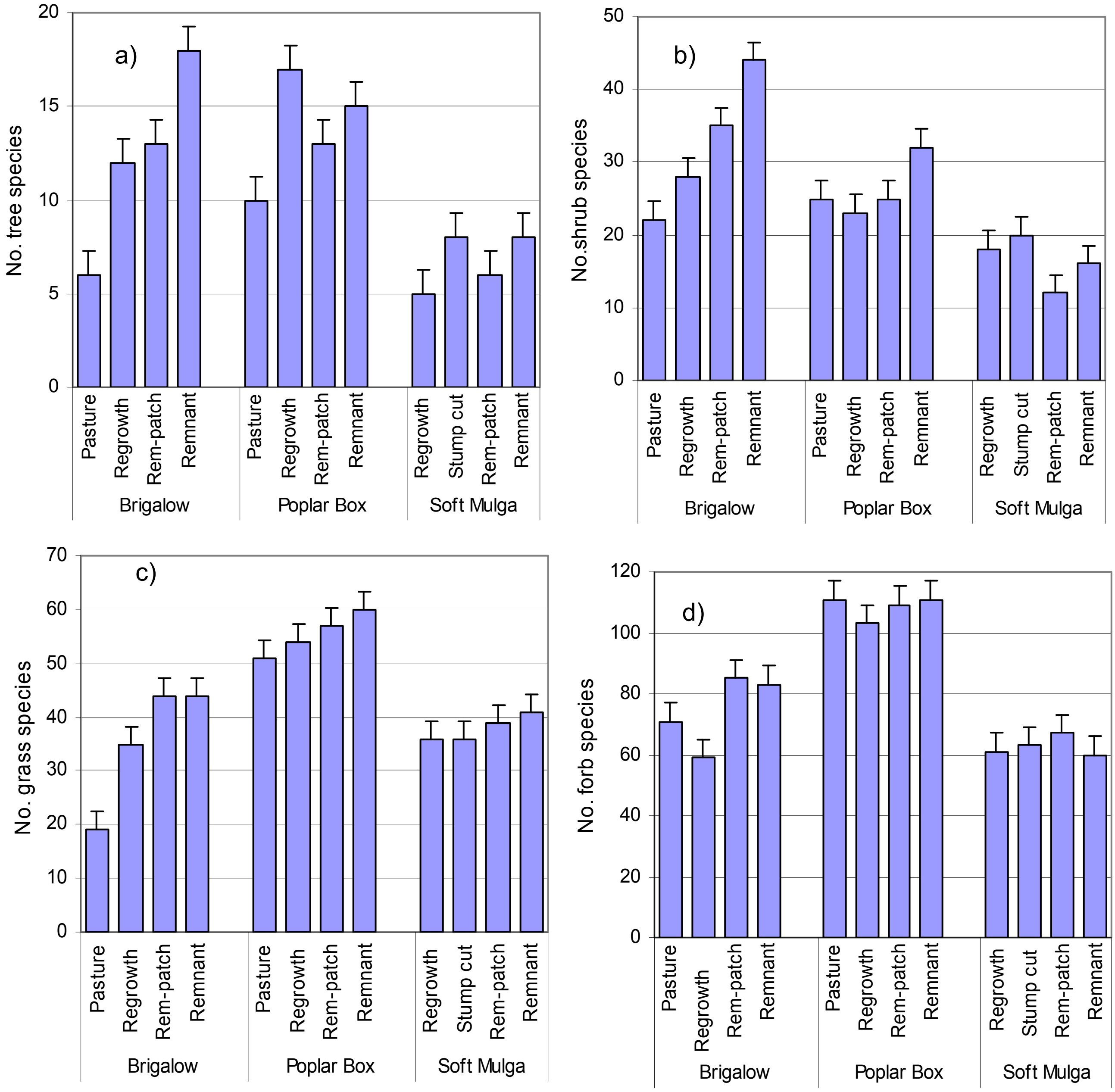


Figure 15: **Number of a) tree, b) shrub, c) grass and d) forb species recorded in each land type and treatment.**

Among 48 exotic species recorded in the project, *Opuntia aurantiaca* (tiger pear), O. stricta (common pest pear or spiny pest pear), *O. tomentosa* (velvety tree pear), and *Parthenium hysterophorus* (parthenium) are declared pest plants throughout the state of Queensland under the *Land Protection (Pest and Stock Route Management) Act 2002*. Appendix 4 provides a complete list of all weed species recorded during the project (those marked with an asterisk).

***Opuntia* species**

4.3 Biodiversity condition (1234) and Grazing land condition (ABCD)

The percentage of sites from the study that were either in direct agreement (e.g. class A and class 1) for grazing land condition and biodiversity condition, and the percentage of sites that were one (e.g. class A and class 2), two (e.g. class A and class 3) or three (e.g. class A and class 4) classes different between the land condition and the biodiversity condition ratings are shown in Table 11.

The majority of sites (approximately 78%) were assessed as in agreement or differed by one class regarding the condition state of the site, from both a grazing land condition or biodiversity condition perspective. See Section 4.3.1 for examples of sites where ABCD and 1234 condition classes aligned.

Table 11: Comparison of assessment of grazing land condition vs 1234 biodiversity condition

Difference between land and biodiversity condition classes	%
In direct agreement	32.7
Difference of one class	45.6
Difference of two classes	11.7
Difference of three classes	9.9

However, variation in the level of agreement occurred across the 3 land types assessed in the study, with the greatest level of agreement occurring in the soft mulga land type, and the least level of agreement occurring in the brigalow belah land type assessed in the study. This difference could be a result of one of the diverging elements between the two condition assessment frameworks: the assessment of exotic pasture grasses. However, it may also be reflecting the difference in mechanical disturbance between each region. The brigalow bioregion has had a long history of intensive and extensive modification of natural habitat through mechanical clearing and re-clearing of native vegetation, as well as conversion to exotic pasture (Seabrook et al. 2006), whereas in the Mulga Lands intensive habitat modification is more patchy and less to do with mechanical clearing or exotic pasture conversion. Within the land condition framework the presence of exotic pasture grasses is rated highly in contrast to the biodiversity condition framework where the presence or dominance of exotic pasture grasses results in a reduction in scores. Impact of the establishment of exotic pastures on biodiversity has been well documented and although are favoured from a grazing perspective, they are commonly associated with loss in native species and can lead to alterations in fire regimes (Fensham and Fairfax, 2000; Tu, 2002; Franks, 2002; Jackson 2005 and Eyre et al 2009).

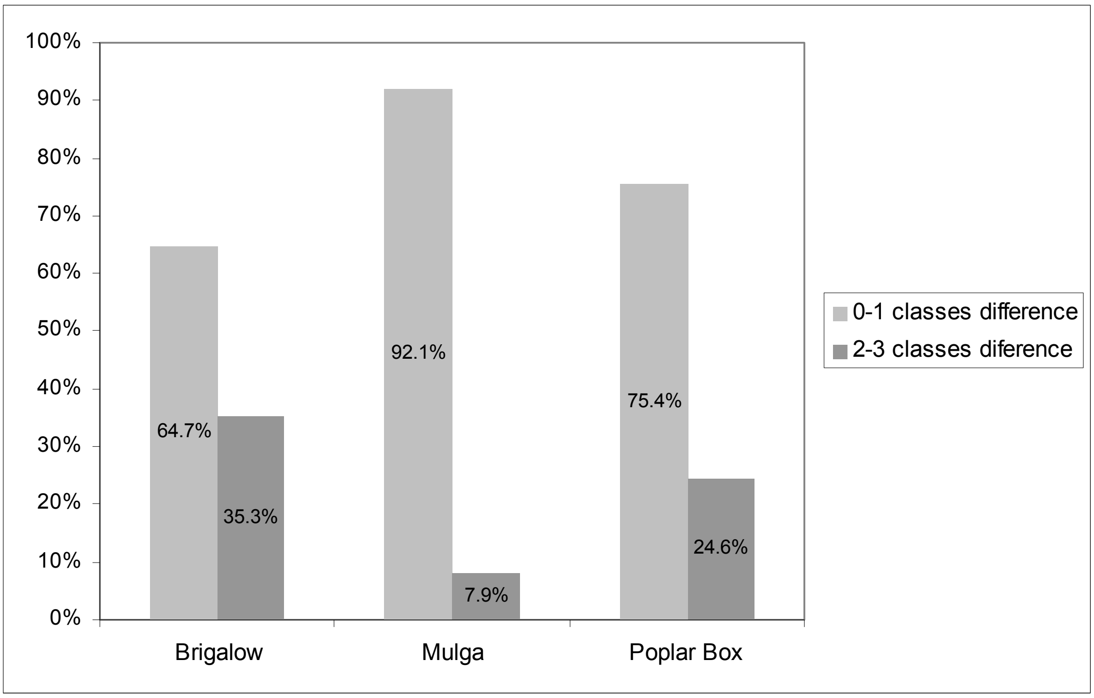


Figure 16: Level of agreement between the land and biodiversity condition frameworks within the Brigalow, Mulga and Poplar box land types.

4.3.1 Where the assessment of land and biodiversity condition differed

Of those sites that differed by two or three classes (See section 4.3.3) between the ABCD land condition and 1234 biodiversity condition scores, 73% of those sites were either a pasture only or regrowth vegetation site (Table 12).

Table 12: Type of sites that differed by two to three condition classes

Site type	Number of sites	Relative % of sites
Pasture and regrowth	27	73.0
Remnant	10	27.0

Further investigation of the sites that differed by 3 classes found that 100% of these sites were either pasture or regrowth (Table 13). This highlights the most notable divergences between the two condition assessment frameworks. The ABCD attributes used for assessment are largely based on the ground layer and include soil condition and pasture condition. In contrast, the 1234 framework involves the assessment of attributes that describe habitat and structural complexity such as numbers of large trees, shrub cover, the abundance of fallen woody material on the ground and functional attributes such as regeneration. In addition, the 1234 biodiversity condition scoring also includes landscape attributes which define the amount of vegetation within the context of the site. In the case of areas of regrowth or pasture many of the attributes used to assess condition for biodiversity are absent or low in quantity and therefore results in an overall reduction to the score and associated rating.

Table 13: Type of sites that differed by three condition classes

Site type	Number of sites	Relative % of sites
Pasture	10	58.8
Regrowth	7	41.2

4.3.2 Where ABCD and 1234 condition classes aligned

Examples of sites assessed for ABCD and 1234 during the project that aligned with regard to good or functional condition, or poor or dysfunctional condition, are given below.

Site: MLA0095

Strata: Poplar box, fragmented landscape, pasture

ABCD class: D

1234 class: 4

This site rated poorly for ABCD land condition as the site received a poor pasture condition rating due to the dominance of unpalatable species and the absence of 3P grasses in the ground layer. The site also scored poorly for 1234 biodiversity condition due to an absence of recruitment, large trees, shrub cover, and very limited native species grass cover.

Site: LWA0245

Strata: Mulga, intact landscape, remnant

ABCD class: A

1234 class: 1

LWA0245 scored well for land condition due to the predominance of 3P grasses and good soil condition. The site also scored highly for biodiversity condition as well, due to high native species richness and ground cover, number of large mature trees, good volume of fallen woody material, as well as the site scoring highly for landscape context attributes such as patch size context, and connectivity.

4.3.3 Where ABCD and 1234 differed by two to three condition classes

Examples of sites assessed for ABCD and 1234 during the project that differed by two to three condition classes are shown in the following.

Site: MLA0005

Strata: Poplar box on alluvial, fragmented landscape, regrowth

ABCD class: A

1234 class: 4

MLA0005 scored well for grazing land condition due to the predominance and yield of Buffel Grass *Pennisetum ciliare* an introduced pasture grass, as well as the presence of Kangaroo Grass *Themeda triandra*, which are both considered preferred 3P grass species. In contrast, the site was assessed as 'dysfunctional' for biodiversity condition due to an absence of large trees and shrub species and cover and low landscape context scores for patch size, connectivity and context.

Site: MLA0038

Strata: Poplar box on alluvial, fragmented landscape, regrowth

ABCD class: A

1234 class: 3

In contrast MLA0038 was also assessed as A. The 1234 biodiversity condition score was 3. This site differed from MLA0005 in that it had some shrubs, a greater diversity of native species in the ground layer, and a low cover of exotic species. In addition, the site had a greater amount of remnant vegetation in the surrounding landscape, improving the context score that the site received. It is the added inclusion of these features, known to be important for biodiversity that strikes the right balance between the sites productive potential and the requirements of biodiversity in the form of the availability of some habitat and foraging resources.

Site: MLA0039

Strata: Poplar box on alluvial, fragmented landscape, regrowth

ABCD class: A

1234 class: 4

MLA0039 had a high land condition rating again due to the predominance and yield of Buffel Grass, and stable soil condition. In contrast, the site scored poorly for biodiversity condition due to an absence of large trees, low native species richness and cover and poor landscape context scores for patch size, connectivity and context.

Site: MLA0044

Strata: Poplar box on alluvial, fragmented landscape, regrowth

ABCD class: A

1234 class: 3

In contrast, MLA0044 was also assessed as an A for grazing land condition, however scored a 3 for biodiversity condition. This site differed from MLA0039 as it had a greater richness of native species and cover, some tree cover, a shrub layer, some litter and fallen woody material, and the site is located in a landscape with a greater cover of remnant and regrowth vegetation. The addition of these elements would result in better outcomes for biodiversity, whilst not detracting from its productive potential.

In conclusion, we found that in the majority, the land condition and BioCondition assessments were in close alignment, particularly in grazed remnant vegetation. However, grazing land condition states are based on pasture and soil attributes, not woody density. Consequently, if woody density was considered in the ranking of grazing land condition, then it is likely that the land condition and BioCondition assessments would not align so well in remnant vegetation. Mulga land types had the most agreement between the ABCD land condition and 1234 BioCondition systems. Divergence between ratings occurred predominantly in the brigalow belah and to a lesser extent in the poplar box land types, where buffel grass pastures tended to be rated as class A, as opposed to BioCondition ratings as class 4.

4.4 The relative importance of key habitat features

Four landscape-scale key features and 26 site-based key features (Table 6) were selected for testing against two broad biodiversity variables; reptile species richness and bird species richness. The aim of this analysis was to further reduce the suite of potential assessable key features, by identifying pairs or groups of highly correlated features and by assessing the relative importance each feature had in explaining the variance in reptile and bird species richness, using hierarchical partitioning.

4.4.1 Landscape-scale key features

This analysis was conducted for the combined land types. Of the four selected landscape-scale features to test, patch size was most highly correlated with the remaining three features, context (r = 0.44), connectivity (r = -0.37) and distance to water (r = 0.38). Context and connectivity were also correlated (r = 0.38). Furthermore, hierarchical partitioning revealed that of the four landscape scale variables, patch size contributed least to contributing to the model explaining both bird species richness and reptile species richness (Figure 17). Consequently, for the rapid assessment version of the more technical BioCondition assessment, the variable patch size was selected for omission.

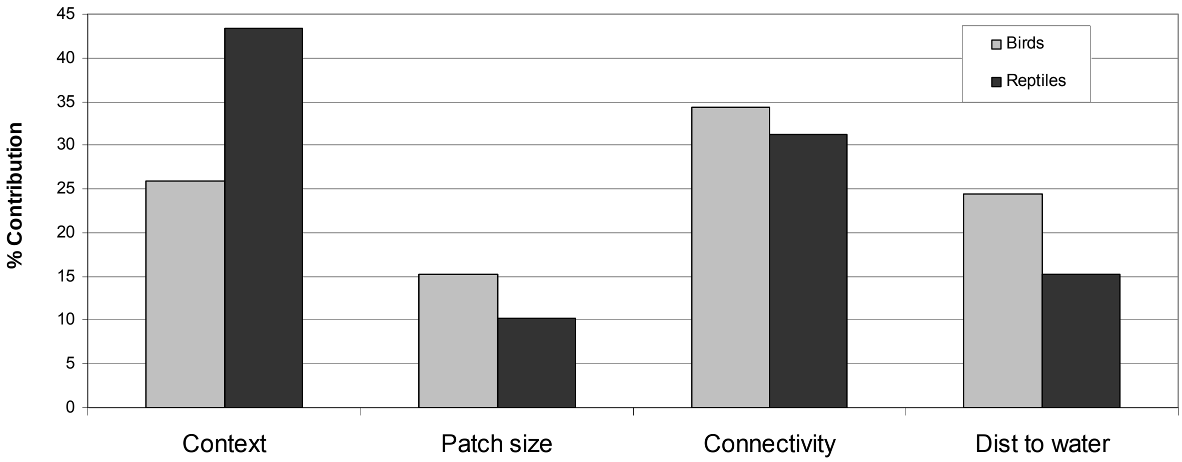


Figure 17: Results of hierarchical partioning of key landscape-scale features and bird and reptile species

4.4.2 Site-based key features

As expected, there was a lot of correlation between the 26 selected features. Following from initial inspection of a Pearson Correlation matrix, one of each pair of highly correlated features were deleted from the dataset prior to the hierarchical partioning analysis which at this stage can cope with a maximum of 13 variables (Walshe and Mac Nally 2007). This initial inspection of the data reduced the set of features from 26 to 12 (Table 14).

Table 14: Reduced set of 12 key site-based features selected for further analysis

Key feature retained for further analysis	Reason why
Tree species richness	No high correlation with other features
Shrub species richness	No high correlation
Grass species richness	Surrogate for species richness for other ground life-forms (forb species richness and other species richness)
Tree canopy cover	Surrogate for tree height (highly correlated)
Shrub canopy cover	No high correlation
Large live trees	Surrogate (high correlation) for live trees with hollows and dead large trees and tree height
Fallen logs	No high correlation
Miner birds	No high correlation
3P grass cover	Good surrogate (highly correlated) with 3P basal area and yield
Perennial forb cover	No high correlation
Litter cover	Highly correlated with the four LFA classes and soil condition
Cryptogram cover	Highly correlated with the four LFA classes and soil condition

Again, combining the data from the three land types, hierarchical partitioning of the set of 12 site-based key features revealed that important features for explaining species richness of birds included tree canopy cover, abundance of miners, 3P (preferred and intermediate) grass cover and litter cover. The most important features for reptile species richness also included tree canopy cover and litter cover, but also large live trees and fallen logs (Figure 18). Using an arbitrary threshold of 5%, below which a feature was deemed of lower importance for explaining species richness for both birds and reptiles, the following features were selected for removal from the assessment scheme; grass species richness, shrub canopy cover, perennial forb cover and cryptogram cover (Figure 18).

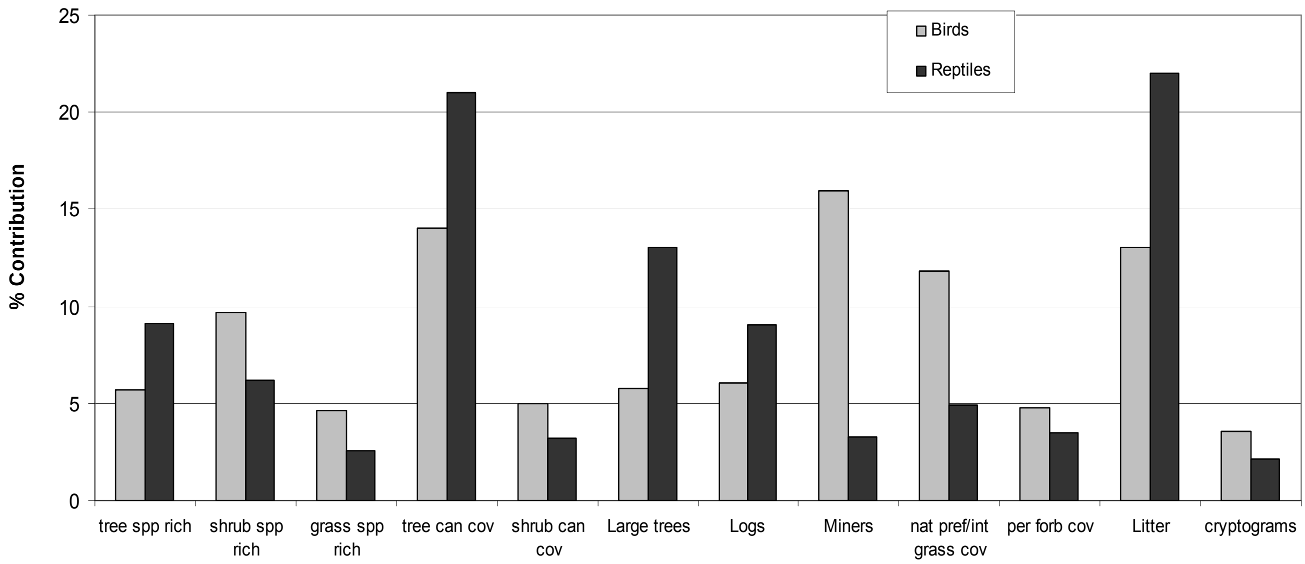


Figure 18: Results of hierarchical partioning of key site-based features and bird and reptile species

However, the deletion of the shrub canopy cover feature did not correspond with existing ecological knowledge on the importance of this feature, particularly for woodland birds (Maron and Kennedy 2007; Eyre *et al.* 2009). Therefore, the hierarchical partitioning analysis of the 12 short-listed key features was conducted again, but this time for each separate land type (soft mulga, brigalow belah and poplar box). These analyses revealed that, across the three land types, perennial forb cover and cryptogram cover were overall still relatively unimportant for both reptile and bird species richness, and the importance of miners was inconclusive. However, grass species richness was very important for reptiles in the soft mulga land types, and shrub canopy cover had relatively high importance in the mulgalands and poplar box land types (Figure 19).

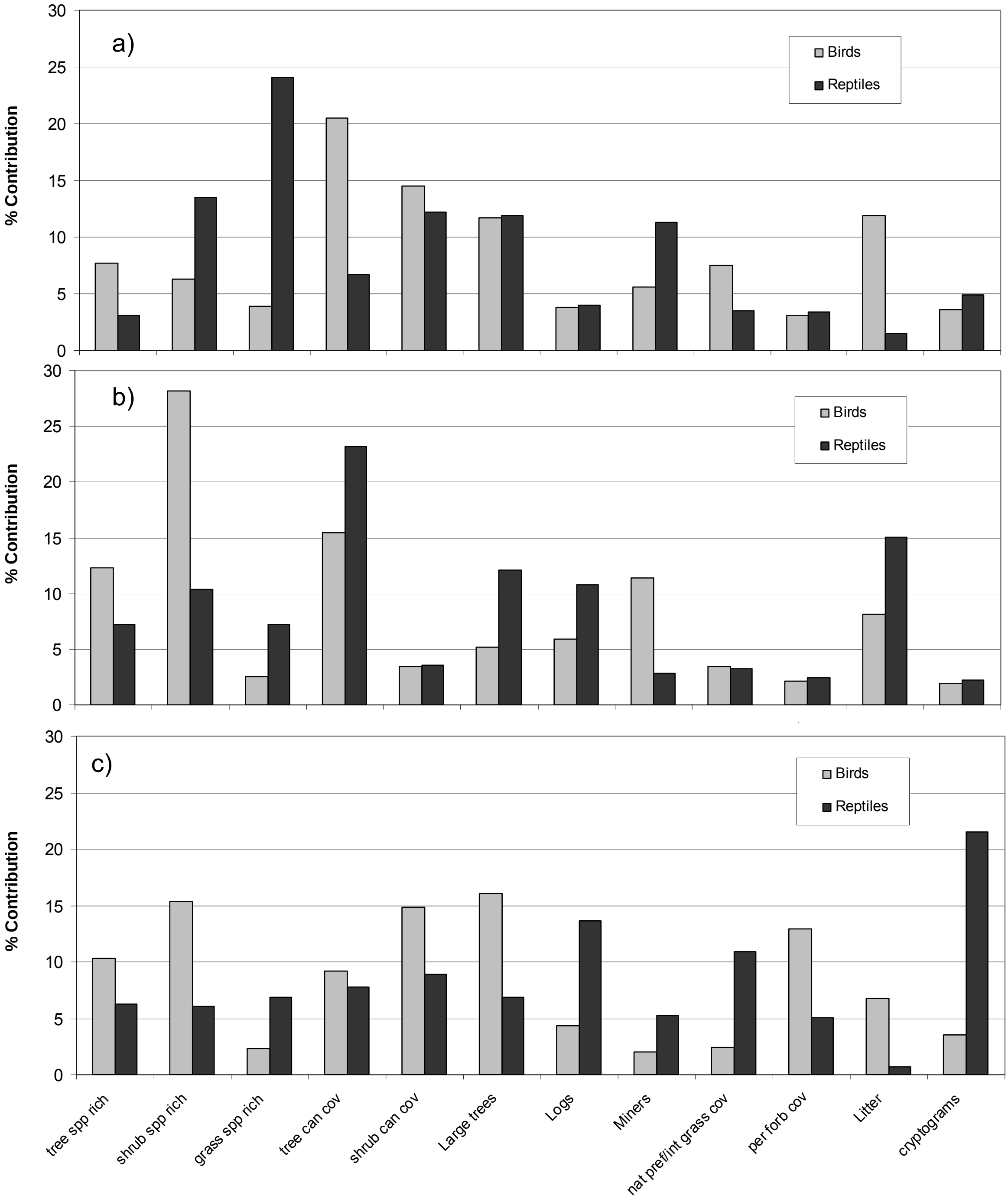


Figure 19: Results of hierarchical partitioning of key site-based features and bird and reptile species for land types a) soft mulga; b) brigalow belah; and c) poplar box

Closer inspection of the data and univariate modelling showed that the reason why shrub canopy cover appeared unimportant in the combined land type analysis was because, in the mulgalands, there is a negative relationship between shrub cover and reptile and bird species richness, while in the poplar box it is a strong positive relationship. That is, in the mulga lands, increased shrub cover corresponds with less species richness, while in the brigalow bioregion (or at least in poplar box land types), increased shrub cover corresponds with more species. Presumably the contrasting trends are due to the strong inclination of mulga country to shrubiness, especially after prolonged grazing pressure while the box country is less prone to be so.

In some land types, an overabundance of shrubs is undesirable, for both grazing land production and wildlife. This is certainly the case in soft mulga land types, where increased densities of shrubs (mostly *Eremophila* species) successfully compete with grasses for limited resources such as moisture, nutrients and space. This has led to lower grass cover and diversity, and overall less ground cover habitat complexity. In the Mulga Lands, a high shrub density coincides with lower diversity of ground foraging birds and terrestrial reptiles. This is because there is less access to open ground area to for birds to search for food, or for reptiles to bask.

Eremophila gilesii

This pasture has 31% shrub cover (includes low shrubs), and supports 6 bird species.

This pasture has 1.5% shrub cover, and supports 22 bird species.

Consequently, the core set of key features finally selected for use in the rapid assessment version included three landscape-scale features (context, connectivity and distance to water) and nine site-based features (tree and shrub species richness, tree and shrub canopy cover, large live trees, fallen logs, 3P / preferred and intermediate grass cover, and litter cover.

4.5 Key features, increasers, decreasers and species richness

This section outlines some analyses which were undertaken specifically for sections of the Biodiversity in Grazed Lands Toolkit.

4.5.1 Miners and small passerine birds

Noisy miners and yellow-throated miners are large, native honeyeaters that live in groups. Each group is very territorial, and miners are very keen on defence. This means they aggressively exclude most small birds from their territories. These small, predominantly passerine, birds tend to be the object of miner's bullying behaviour. Noisy miners are prevalant in the brigalow bioregion, whereas the yellow-throated miner is prevalent in the mulga lands.

Small passerines are defined as 'perching' birds that are < 25 cm head-tail length. Only very recent literature has been published on the status and habitat requirements of these birds in the brigalow bioregion, and there is extremely little published on birds in general in the mulgalands. In the brigalow bioregion, recent literature has identified small passerines such as the weebill, rufous whistler, striated pardalote, grey fantail and white-browed treecreeper as being sensitive to habitat alteration and loss of condition, and miners (Woinarski *et al.* 2006; Collard *et al.* 2008; Eyre *et al.* 2009). Therefore, despite the earlier analysis suggesting that miner abundance was a less important variable for bird species richness overall, we wanted to test the relationship between miners and small passerines, these being a key group of decreaser species. From our data across the three land types, there was a significant negative association between the abundance of miners (noisy miners and yellow-throated miners combined) and the abundance of small passerine birds (Figure).

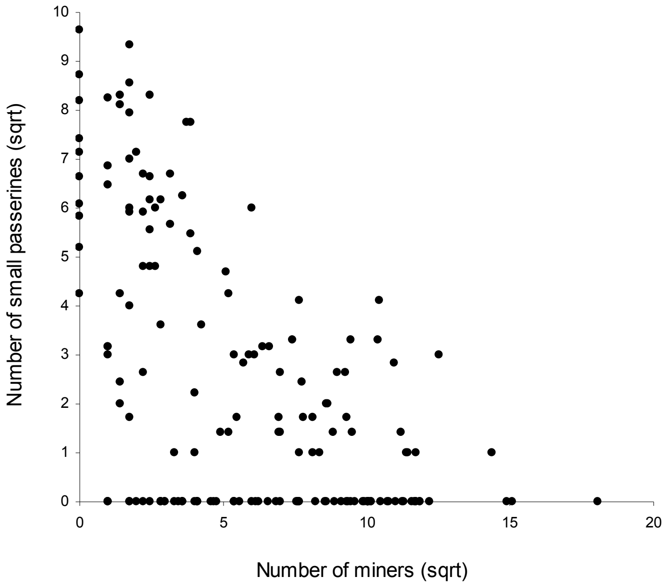


Figure: Scatter plot showing the relationship between abundance of miners and abundance of small passerine birds

Across the three land types, miner abundance was most highly explained by distance to water, and 3P/preferred and intermediate grass cover and yield (Figure 21). Since both of these features were already selected for inclusion in the rapid BioCondition assessment procedure, we decided not to include miner abundance as a key feature, but to use noisy miners and yellow-throated miners for case studies in the Toolkit on ‘increaser’ species.

Figure 20: Independent effects (%) of selected key features upon abundance of miners, using hierarchical partitioning.

4.5.2 Shrub cover

The issue with shrub cover is that more does not necessarily correspond with a better outcome for biodiversity (or for grazing land production). Combining data from across the land types, but restricted only to the cleared pastureland, a one-way ANOVA showed a significant relationship between mean reptile species richness and classes of increasing shrub cover ($F_{(3,58)}$ = 8.2, P < 0.0001), and a similar pattern was observer for birds albeit not as strong ($F_{(3,58)}$ = 3.1, P < 0.0357).

The analysis shows that maintaining between 1 to 10% shrub cover almost doubles the number of reptile and bird species. However, shrub cover > 10% results in a decline in species richness, probably as a consequence of less access to ground habitat, which is vital for ground-foraging bird species and reptiles (Figure 21).

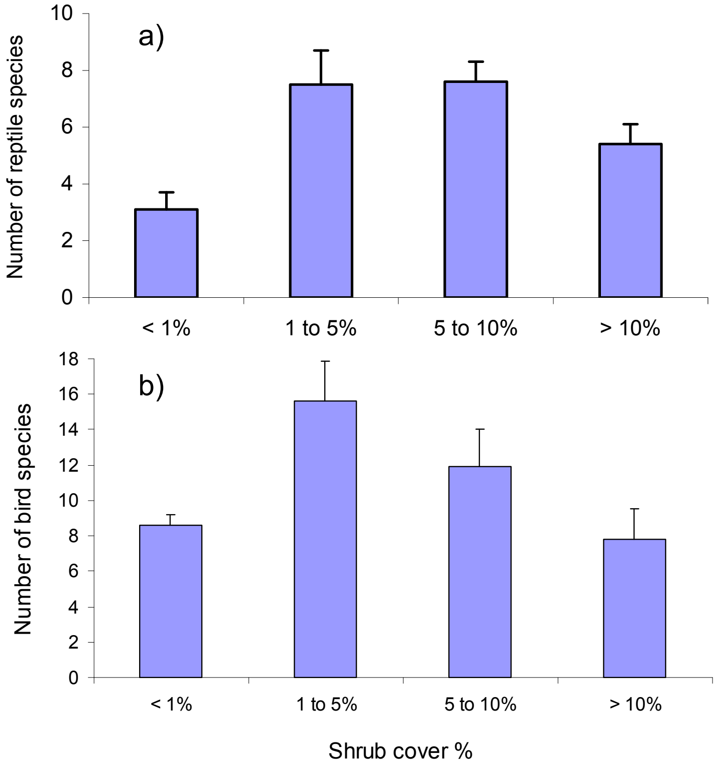


Figure 21: Relationship of mean species richness (+s.e) of a) reptiles and b) birds and shrub cover classes

4.5.3 Large live trees

Restricting the dataset to sites located in cleared pasturelands across the three land types, a one-way ANOVA showed that for both reptile species richness and bird species richness there was a significant difference between having no large live trees in the paddock compared with having one to six large trees (Figure 22). Therefore, relative to a totally cleared paddock, the retention of one to six large trees per hectare will significantly increase the habitat value for reptile and bird species.

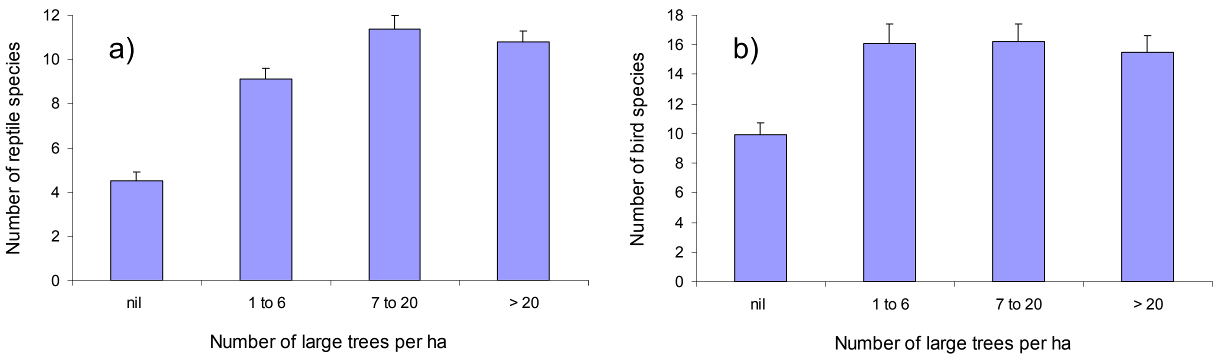


Figure 22: Relationship of mean species richness (+s.e) of a) reptiles and b) birds and large live tree abundance classes

4.5.4 Distance to waterpoints

Miners need to be closer to water than small passerine species. They also cope very well in highly grazed habitat. Consequently, we see that closer to waterpoints there are increased numbers of miners, and this was significant (one-way ANOVA; $F_{(4,166)}$ = 5.21, P < 0.0006) Post hoc Tukey tests revealed that the significant difference in miner abundance was between < 500 m and 500 m to 1 km classes and the remaining classes (> 1 km), suggesting a 1 km threshold. A similar pattern was observed for the small passerines ($F_{(4,166)}$ = 5.08, P < 0.0007 However, small passerine species increase in numbers the further away from waterpoints. This may be partially an effect of lighter grazing, but even more so is the effect of reduced bullying from miners.

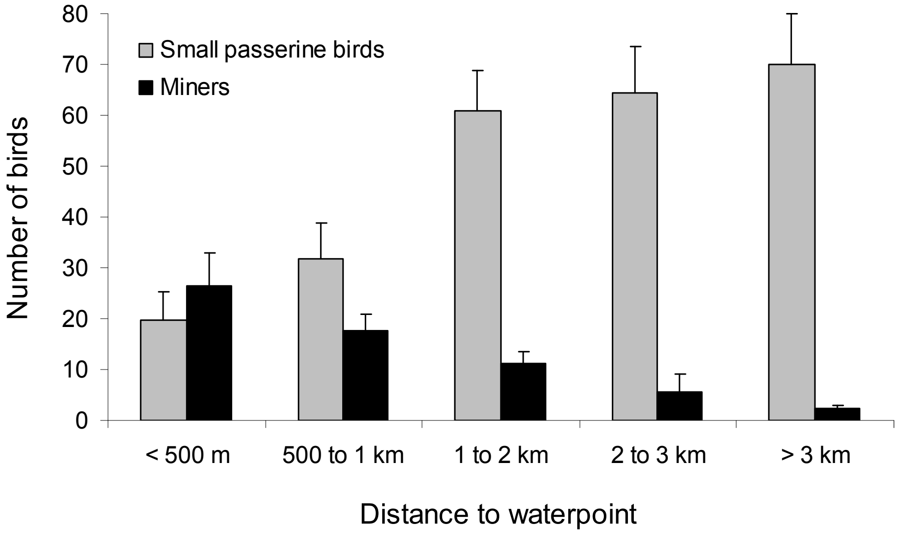


Figure 23: Relationship between the mean number (+s.e.) of small passerine birds and miner birds (noisy and yellow-throated) and distance to waterpoint

4.6 Biodiversity and ABCD and 1234 condition classes

4.6.1 Grasses and condition classes

A total of 102 native and 8 exotic grass species were recorded from the 171 sample sites across the soft mulga, poplar box and brigalow belah land types. Of these, 37 grass species (including seven exotic species) were recorded at < 10 sites, so these were excluded from the ordination and PERMANOVA analyses.

Species richness

The two-way ANOVA revealed that mean grass species richness varied significantly between the three land types ($F_{2,159}$ = 14.525, P < 0.0000) and the grazing land condition classes ($F_{3,159}$ = 8.598, P < 0.0000). The interaction between land type and grazing land condition classes was not significant. Post hoc Tukey tests showed that there was no significant difference in mean grass species richness between sites in the soft mulga or poplar box

(Figure 24a), and that mean grass species richness did not significantly vary between classes A, C and D (Figure 24b).

A similar pattern was shown by the two-way ANOVA between land types and BioCondition classes. The analysis revealed that mean grass species richness varied significantly between the three land types ($F_{2,159}$ = 14.525, P < 0.0000) and the BioCondition classes ($F_{3,159}$ = 8.598, P < 0.0000), but the interaction between the two factors was not significant. Post hoc Tukey tests showed that mean grass species richness was similar between BioCondition classes 2 and 3 (Figure 24c).

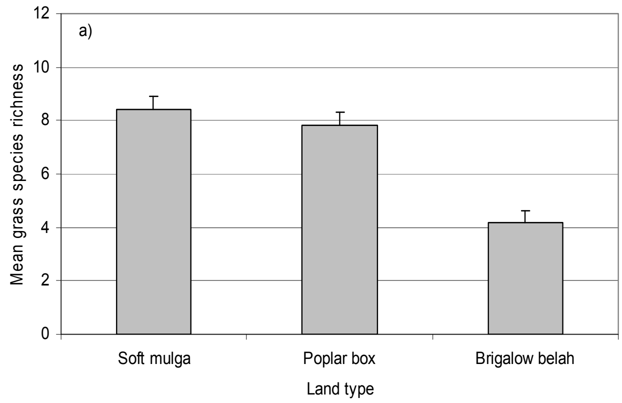
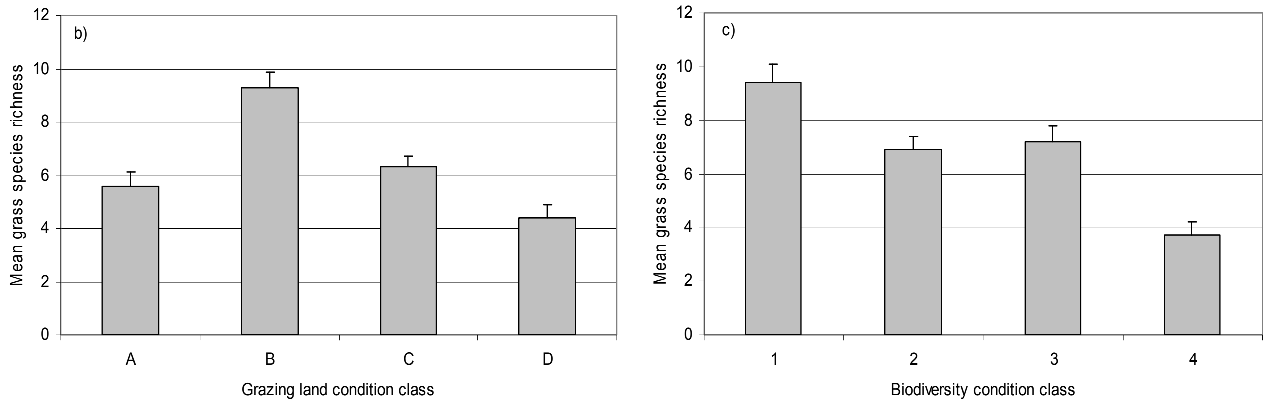


Figure 24: Mean grass species richness (+ std error) by a) land types; and b) grazing land condition classes; and c) BioCondition classes.



The PERMANOVA analyses revealed a significant difference in grass species composition between the ABCD land condition classes ($F_{3,159}$ = 2.4648, P = 0.0002; Figure 25a) and the 1234 biodiversity classes ($F_{3,159}$ = 3.471, P = 0.0001; Figure 25b). There was a very clear delineation in species assemblages between the three land types ($F_{2,159}$ = 22.842, P = 0.0001;Figure 26), and the interactions between land types and both the ABCD condition classes and 1234 biodiversity classes were significant too ($F_{2,159}$ = 1.622, P = 0.0019 and $F_{2,159}$ = 2.3453, P = 0.0001).

Post-hoc pairwise comparisons revealed that grass species assemblages were dissimilar between all ABCD land condition classes within soft mulga, except between A and C. In poplar box land types, species assemblages in class A significantly differed from those in classes B, C and D. In the brigalow belah land types, grass species assemblages did not vary except for between classes A and D. BioCondition classes better reflected variation in grass species assemblages across the three land types. In soft mulga, grass species in condition class 1 were significantly different from those in classes 3 and 4. In poplar box, again there were different grass species in class 1 as compared with classes 3 and 4, as well as between classes 2 and 4 and classes 3 and 4. In the brigalow belah land types, grass species assemblages significantly differed between all four condition classes.

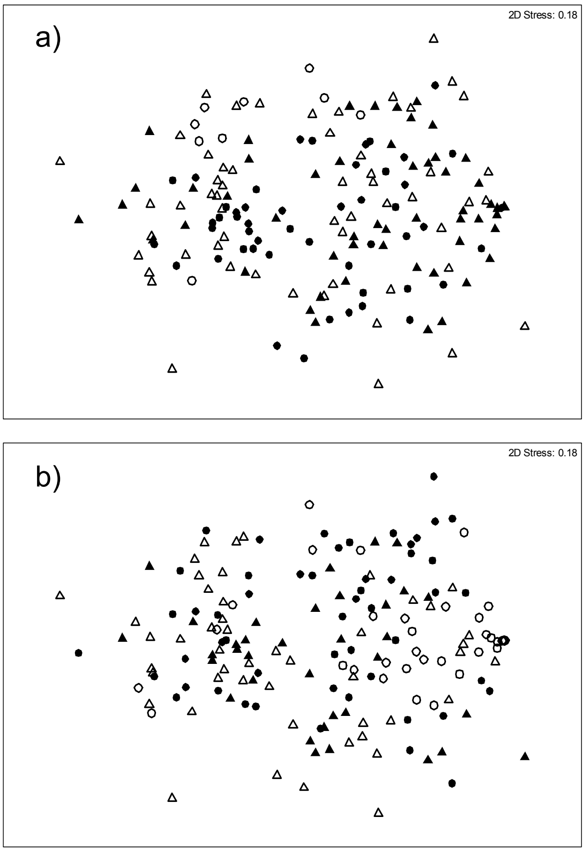


Figure 25: Multidimensional scaling ordination of grass assemblages across the a) ABCD land condition classes and b) the 1234 biodiversity condition classes. Closed triangles = A or 1; closed circles = B or 2; open triangles = C or 3; and open circles = D or 4

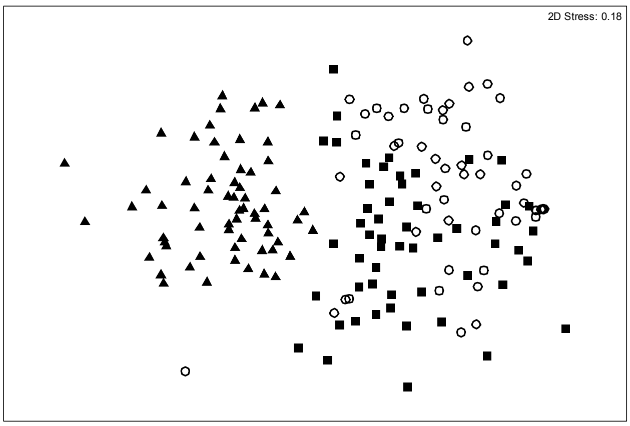


Figure 26: Multidimensional scaling ordination of grass assemblages across the three land types. Closed triangles = soft mulga; closed squares = poplar box; and open circles = brigalow belah.

SIMPER analyses showed that the native ‘preferred’ Mulga Mitchell grass *Thyridolepis mitchelliana* characterised sites in the soft mulga land types assessed as A and B grazing land condition (Table 15a). Jericho Wiregrass *Aristida jerichoensis*, a species known to indicate overgrazed areas (Henry *et al.* 1995), characterised sites in C condition, and Five Minute Grass *Tripogon loliiformis* characterised sites in D condition (Table 15a). A dominance of Five Minute Grass indicates poor pasture condition in the mulga lands (Henry *et al.*, 1995). In the poplar box land types, 3P grass species typified classes A and B, and intermediate and undesirable grass species largely characterised class C (Table 16a). This was expected, given the weight given to 3P grass species in the ABCD condition assessment framework. Regarding the BioCondition classes, class 1 was characterised by native 3P grasses, and class 4 was largely characterised by the non-native (but 3P) buffel grass *Pennisetum ciliare*, there was less clear discrimination between the BioCondition classes 2 and 3, and did not appear to reflect condition states as well as the ABCD framework (Table 16b).

Few grass species defined assemblages in the brigalow belah sites as compared with the soft mulga and poplar box land types. However, both the ABCD and 1234 condition assessments produced the expected distinctions between desirable and undesirable condition states for pastoral use and biodiversity respectively. That is, classes A and B were characterised by preferred and intermediate species, and predominantly buffel grass which is a highly desirable pastoral species (Table 17a), whereas the opposite was reflected in the BioCondition classes (i.e. classes 1 and 2 characterised by native species and classes 3 and 4 characterised by buffel grass; Table 17b).

Table 15: SIMPER analysis of similarity in the composition of grass species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in soft mulga land types. *** Only species explaining approximately 75% of the similarity per condition class are shown.**

Common name	Scientific name	% contribution
a) Grazing land condition classes		
Class A		
Mulga Mitchell Grass	*Thyridolepis mitchelliana*	33.3
Kerosene Grass	*Aristida contorta*	11.7
Woollybutt	*Eragrostis eriopoda*	11.5
Mulga Oats	*Monachather paradoxus*	9.6
Walwhalleya	*Walwhalleya subxerophila*	6.5
Class B		
Mulga Mitchell Grass	Thyridolepis mitchelliana	19.5
Purple Lovegrass	Eragrostis lacunaria	13.7
Jericho Wiregrass	Aristida jerichoensis	10.3
Cotton Panic	Digitaria brownii	7.8
Five Minute Grass	Tripogon loliiformis	7.5
Mulga Oats	Monachather paradoxus	7.1
Hairy Panic	Panicum effusum	5.6
Class C		
Jericho Wiregrass	*Aristida jerichoensis*	21.9
Mulga Mitchell Grass	*Thyridolepis mitchelliana*	18.3
Walwhalleya	*Walwhalleya subxerophila*	13.3
Five Minute Grass	*Tripogon loliiformis*	8.5
Woollybutt	*Eragrostis eriopoda*	7.5
Class D		
Five Minute Grass	*Tripogon loliiformis*	44.7
Delicate Lovegrass	*Eragrostis tenellula*	18.1
b) BioCondition classes		
Class 1		
Mulga Mitchell Grass	*Thyridolepis mitchelliana*	20.1
Purple Lovegrass	*Eragrostis lacunaria*	14.5
Cotton Panic	*Digitaria brownii*	12.9
Five Minute Grass	*Tripogon loliiformis*	12.7
Mulga Oats	*Monachather paradoxus*	7.7
Rare Panic	*Paspalidium rarum*	4.6
Class 2		
Mulga Mitchell Grass	*Thyridolepis mitchelliana*	23.2
Jericho Wiregrass	*Aristida jerichoensis*	13.1
Five Minute Grass	*Tripogon loliiformis*	11.1
Walwhalleya	*Walwhalleya subxerophila*	10.4
Cotton Panic	*Digitaria brownii*	7.5
Purple Lovegrass	*Eragrostis lacunaria*	5.4
Mulga Oats	*Monachather paradoxus*	5.2
Class 3		
Mulga Mitchell Grass	*Thyridolepis mitchelliana*	16.7
Jericho Wiregrass	*Aristida jerichoensis*	14.9
Walwhalleya	*Walwhalleya subxerophila*	12.9
Umbrella Grass	*Digitaria hystrichoides*	9.5
Five Minute Grass	*Tripogon loliiformis*	8.9
Woollybutt	*Eragrostis eriopoda*	8.1
Class 4		
Jericho Wiregrass	*Aristida jerichoensis*	56.3
Mulga Mitchell Grass	*Thyridolepis mitchelliana*	28.7

Table 16: SIMPER analysis of similarity in the composition of grass species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in poplar box land types. * Only species explaining approximately 75% of the similarity per condition class are shown.

Common name	Scientific name	% contribution
a) Grazing land condition classes		
Class A		
Buffel Grass	*Pennisetum ciliare*	54.5
Purple Wiregrass	*Aristida personata*	9.6
Kangaroo Grass	*Themeda triandra*	6.8
Slender Queensland Bluegrass	*Dichanthium sericeum*	4.5
Class B		
Pitted Bluegrass	*Bothriochloa decipiens*	14.7
Buffel Grass	*Pennisetum ciliare*	14.6
Slender Chloris	*Chloris divaricata*	11.8
Tall Windmill Grass	*Chloris ventricosa*	10.3
Kangaroo Grass	*Themeda triandra*	7.1
Barbed-wire Grass	*Cymbopogon refractus*	5.1
Coolibah Grass	*Thellungia advena*	4.9
Small Burr Grass	*Tragus australianus*	3.4
Five Minute Grass	*Tripogon loliiformis*	3.2
Class C		
Buffel Grass	*Pennisetum ciliare*	16.8
Dark Wiregrass	*Aristida calycina*	13.9
Five Minute Grass	*Tripogon loliiformis*	13.9
Small Burr Grass	*Tragus australianus*	10.1
Pitted Bluegrass	*Bothriochloa decipiens*	9.6
Tall Windmill Grass	*Chloris ventricosa*	6.8
Slender Chloris	*Chloris divaricata*	5.7
Class D		
Less than 2 samples		
b) BioCondition classes		
Class 1		
Purple lovegrass	*Eragrostis lacunaria*	15.1
Slender Chloris	*Chloris divaricata*	10.9
Lovegrass	*Eragrostis alveiformis*	9.8
Kangaroo Grass	*Themeda triandra*	9.2
Tall Windmill Grass	*Chloris ventricosa*	8.5
Buffel Grass	*Pennisetum ciliare*	6.2
Hairy Panic	*Panicum effusum*	5.8
Purple Wiregrass	*Aristida personata*	5.5
Class 2		
Buffel Grass	*Pennisetum ciliare*	30.6
Five Minute Grass	*Tripogon loliiformis*	10.9
Purple Wiregrass	*Aristida personata*	7.5
Brigalow Grass	*Paspalidium caespitosum*	6.5
Tall Windmill Grass	*Chloris ventricosa*	5.8
Curly Windmill Grass	*Enteropogon acicularis*	5.3
Slender Nineawn	*Enneapogon gracilis*	4.9
Class 3		
Pitted Bluegrass	*Bothriochloa decipiens*	28.3
Buffel Grass	*Pennisetum ciliare*	13.1
Small Burr Grass	*Tragus australianus*	13.0
Tall Windmill Grass	*Chloris ventricosa*	8.6
Dark Wiregrass	*Aristida calycina*	8.1
Kangaroo Grass	*Themeda triandra*	7.8

Common name	Scientific name	% contribution
Class 4		
Buffel Grass	*Pennisetum ciliare*	60.1
Slender Queensland Bluegrass	*Dichanthium sericeum*	13.4

Table 17: SIMPER analysis of similarity in the composition of grass species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in brigalow belah land types. * Only species explaining approximately 85% of the similarity per condition class are shown.

Common name	Scientific name	% contribution
a) Grazing land condition classes		
Class A		
Buffel Grass	*Pennisetum ciliare*	58.3
Brigalow Grass	*Paspalidium caespitosum*	17.1
Hooky Grass	*Ancistrachne uncinulata*	8.7
Class B		
Buffel Grass	*Pennisetum ciliare*	44.9
Brigalow Grass	*Paspalidium caespitosum*	27.3
Yakka grass	*Sporobolus caroli*	9.9
Class C		
Brigalow Grass	*Paspalidium caespitosum*	47.4
Buffel Grass	*Pennisetum ciliare*	17.2
Slender Chloris	*Chloris divaricata*	14.3
Class D		
Brigalow Grass	*Paspalidium caespitosum*	100
b) BioCondition classes		
Class 1		
Hooky Grass	*Ancistrachne uncinulata*	8.7
Brigalow Grass	*Paspalidium caespitosum*	17.1
Slender Chloris	*Chloris divaricata*	14.3
Barbed-wire Grass	*Cymbopogon refractus*	6.1
Class 2		
Brigalow Grass	*Paspalidium caespitosum*	68.9
Curly Windmill Grass	*Enteropogon acicularis*	9.1
Buffel Grass	*Pennisetum ciliare*	5.2
Class 3		
Buffel Grass	*Pennisetum ciliare*	52.9
Brigalow Grass	*Paspalidium caespitosum*	19.6
Yakka grass	*Sporobolus caroli*	13.5
Class 4		
Buffel Grass	*Pennisetum ciliare*	89.7

4.6.2 Forbs and condition classes

A total of 227 native forb species were recorded from the flora survey quadrats in the 171 sample sites across the soft mulga, poplar box and brigalow belah land types. Of these, 63 forb species were recorded at 10 or more sites.

Species richness

The two-way ANOVA revealed that mean forb species richness varied significantly between the three land types ($F_{2,159}$ = 10.69, P < 0.0000), but not the grazing land condition classes ($F_{3,159}$ = 1.74, P = 0.162). The interaction between land type and grazing land condition classes was not significant either ($F_{3,159}$ = 1.29, P = 0.264). Post hoc Tukey tests showed that there was no significant difference in mean forb species richness between sites in the soft mulga and poplar box (Figure 27a), and both these land types had significantly higher forb species richness than the brigalow belah land type (Figure 27a). A similar pattern was revealed by the two-way ANOVA between land types and BioCondition classes. There were no significant differences in mean forb species richness between any of the grazing condition classes (Figure 28b) or between any of the BioCondition classes (Figure 27c).

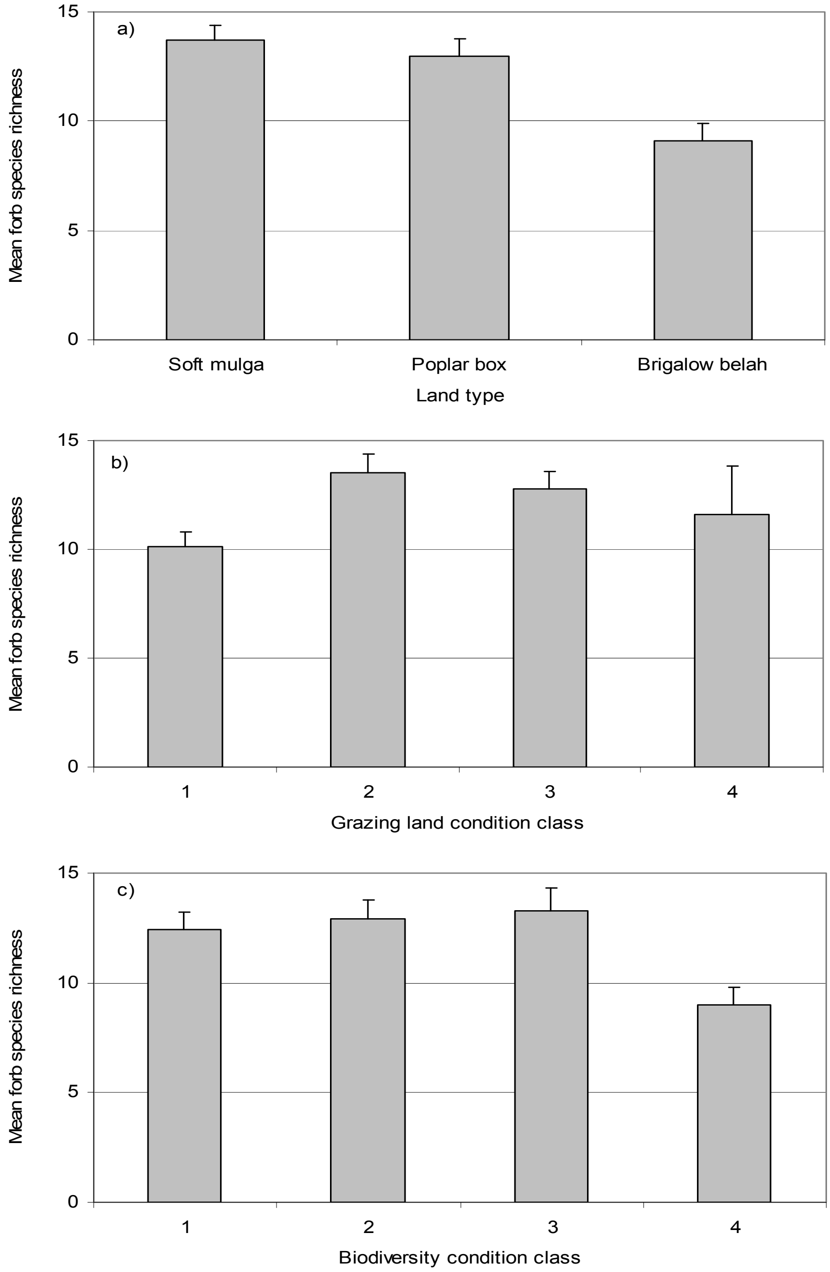


Figure 27: Mean forb species richness (+ std error) by a) land types; and b) grazing land condition classes; and c) BioCondition classes.

4.6.3 Reptiles and condition classes

A total of 77 reptile species were recorded from the 171 sample sites across the soft mulga, poplar box and brigalow belah land types. Of these, 35 species were detected at ten or more sites, and these species were used in the ordination and PERMANOVA analyses.

Species richness

The two-way ANOVA revealed that mean reptile species richness varied significantly between the three land types ($F_{2,159}$ = 3.43, P = 0.035; Figure 28a). Post hoc Tukey tests showed that reptile species richness was significantly higher in the soft mulga and brigalow belah as compared with that in poplar box land types, but there was no real difference between soft mulga and brigalow belah. There was no significant variation in mean species richness between the grazing land condition classes ($F_{3,159}$ = 0.201, P = 0.891; Figure 28b). The interaction between land type and grazing land condition classes was not significant either.

A similar pattern was showed by the two-way ANOVA between land types and BioCondition classes. The analysis revealed that mean reptile species richness varied significantly between the three land types ($F_{2,159}$ = 9.78, P < 0.0001) and the BioCondition classes ($F_{3,159}$ = 9.02, P < 0.0001), and the interaction between the two factors was also significant ($F_{6,159}$ = 2.67, P < 0.0167). Post hoc Tukey tests showed that mean reptile species richness was similar between BioCondition classes 1, 2 and 3 but each of these classes significantly differed from class 4 (Figure 28c).

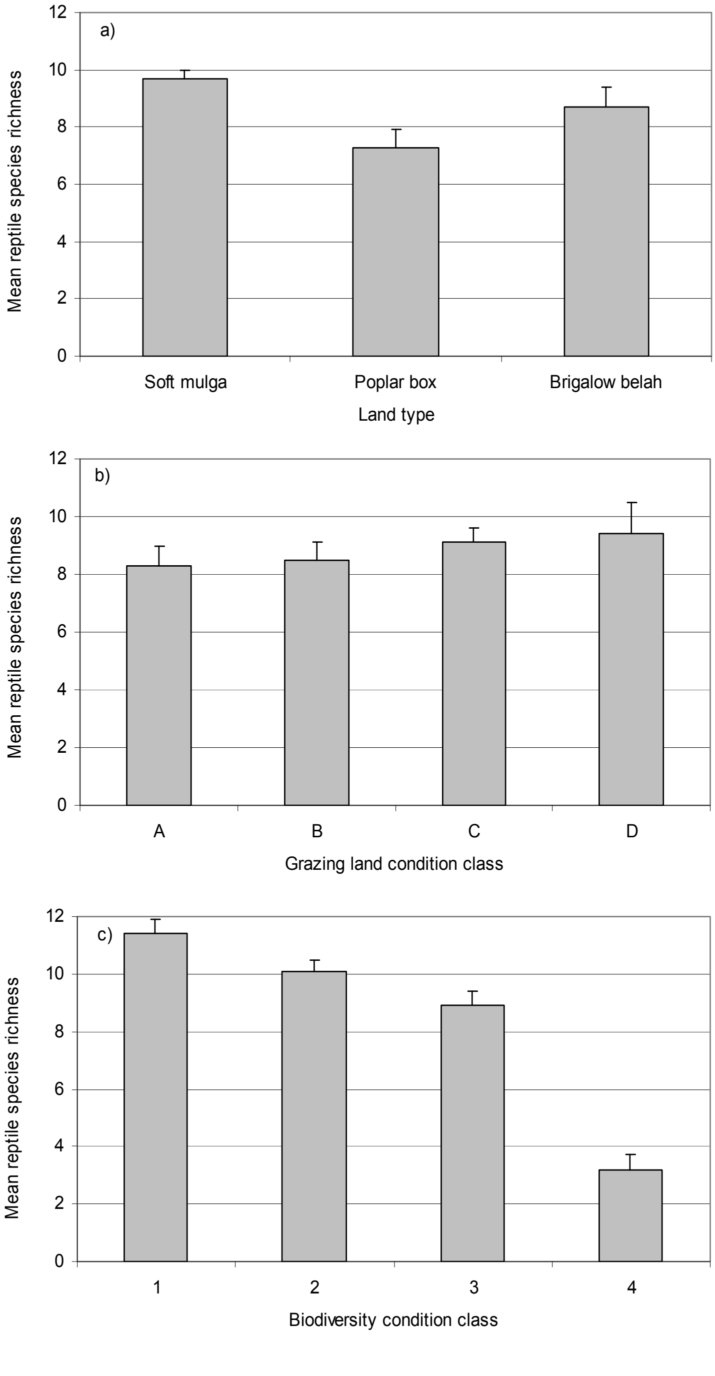


Figure 28: Mean reptile species richness (+ std error) by a) land types; and b) grazing land condition classes; and c) BioCondition classes.

Species composition

The PERMANOVA analyses revealed that there was no significant difference in reptile species composition between the ABCD land condition classes ($F_{3,159}$ = 0.951, P = 0.06; Figure 29a), but there was for the 1234 biodiversity classes ($F_{3,159}$ = 3.14, P = 0.0001; Figure 29b). Reptile species assemblages differed significantly between the three land types ($F_{2,159}$ = 10.922, P = 0.0001; Figure 30), and the interaction between land types and the 1234 biodiversity classes was also significant ($F_{2,159}$ = 1.473, P = 0.0014). The interaction between land types and ABCD land condition classes was not significant.

However, pairwise comparisons revealed that within each of the three land types, reptile species assemblages did not vary between any of the grazing land condition classes. BioCondition classes better reflected variation in reptile species assemblages within each of the three land types. In soft mulga, reptile species composition in condition classes 1 and 2 were significantly different from those in classes 3 and 4. In poplar box, assemblages were similar in classes 1 and 2, but all other pairs significantly differed. Similar to soft mulga, reptile species composition was only similar between classes 1 and 2, and 3 and 4 in the brigalow belah land types.

Each of the grazing land condition and BioCondition classes were largely characterised by dominance of the tree dtella *Gehyra variegata* and the wood mulch slider *Lerista muelleri* in the soft mulga (Table 18), which explains the lack of significant difference in species composition between the ABCD classes and BioCondition classes 1 and 2. However, Biocondition class 3 did differ in composition, due to the absence of the ragged snake-eyed skink *Cryptoblepharus pannosus*, and higher numbers of the beaked *gecko Rhynchoedura ornata*.

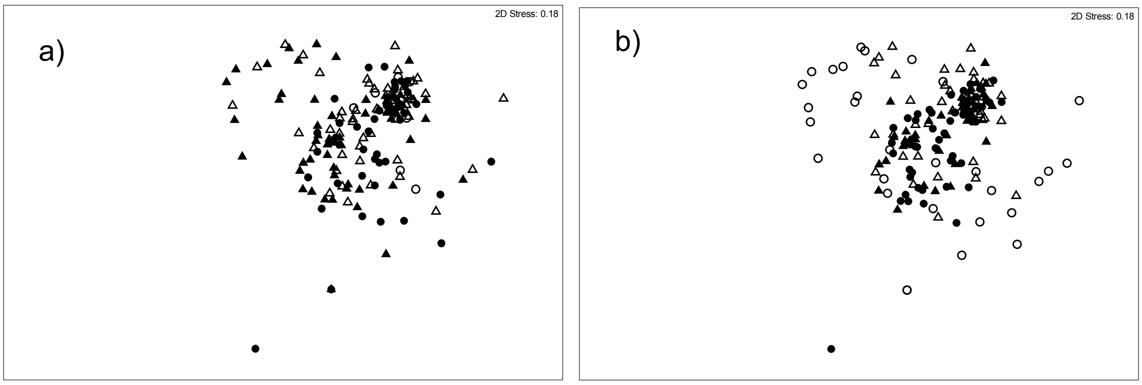


Figure 29: Multidimensional scaling ordination of reptile assemblages across the a) ABCD land condition classes and b) the 1234 biodiversity condition classes. Closed triangles = A or 1; closed circles = B or 2; open triangles = C or 3; and open circles = D or 4

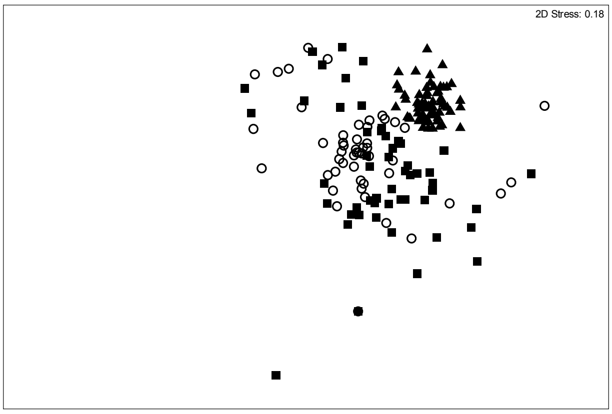


Figure 30: Multidimensional scaling ordination of reptile assemblages across the three land types. Closed triangles = soft mulga; closed squares = poplar box; and open circles = brigalow belah.

Table 18: SIMPER analysis of similarity in the composition of reptile species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in soft mulga land types. * Only species explaining approximately 80% of the similarity per condition class are shown.

Common name	Scientific name	% contribution
a) Grazing land condition classes		
Class A		
Tree dtella	*Gehyra variegata*	27.9
Wood mulch slider	*Lerista muelleri*	17.5
Boulanger's skink	*Morethia boulengeri*	12.1
Bynoe's gecko	*Heteronotia binoei*	11.6
Ragged snake-eyed skink	*Cryptoblepharus pannosus*	7.4
Class B		
Tree dtella	*Gehyra variegata*	29.8
Wood mulch slider	*Lerista muelleri*	17.5
Bynoe's gecko	*Heteronotia binoei*	11.6
Ragged snake-eyed skink	*Cryptoblepharus pannosus*	7.4
Class C		
Tree dtella	*Gehyra variegata*	25.5
Wood mulch slider	*Lerista muelleri*	15.7
Bynoe's gecko	*Heteronotia binoei*	15.2
Beaked gecko	*Rhynchoedura ornata*	11.5
Boulanger's skink	*Morethia boulengeri*	8.9
Class D		
Wood mulch slider	*Lerista muelleri*	28.7
Tree dtella	*Gehyra variegata*	21.9
Striped skink	*Ctenotus allotropis/strauchii*	13.7
b) BioCondition classes		
Class 1		
Tree dtella	*Gehyra variegata*	29.8
Wood mulch slider	*Lerista muelleri*	18.3
Ragged snake-eyed skink	*Cryptoblepharus pannosus*	11.7
Bynoe's gecko	*Heteronotia binoei*	11.0
Velvet gecko	*Oedura marmorata*	7.2
Tree skink	*Egernia striolata*	6.1
Class 2		
Tree dtella	*Gehyra variegata*	28.1
Wood mulch slider	*Lerista muelleri*	17.2
Bynoe's gecko	*Heteronotia binoei*	15.5
Ragged snake-eyed skink	*Cryptoblepharus pannosus*	9.9
Class 3		
Tree dtella	*Gehyra variegata*	25.8
Wood mulch slider	*Lerista muelleri*	19.9
Bynoe's gecko	*Heteronotia binoei*	13.6
Beaked gecko	*Rhynchoedura ornata*	11.8

Common name	Scientific name	% contribution
Class 4		
Less than 2 samples		

In the poplar box, BioCondition classes 1 and 2 were very similar in reptile composition, both being dominated by Boulenger's skink *Morethia boulengeri, C. pannosus* and the open-litter rainbow skink *Carlia pectoralis* (Table 19). Classes 3 and 4 were also similar in composition, being characterised by the eastern striped skink *Ctenotus robustus*. This skink characterised grazing land condition class A too, but it wasn't a significant variation. In the brigalow belah, the reptile composition of BioCondition class 4 was quite distinctive; with *C. robustus* and the common bearded dragon *Pogona barbata* commonly occupying these sites, similar to class 4 sites in poplar box (Table 20).

Table 19: SIMPER analysis of similarity in the composition of reptile species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in poplar box land types. * Only species explaining approximately 80% of the similarity per condition class are shown.

Common name	Scientific name	% contribution
a) Grazing land condition classes		
Class A		
Eastern striped skink	*Ctenotus robustus*	30.1
Boulenger's skink	*Morethia boulengeri*	21.3
Snake-eyed skink	*Cryptoblepharus pulcher pulcher*	8.1
Grey dwarf skink	*Menetia greyii*	5.6
Burnett's skink	*Carlia foliorum*	5.4
Open-litter rainbow skink	*Carlia pectoralis*	4.9
Class B		
Boulenger's skink	*Morethia boulengeri*	33.7
Common dtella	*Gehyra dubia*	13.4
Bynoe's gecko	*Heteronotia binoei*	12.9
Box-patterned gecko	*Lucasium steindachneri*	9.3
Grey dwarf skink	*Menetia greyii*	7.7
Class C		
Boulenger's skink	*Morethia boulengeri*	27.7
Bynoe's gecko	*Heteronotia binoei*	14.6
Common bearded dragon	*Pogona barbata*	8.7
Box-patterned gecko	*Lucasium steindachneri*	6.5
Common dtella	*Gehyra dubia*	6.4
Eastern striped skink	*Ctenotus robustus*	5.8
Grey dwarf skink	*Menetia greyii*	4.7
Ragged snake-eyed skink	*Cryptoblepharus pannosus*	4.1
Tree skink	*Egernia striolata*	3.9
Class D		
Less than 2 samples		
b) BioCondition classes		
Class 1		
Boulenger's skink	*Morethia boulengeri*	30.4
Ragged snake-eyed skink	*Cryptoblepharus pannosus*	11.7
Open-litter rainbow skink	*Carlia pectoralis*	10.6
Snake-eyed skink	*Cryptoblepharus pulcher pulcher*	10.3
Common dtella	*Gehyra dubia*	8.7
Bynoe's gecko	*Heteronotia binoei*	6.4
Class 2		
Boulenger's skink	*Morethia boulengeri*	35.1

Common name	Scientific name	% contribution
Common dtella	*Gehyra dubia*	12.8
Bynoe's gecko	*Heteronotia binoei*	10.3
Grey dwarf skink	*Menetia greyii*	7.1
Open-litter rainbow skink	*Carlia pectoralis*	5.9
Ragged snake-eyed skink	*Cryptoblepharus pannosus*	5.7
Class 3		
Boulenger's skink	*Morethia boulengeri*	23.1
Eastern striped skink	*Ctenotus robustus*	21.9
Bynoe's gecko	*Heteronotia binoei*	14.2
Common dtella	*Gehyra dubia*	7.3
Box-patterned gecko	*Lucasium steindachneri*	6.7
Wood mulch slider	*Lerista muelleri*	4.2
Class 4		
Eastern striped skink	*Ctenotus robustus*	46.9
Common bearded dragon	*Pogona barbata*	29.2

Table 20: SIMPER analysis of similarity in the composition of reptile species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in brigalow belah land types. * Only species explaining approximately 85% of the similarity per condition class are shown.

Common name	Scientific name	% contribution
a) Grazing land condition classes		
Class A		
Open-litter rainbow skink	*Carlia pectoralis*	14.7
Boulenger's skink	*Morethia boulengeri*	11.5
Bynoe's gecko	*Heteronotia binoei*	10.5
Eastern striped skink	*Ctenotus robustus*	9.2
Common dtella	*Gehyra dubia*	8.7
Velvet gecko	*Oedura monilis*	8.4
Tree skink	*Egernia striolata*	7.2
Chain-backed tree dtella	*Gehyra catenata*	6.3
Class B		
Boulenger's skink	*Morethia boulengeri*	27.3
Velvet gecko	*Oedura monilis*	18.3
Bynoe's gecko	*Heteronotia binoei*	13.5
Common dtella	*Gehyra dubia*	12.7
Chain-backed tree dtella	*Gehyra catenata*	6.1
Class C		
Bynoe's gecko	*Heteronotia binoei*	19.5
Boulenger's skink	*Morethia boulengeri*	14.4
Eastern striped skink	*Ctenotus robustus*	9.8
Chain-backed tree dtella	*Gehyra catenata*	9.5
Burns' dragon	*Amphibolurus burnsi*	7.9
Common dtella	*Gehyra dubia*	7.8
Tree skink	*Egernia striolata*	7.7
Class D		
Ingram's striped skink	*Ctenotus ingrami*	24.3
Burns' dragon	*Amphibolurus burnsi*	24.3
Tree dtella	*Gehyra variegata*	17.2
b) BioCondition classes		
Class 1		
Open-litter rainbow skink	*Carlia pectoralis*	18.1
Bynoe's gecko	*Heteronotia binoei*	17.2
Chain-backed tree dtella	*Gehyra catenata*	11.4
Tree skink	*Egernia striolata*	9.4
Boulenger's skink	*Morethia boulengeri*	8.4
Common dtella	*Gehyra dubia*	7.9
Velvet gecko	*Oedura monilis*	6.9
Class 2		
Bynoe's gecko	*Heteronotia binoei*	18.7
Boulenger's skink	*Morethia boulengeri*	18.0

Common name	Scientific name	% contribution
Chain-backed tree dtella	*Gehyra catenata*	10.5
Velvet gecko	*Oedura monilis*	9.0
Tree skink	*Egernia striolata*	7.6
Burns' dragon	*Amphibolurus burnsi*	7.3
Common dtella	*Gehyra dubia*	7.0
Class 3		
Common dtella	*Gehyra dubia*	22.7
Velvet gecko	*Oedura monilis*	19.6
Burns' dragon	*Amphibolurus burnsi*	15.2
Bynoe's gecko	*Heteronotia binoei*	13.0
Boulenger's skink	*Morethia boulengeri*	8.2
Class 4		
Eastern striped skink	*Ctenotus robustus*	46.9
Boulenger's skink	*Morethia boulengeri*	8.2
Common bearded dragon	*Pogona barbata*	29.2

4.6.4 Diurnal birds and condition classes

A total of 143 bird species were recorded from the 171 sample sites across the soft mulga, poplar box and brigalow belah land types. Of these, 71 species were recorded at < 10 sites, so these were excluded from the ordination and PERMANOVA analyses.

Species richness

The two-way ANOVA revealed that mean bird species richness varied significantly between the three land types ($F_{2,159}$ = 10.867, P < 0.0001; Figure 31a), but not between the grazing land condition classes ($F_{3,159}$ = 0.581, P = 0.6283; Figure 31b). The interaction between land type and grazing land condition classes was not significant either. Post hoc Tukey tests showed that there was no significant difference in mean bird species richness between grazing land condition, sites in the soft mulga or in the brigalow belah. Even when reducing the dataset to consider sites with remnant vegetation only, mean bird species richness still did not vary between AB or CD condition classes ($F_{1, 163}$ = 1.139, P = 0.2874).

In contrast, the two-way ANOVA between land types and BioCondition classes showed significant variation in mean bird species richness between the three land types ($F_{2,159}$ = 25.812, P < 0.0001), the BioCondition classes ($F_{3,159}$ = 15.611, P < 0.0001), and the interaction between the two factors ($F_{6,159}$ = 2.445, P = 0.027). Post hoc Tukey tests showed that mean bird species richness was similar between BioCondition classes 1, 2 and 3, but these three classes all differed significantly from class 4 (Figure 31c).

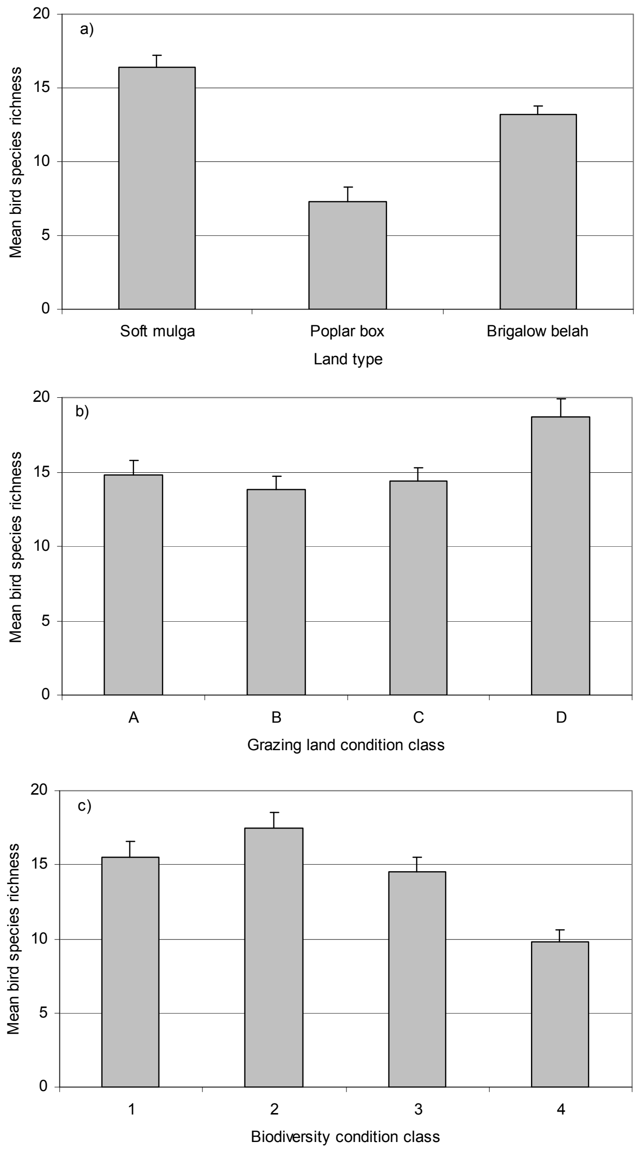


Figure 31: Mean bird species richness (+ std error) by; a) land types; and b) grazing land condition classes; and c) BioCondition classes.

Species composition

The PERMANOVA analyses revealed no significant differences in bird species composition between the ABCD land condition classes ($F_{3,159}$ = 1.025, P = 0.401; Figure 32a). Species assemblages were characterised by similar species in each land condition class, predominantly the chestnut-rumped thornbill, rufous whistler, and willie wagtail in the soft mulga (Table 21), Even when reducing the dataset to consider only sites with remnant vegetation, there was no significant variation in species composition between land condition classes ($F_{3,101}$ = 1.429, P = 0.099; Figure 32b). However, there was a significant difference in bird species composition between the 1234 biodiversity classes ($F_{3,159}$ = 5.529, P = 0.001; Figure 32c).

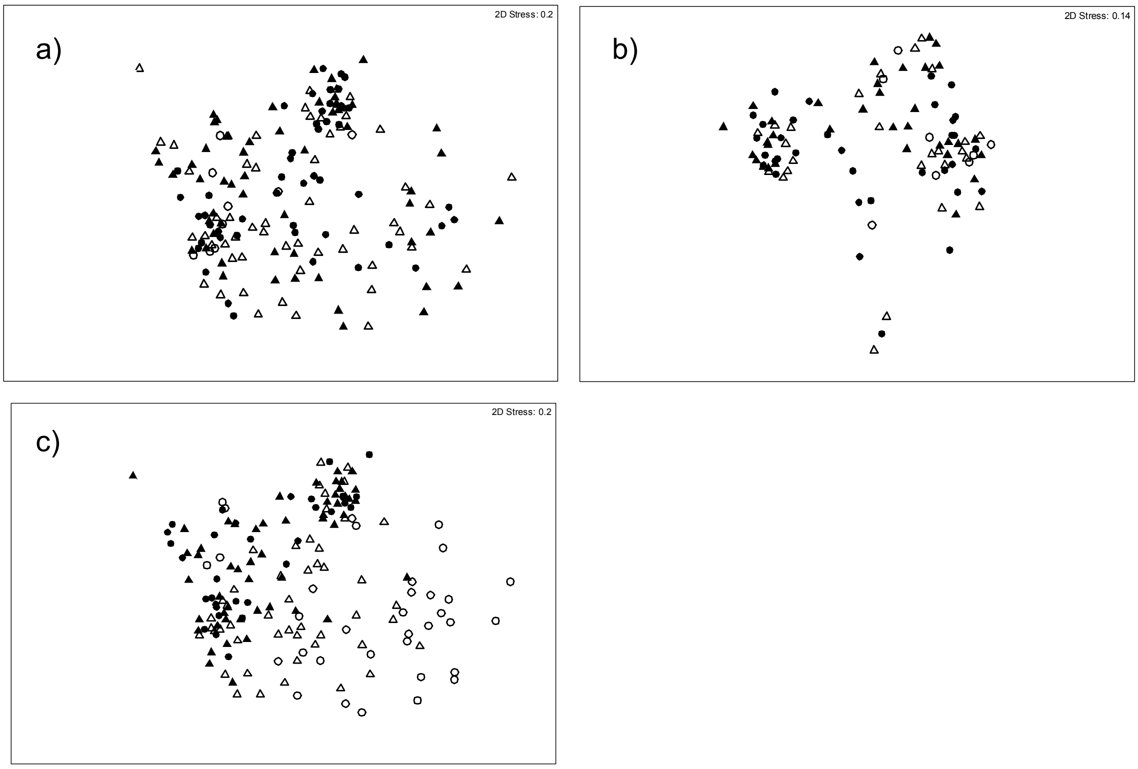


Figure 32: Multidimensional scaling ordination of diurnal bird assemblages across the a) ABCD land condition classes for all sites; b) ABCD land condition classes for remnant sites only; and c) the 1234 BioCondition classes. Closed triangles = A or 1; closed circles = B or 2; open triangles = C or 3; and open circles = D or 4.

As expected, there was a significant difference in species assemblages between the three land types ($F_{2,159}$ = 8.718, P = 0.001; Figure 33). There was no significant interaction between land types and the land condition classes ($F_{2,\,159}$ = 1.037, P = 0.352), but there was with the BioCondition classes ($F_{2,159}$ = 2.774, P = 0.001). Post-hoc pairwise comparisons indicated that bird assemblages were dissimilar between all BioCondition classes, except between classes 1 and 2. This pattern was consistent within each of the three land types.

In the soft mulga and brigalow belah land types, the ABCD classes were largely characterised by similar species (Table 21a, Table 23a). There was some variation between the poplar box classes although this was not significant probably due to the predominance of noisy miners in each class (Table 22a). Inspection of the species characterising each BioCondition class within the poplar box land type revealed that the classes representing most functional condition (classes 1 and 2) were dominated by hyper-aggressive and predatory bird species (noisy miner, grey butcherbirds). These species have been shown to dominate and exclude smaller bird species, and are thought to indicate less functional vegetation condition states (Maron and Kennedy, 2007; Eyre *et al.*, 2009). Although still characterised by noisy miners, class 3 included declining, small passerine species (weebill and striated pardalote), which was not expected. Similalry, in the mulga, Biocondition classes 1 and 2 and to a lesser extent class 3 where characterised by small woodland bird species, whereas class 4 was characteristed by yellow-throated miners – a conger of the noisy miner and a known increaser species in more western regions (Kutt and Fisher 2011).

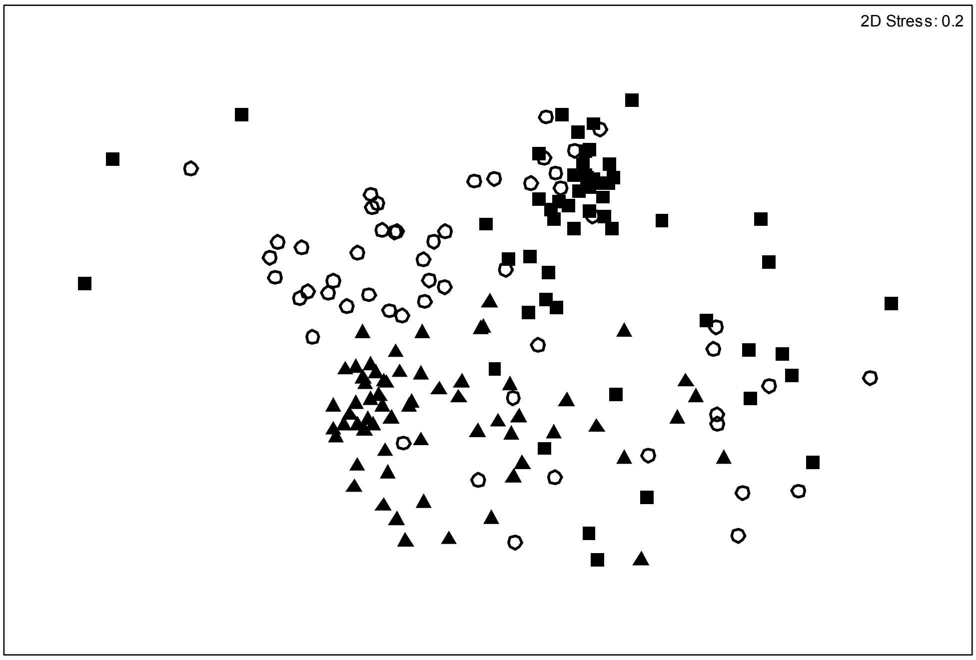


Figure 33: Multidimensional scaling ordination of diurnal bird assemblages across the three land types. Closed triangles = soft mulga; closed squares = poplar box; and open circles = brigalow belah.

Table 21: SIMPER analysis of similarity in the composition of bird species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in soft mulga land types. *** Only species explaining approximately 70% of the similarity per condition class are shown.**

Common name	% contribution	Common name	% contribution
a) Grazing land condition classes		**b) BioCondition classes**	
Class A		**Class 1**	
Chestnut-rumped thornbill	18.8	Weebill	11.7
Willie wagtail	10.2	Rufous whistler	11.5
Rufous whistler	8.7	Yellow thornbill	8.4
Yellow-rumped thornbill	7.4	Chestnut-rumped thornbill	8.1
Striated pardalote	6.7	Willie wagtail	5.7
Weebill	6.2	Red-capped robin	4.9
Yellow thornbill	4.4	Striated pardalote	4.7
Red-capped robin	4.3	Jacky winter	4.7
Diamond dove	4.0	White-browed treecreeper	3.9
		Western gerygone	3.6
Class B		**Class 2**	
Striated pardalote	10.1	Chestnut-rumped thornbill	11.3
Weebill	7.8	Rufous whistler	8.8
Rufous whistler	7.5	Willie wagtail	8.0
Chestnut-rumped thornbill	5.9	Striated pardalote	6.8
Jacky winter	5.8	White-browed treecreeper	4.6
Willie wagtail	5.6	Jacky winter	4.4
Australian ringneck	3.4	Yellow-rumped thornbill	4.4
Yellow thornbill	3.3	Red-capped robin	4.3
Black-faced cuckoo-shrike	3.2	Hooded robin	3.8
Crested pigeon	3.0	Weebill	3.7
White-browed treecreeper	2.9	Little friarbird	3.2
Yellow-rumped thornbill	2.8	Spiny-cheeked honeyeater	3.2
Brown treecreeper	2.7	Yellow thornbill	2.9
Striped honeyeater	2.6		
Class C		**Class 3**	
Willie wagtail	12.7	Striated pardalote	11.3
Chestnut-rumped thornbill	9.8	Chestnut-rumped thornbill	10.9
Striated pardalote	9.6	Willie wagtail	10.2
Yellow-throated miner	7.1	Yellow-rumped thornbill	6.9
Weebill	7.1	Crested pigeon	6.3
Rufous whistler	5.5	Spiny-cheeked honeyeater	5.4
Yellow-rumped thornbill	5.1	Rufous whistler	7.8
Red-capped robin	4.7	Weebill	4.4
Spiny-cheeked honeyeater	3.7	Yellow-throated miner	4.3
Crested pigeon	2.9	Australian magpie	4.2
Class D		**Class 4**	
Chestnut-rumped thornbill	17.1	Yellow-throated miner	29.0
Rufous whistler	10.4	Weebill	24.1
Red-capped robin	10.3	Willie wagtail	16.8
White-browed treecreeper	7.9		
Inland thornbill	7.8		
Willie wagtail	6.3		
Yellow-rumped thornbill	4.8		
Spiny-cheeked honeyeater	4.2		

Table 22: SIMPER analysis of similarity in the composition of bird species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in poplar box land types. * Only species explaining approximately 75% of the similarity per condition class are shown.

Common name	% contribution	Common name	% contribution
a) Grazing land condition classes		**b) BioCondition classes**	
Class A		**Class 1**	
Noisy miner	43.5	Noisy miner	63.3
Weebill	7.8	Grey butcherbird	9.6
Torresian crow	7.7	Pale-headed rosella	4.6
Pale-headed rosella	7.6		
Grey butcherbird	6.8		
Class B		**Class 2**	
Noisy miner	51.1	Noisy miner	48.3
Grey butcherbird	8.7	Grey butcherbird	11.4
Striated pardalote	7.8	Apostlebird	10.1
Weebill	5.4	Australian magpie	9.1
Class C		**Class 3**	
Noisy miner	34.7	Noisy miner	29.6
Australian magpie	13.1	Weebill	26.9
Pipit	9.4	Striated pardalote	11.4
Apostlebird	9.3	Australian magpie	6.4
Class D		**Class 4**	
Less than 2 samples		Pipit	36.4
		Torresian crow	32.3
		Nankeen kestrel	7.5

Table 23: SIMPER analysis of similarity in the composition of bird species within each of the a) ABCD grazing land condition classes and b) 1234 BioCondition classes in brigalow belah land types. *** Only species explaining approximately 70% of the similarity per condition class are shown.**

Common name	% contribution	Common name	% contribution
a) Grazing land condition classes		**b) BioCondition classes**	
Class A		**Class 1**	
Yellow thornbill	7.9	Silvereye	10.1
Weebill	7.6	Weebill	9.7
Inland thornbill	6.8	Yellow thornbill	9.1
Pipit	6.7	Inland thornbill	8.4
Noisy miner	6.7	Rufous whistler	7.7
Grey butcherbird	6.3	Speckled warbler	7.4
Rufous whistler	5.7	Grey shrike-thrush	7.3
Grey shrike-thrush	3.9	Grey butcherbird	6.1
Willie wagtail	3.4	Mistletoebird	6.1
Mistletoebird	3.3		
Striped honeyeater	3.2		
Double-barred finch	3.1		
Grey fantail	2.8		
Class B		**Class 2**	
Noisy miner	28.3	Noisy miner	13.8
Grey butcherbird	20.2	Weebill	11.5
Australian magpie	15.1	Rufous whistler	10.5
Weebill	6.6	Grey butcherbird	9.9
		Inland thornbill	7.2
		Grey fantail	5.8
		Mistletoebird	4.3
		Yellow thornbill	4.2
Class C		**Class 3**	
Weebill	11.4	Noisy miner	30.6
Noisy miner	7.3	Grey butcherbird	18.9
Inland thornbill	7.0	Australian magpie	9.5
Rufous whistler	6.4	Grey-crowned babbler	8.6
Australian magpie	5.8	Crested pigeon	8.4
Grey butcherbird	5.8		
Willie wagtail	5.7	**Class 4**	
Striped honeyeater	4.6	Pipit	29.2
Yellow-faced honeyeater	4.1	Willie wagtail	16.5
Grey fantail	3.6	Pied butcherbird	6.3
Pale-headed rosella	3.2	Australian magpie	5.2
Yellow-rumped thornbill	2.7	Nankeen kestrel	4.3
Speckled warbler	2.5	Crested pigeon	3.5
Class D			
Rufous whistler	27.8		
Weebill	24.1		
Bar-shouldered dove	17.1		

4.7 Testing the value of the rapid 1234 assessment

Over many years we have tested and refined BioCondition to measure essentially habitat condition for supporting a range of biodiversity. BioCondition is a science-based methodology that uses techniques to quantitatively measure a number of attributes. We have also developed a more rapid 1234 assessment of biodiversity to allow anyone to take a quick look at the condition of their paddock or patch of bush.

With the rapid 1234 assessment we've tried to remove exact measures, opting for broad categories that can easily and quickly be estimated for a site. We have also reduced the number of attributes assessed based on the key features described in toolkit 2 (see section 4.4 of Appendix 5). Like BioCondition, the rapid assessment categories for each attribute are based on the benchmarks for each of the land types, except we have used actual values to derive datasheets for each land type (see Toolkit 3a, b and c, Appendix 5).

In many respects the rapid assessment is more about education by showing which elements, important for biodiversity, are present or lacking from an area, highlighting features that can be improved to increase the conservation of biodiversity. In this section we will examine how well this rapid assessment predicts biodiversity condition, in comparison to the already tested BioCondition tool that people will use if they are looking for a more detailed, accurate assessment of biodiversity condition.

The attributes from BioCondition that we have retained for the Rapid Assessment and their score or weight incorporated into the datasheet are shown in Table 24. We have retained these attributes based on analyses of key features for biodiversity (see section 4.4 of Appendix 5). The following section examines how well each of these attributes' scores align with BioCondition. The analysis used 190 sites, 54 from Brigalow, 54 from Poplar Box and 82 from Soft Mulga.

Table 24: The assessable attributes and weightings for deriving the final Rapid 1234 Assessment score.

	Attribute	Weighting
Site-based Condition Attributes	Tree species richness	5
	Tree canopy cover	5
	Shrub species richness	5
	Shrub canopy cover	10
	Number of large trees	20
	Number of fallen logs	10
	Native preferred and intermediate grass cover	10 5
	Litter cover	5
	Weed cover *(selected fragmented land types)**	*10 (frag)*
Landscape attributes	Context	10
	Connectivity	10
	Distance to water *(selected intact land types)**	*10 (intact)*

* 'Weed cover' in fragmented landscapes replaces 'distance to water' that is used in intact landscapes.

4.7.1 Tree and shrub species richness

In BioCondition we use tree and shrub species richness as half the weighting for the native plant species richness attribute. In the Rapid Assessment we use only tree species and shrub species richness as key features, with the other species richness attributes (e.g. grasses) being highly correlated with other attributes we assess here and will examine later. Across the three land types (Brigalow, Poplar box and Soft mulga) we've developed the Rapid Assessment scores for these two attributes so that they matched 100% of the time with those obtained in BioCondition.

4.7.2 Tree canopy cover

For the Rapid 1234 Assessment we have broad categories and guides to help estimate canopy cover, in comparison to a more accurate measure taken in BioCondition. BioCondition also assesses the health of the canopy, something not included in the rapid assessment. Using the rapid assessment gave the same score as BioCondition 86% of the time. The rest of the time unusually poor canopy health meant that the rapid 1234 assessment over-estimated this attribute score in comparison to BioCondition.

4.7.3 Shrub canopy cover

In the rapid assessment we have doubled the score of shrub canopy cover, as this attribute has been shown to be very important for a number of fauna groups including small passerine birds (see toolkit 2 and section 4.5). As with tree canopy cover, the rapid 1234 assessment uses relatively broad categories to estimate cover. The BioCondition and rapid assessment scores for this attribute match 82% of the time.

Our analysis has been based on using canopy cover scores that were not estimates but rather data collected more accurately. For this reason, for land types where shrubs are relatively uncommon and the benchmark is low, like poplar box and brigalow, we suspect amounts of shrub cover will be over-estimated. For example we may measure less than 1% shrub cover yet would likely round this up to 1 or 2% when estimating this cover. We have accounted for this in the rapid assessment score sheets but our analysis, based on actual measures, gives some variance in the scores. If for analysis we round scores, as we would making an estimate, we see the rapid scores matching the BioCondition scores almost 100% of the time. In a land type where shrubs are common, and the attribute values are broad such as brigalow, we see estimate scores matching measured scores on all occasions.

4.7.4 Large live trees

Mature trees are one of the most important features for biodiversity, and the high score in the rapid assessment reflects this. As tree canopy height is also strongly correlated to this attribute (see section 4.4.2) we have included the BioCondition scoring for tree canopy height into the large live tree attribute to make a score of 20 (Table 24). This attribute is one of the few that uses a quantitative measure, but is still grouped in relatively broad categories, so it doesn't matter if a large tree is missed when counting.

In BioCondition we also count hollows (important for hollow-nesting fauna) and differentiate between eucalypt and non-eucalypt species because of their differing abilities to form hollows. In the rapid assessment we do not make these differentiations as it can be complicated. For the rapid assessment we make the generally true assumption that the more large old trees you have the more likely you are to have hollows forming. We also assume, based on the high correlation, that if you have reasonable numbers of large live trees then the canopy height will also be appropriate for the land type.

When we compare the BioCondition scores (large trees – 15 and tree canopy height – 5) to the rapid assessment score (large live trees – 20), we see a variance in the scores of up to 25% at approximately 75% of sites. Generally, the variance between BioCondition and the rapid assessment for each site is relatively low and is the result of two potential scenarios:

- The rapid assessment under-scores when there are no or few large trees but the average canopy height still meets the benchmark;
- The rapid assessment over-scores when there are lots of large trees but they lack hollows.

4.7.5 Fallen logs

Another key feature for biodiversity is fallen timber (see Toolkit 2, Appendix 5). Because of its importance for ground dwelling wildlife we've increased the weighting in the rapid assessment from 5 to 10. This attribute requires a quick count of fallen wood, greater than a certain size within a small area surrounding the site marker. In BioCondition, fallen woody material is also attributed to a decay class as this is often important for wildlife. For the rapid assessment we assume that the more fallen logs you have the more likely some are going to be in an advanced state of decay.

Comparing the scores we find good correlation between BioCondition and the rapid assessment with scores matching more than 80% of the time. We see the greatest difference in scores in the soft mulga land type, where the rapid assessment often over-scores slightly the value of fallen logs due to the fact that mulga timber decays very slowly.

4.7.6 Preferred and intermediate grass cover

In the rapid assessment we estimate the percentage of the assessment area covered by preferred and intermediate native grass cover. The scores are based on broad values and allow easy estimates to be made in reference to cover guides (Toolkit 3a, b and c, Appendix 5). As grass cover and grass species richness attributes are highly correlated (section 4.4.2, Appendix 5), we combined these two attributes from BioCondition to form one estimate in the rapid assessment.

The grass cover scores were all equal across the three land types. However, when grass species richness was included, we saw more variance in the scores due to high cover of preferred and intermediate grasses but of only one or two species; or, conversely, a high diversity of grass species but with very little cover (usually rare).

4.7.7 Litter and weed cover

Both litter and weed cover are estimated across the assessment area and both have the same weighting in BioCondition. Litter cover has been identified as a key feature for biodiversity (see Toolkit 2, Appendix 5). Weed cover is also identified as an important attribute but mainly in fragmented landscapes. In intact landscapes weeds are of less concern and appear to have less impact on biodiversity. For this reason, in applying the 1234 assessment to intact landscapes, we replaced the weed cover attribute with the landscape attribute, distance to water.

4.7.8 Landscape attributes

The landscape attributes are assessed in the same way as BioCondition, however patch size is not assessable as it is difficult to obtain quickly. For fragmented landscapes, the landscape score is out of 20, as in BioCondition. However, for intact landscapes we score the landscape attributes out of a total of 30. This is because distance to water has been shown to be more important in intact landscapes – or at least Mulga landscapes – than weed cover. We therefore substitute distance to water into the rapid assessment in place of weed cover in intact landscapes.

4.7.9 Overall rapid scores and condition classes

Finally, we'll examine how well all the attributes combined correlate with the final scores from BioCondition. The scores for each of the attributes are important as they highlight where an assessment area is doing well, or poorly, for biodiversity. The final score out of 100 for the rapid assessment is much less important and we can simplify it into categories or condition classes from 1 to 4 as we do in BioCondition. It is interesting, however, to note that the scores obtained in the rapid assessment do mirror those from BioCondition (Figure 34), where variation in the rapid assessment accounts for approximately 88% of variation in the BioCondition scores. The outliers on the graph in Figure 34 are explained by examining those differences in individual scores, as we have done.

We can categorise these scores into the condition classes from 1 (for 'functional' condition) to 4 (for 'dysfunctional' condition), using the same ranges as BioCondition (see Table 25). When we do this we get 71.1% of the classes in direct agreement and 28.9% being one class different (Table 26). Many of these differences are those sites which score near the divisions between two classes.

Table 25: Final classification of rapid assessment scores (follows BioCondition method)

Condition Class	Score
1	> 80
2	60 – 80
3	40 - 59
4	< 40

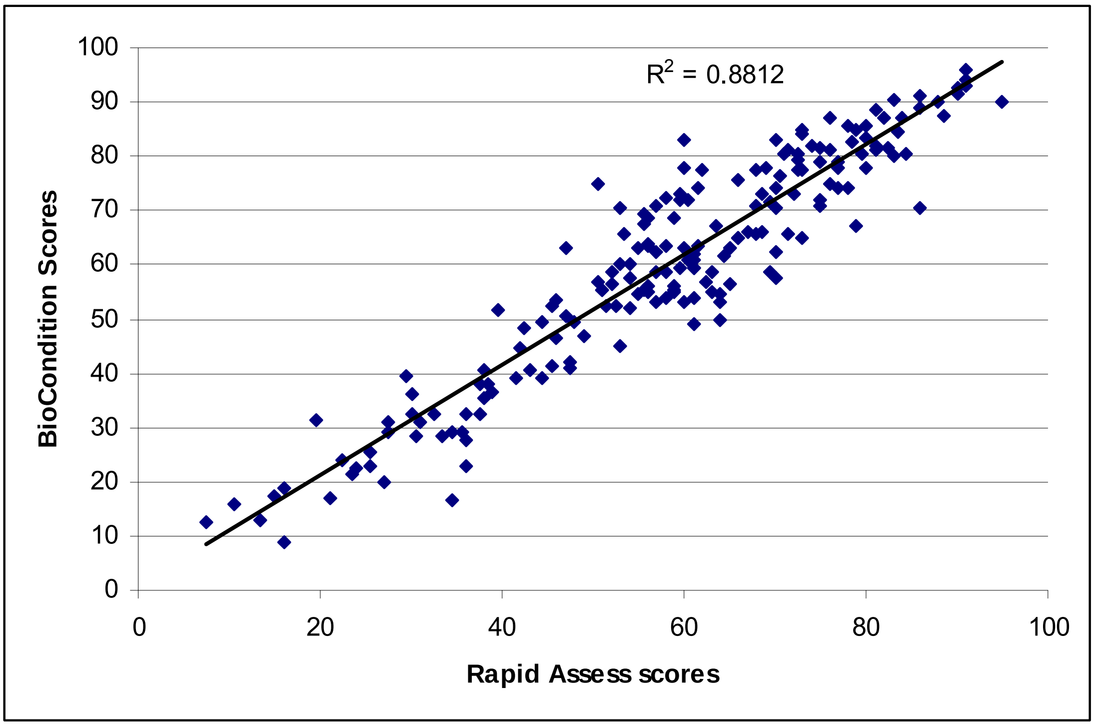


Figure 34: Comparison of Rapid 1234 Assessment scores with BioCondition Scores for individual sites.

The rapid 1234 assessment therefore does a very good job in highlighting the key features either present or lacking from an assessment area, quickly giving an appraisal of biodiversity condition and the attributes that may be improved in that area to increase its biodiversity value. A BioCondition assessment should be undertaken if a more accurate appraisal of biodiversity condition is required as the rapid assessment does not assess all components important for biodiversity (e.g. hollows, regeneration, etc).

Table 26: Comparison of biodiversity condition classes between Rapid 1234 Assessment and BioCondition assessment.

Difference between Rapid 1234 Class and BioCondition Class	%
In direct agreement	71.1
Difference of one class	28.9
• One class up	10
• One class down	18.9

4.8 Mapping condition in the mulga lands

An increase in FPC with PALSAR backscatter was observed for both remnant and regrowth field sites. Remnant vegetation sites can exhibit quite low FPC values (~10% FPC) and, conversely, regrowth sites quite high FPC values (~17% FPC), hence the discrimination of remnant and regrowth areas using only Landsat FPC data would not be reliable. However, regrowth vegetation sites exhibit much lower backscatter values than remnant sites due to the absence of woody components of sufficient size to evoke a discernible double bounce scattering towards the sensor. A classification using the Landsat-derived FPC and PALSAR backscatter data was developed based on similar findings of Lucas *et al*. (2006), to discriminate remnant and regrowth vegetation and the structural components within these 2 broad structural classes. For a more detailed explanation of this classification refer to Buck *et al*. (2009). A further 29 field sites were visited to assess the accuracy of the mapped classification of structural attributes of vegetation.

Results indicate that a very good relationship exists between estimates of FPC and the assessable indicator *tree canopy cover* (r^2=0.81). A positive but complex relationship was found between the attribute *total number of large trees* and PALSAR backscatter. PALSAR backscatter interacts with a range of tree size classes, not just large trees. Additionally higher backscatter PALSAR values were obtained for smaller sized stems than those used to define large trees. As a result PALSAR radar imagery alone cannot be used to map this attribute. The findings justified the development of an object oriented classification using a combination of Landsat FPC and PALSAR radar data to discriminate remnant and regrowth vegetation and the structural components within these 2 broad structural classes. The accuracy of the classification in terms of discriminating regrowth and remnant forest is quite good with a Kappa Statistic of 0.79 as shown in Table 27.

Table 27: Accuracy assessment of Definiens classification based on 67 field sites

		Definiens Classification Classes		
		Remnant	Regrowth	Total
Field Sites	Remnant	32	0	**32**
	Regrowth	7	28	**35**
	Total	**39**	**28**	**67**

Kappa Statistic = 0.79

The classification identified 4 structural regrowth classes: *structurally mature, regenerating, cleared* and *selectively cut*. As existing field sites did not occur in either *structurally mature* or *selectively cut*, accuracy assessment of these regrowth classes was not possible without further field work. A further 29 field sites were obtained with the aim of assessing the accuracy of the mapped regrowth classes and the results are shown in Table 28. As only a very small area was mapped as *selectively cut* and only 2 sites were sampled, it was decided not to include this class in the accuracy assessment.

Table 28: Accuracy assessment of Classification based on 96 field sites

		Regrowth Classification Classes				
		Cleared	Regenerating	Structurally Mature	Remnant	Total
Field Sites	Cleared	**7**	**4**	**1**	**2**	**14**
	Regenerating	**17**	**12**	**0**	**6**	**35**
	Structurally Mature	**0**	**2**	**3**	**1**	**6**
	Remnant	**0**	**2**	**0**	**39**	**41**
	Total	**24**	**20**	**4**	**48**	**96**

Kappa Statistic = 0.4574

A Kappa statistic of 0.4574 suggests that the classification is not discriminating between remnant vegetation and the different regrowth structural classes very well. The sample size for structurally mature is low but, again, only a small area was actually mapped as structurally mature. The main reason for the poor result is probably due to the inability of the remotely sensed imagery to provide information on either height of vegetation or species composition which are necessary for defining the various stages in structural development of vegetation. To further develop this methodology a means for incorporating at least height information is essential.

4.9 Quantification of ABCD rapid assessment

Quantitative data on ground cover and landscape function was collected from 175 sites from the Mulga Lands and Brigalow Belt South bioregions. Within these bioregions, a total of 59 sites on soft mulga, 54 on brigalow-belah and 62 on poplar box on alluvial plains land types (Whish 2010) were assessed using ground cover, landscape function and grazing land condition procedures. Across all land types, 'D' grazing land condition was poorly represented (<10% of region sites). Over 70% of the poplar box and soft mulga study sites were either in 'B' or 'C' grazing land condition. Over half the study sites in the brigalow-belah land type were assessed to be in 'A' land condition (Table 29).

Table 29: Soft mulga, brigalow-belah and poplar box on alluvial plains land type study sites where ground cover, landscape function and land condition assessments were conducted.

Grazing Land Condition	Soft Mulga sites	Brigalow-belah sites	Poplar Box on alluvial plains sites
A	11	27	17
B	21	10	28
C	22	15	16
D	5	2	1
Total Sites Assessed	59	54	62

4.9.1 Mulga region – soft mulga sites

The mulga sites were dominated by bare ground runoff areas (LFZ 0). The proportion (not significant) and average patch length (P<0.05) of bare ground increases from approximately 70% and 5m at sites in A condition to over 90% and 14m at sites in D land condition (Table 30). The mulga sites in D condition had significantly higher number of perennial forbs +/or log patches (LFZ 1) equating to approximately 10% of ground area. These sites in poor land condition had significantly less (<1%) perennial grass cover (LFZ 2 and 3) (Table 30). Mulga sites in good land condition (A) had significantly greater cover (12%, average length of 2.5m) of perennial grass patches. At these sites the number of grass patches (P<0.001) were almost three times that of sites in poorer condition, and suggests that individual perennial grass tussocks were common components of LFZ 3 in A condition sites. There was no significant difference between mulga sites in B and C condition for both perennial grass zones (LFZ 2 and 3). The mulga sites in C condition had less perennial grass cover (LFZ 2 and 3) than B condition sites but a higher number of perennial grass patches.

Landscape Function Indicators (LFI) of annual grass, perennial grass and crust-disturbance varied significantly between land condition classes for Mulga sites (Table 31). A condition sites had more annual grasses than all other land condition classes, and more perennial grasses than sites in poorer condition (C, D). Sites in good condition (A) had less crusting or disturbance to soil surface than sites in poorer C condition Grass tussocks, annual and perennial forbs, organic cover and live tree basal areas did not vary significantly between the land condition classes.

4.9.2 Brigalow belt south region – brigalow-belah sites

The brigalow-belah study sites in A condition were significantly dominated (approximately 70%) by perennial grass patches (LFZ 2 and 3), with 23% of the ground area comprised of dense perennial grass patches (LFZ 3; Table 32)). Bare ground (LFZ 0) was significantly lower (33%) at A condition sites than other poorer condition sites. Conversely, brigalow-belah sites in D condition were characterised with significantly higher bare ground cover (LFZ 0) of over 90% and lower (<2%) perennial grass patches (LFZ 2 and 3). D condition sites also had significantly higher perennial forb + / or log patches (LFZ 1). Brigalow-belah sites in B and C condition had statistically similar bare ground, perennial forbs and perennial grass cover; however, B condition sites had twice the perennial forb cover (5%, 2.7%), greater grass patch (40%, 30%) and less bare ground (46%, 53%) than C condition sites.

Landscape Function Indicators (LFI) of organic cover, grass tussocks, annual grass, perennial grass and live tree basal area varied significantly between land condition classes for Brigalow-belah sites (Table 33). The two D condition sites assessed had no trees, no perennial grasses, no grass tussocks, and the lowest organic cover (52%). A condition sites had significantly high organic cover (77%), grass tussocks (28%) and perennial grasses (14%) and no annual grasses. Perennial grasses, grass tussocks and organic cover for brigalow-belah sites in B and C condition were statistically similar, but all indices were higher at the better condition sites. Crust-disturbance and annual and perennial forbs did not vary significantly between the land condition classes.

Table 30: Mean values of percent ground cover, average length of zone, and number of patches for four Landscape Function Zones (LFZ) measured at Mulga sites. * Indicates log transformed data.

Grazing Land Condition	**LFZ 0** Runoff zone with bare ground, litter and annuals		**LFZ 1** Runon zone dominated by perennial forbs +/- permanent logs			**LFZ 2** Runon zone dominated by perennial grass +/- shrubs+/- permanent logs			**LFZ 3** Runon zone dominated with perennial grass – grass tussock or dense perennial grass patch		
	Proportion of area (%)	Length (m)	Proportion of area (%)	Length (m)	Number of patches	Proportion of area (%)	Length (m)	Number of patches	Proportion of area (%)	Length (m)	Number of patches
A – n=11	68.86	5.24; 0.67*	2.06	0.93	2.46; 0.07*	13.03; 0.60*	1.80; 0.07*	8.82; 0.78*	11.78; 0.61*	2.47; −0.11*	22.91; 1.11*
B – n=21	70.35	7.76, 0.78*	4.95	1.20	7.67; 0.63*	18.96; 0.62*	2.80; 0.12*	10.33; 0.52*	5.74; −0.25*	0.77; −0.56*	6.95; 0.37*
C – n=22	80.56	7.73; 0.82*	2.73	0.71	5.64; 0.43*	13.89; 0.76*	2.20; 0.13*	11.68; 0.79*	2.83; −0.27*	0.56; −0.60*	8.50; 0.46*
D – n=5	90.28	13.58; 1.13*	8.76	1.71	10.8; 1.02*	0.95; −0.64*	0.78; −0.66*	0.6; −0.53*	0.01; −0.97*	0.00; −0.99*	0.4; −0.74*
Level of significance	NS	P<0.05*	NS	NS	P<0.05*	P<0.05*	P<0.1*	P<0.05*	P<0.05*	P<0.05*	P<0.001*
Average SE mean		0.1226*			0.2836*	0.3911*	0.2642*	0.3353*	0.3481*	0.2280*	0.3397*
Average LSD 5%		0.2456*			0.5684*	0.7838*	0.5295*	0.6720*	0.6977*	0.4569*	0.6807*

Table 31: Mean values of Landscape Function Indicators (crust disturbance, organic cover, grass tussock, annual grass and forbs, and perennial grass and forbs) and tree basal area (tba) of live trees measured at Mulga sites. * Indicates log transformed data.

Grazing Land Condition	**Crust-disturbance**	**Organic cover**	**Grass tussock**	**Annual forb**	**Annual grass**	**Perennial forb**	**Perennial grass**	**tba-live**
A – n=11	45.2; 1.57*	54.5	0.41	1.05	4.55; −0.16*	1.36	6.05; 0.60*	9.35 (n=11)
B – n=21	50.4; 1.68*	49.2	3.10	0.5	0.45; −0.74*	1.14	3.83; 0.24*	7.92 (n=21)
C – n=22	60.3; 1.76*	44.1	0.98	0.64	0.32; −0.75*	0.80	1.93; −0.10*	4.77 (n=22)
D – n=5	41.1; 1.61*	58.5	0.0	0.0	0.20; −0.79*	0.5	0.2; −0.69*	6.4 (n=5)
Level of significance	P<0.1*	NS	NS	NS	P<0.05*	NS	P<0.001*	NS
Average SE mean	0.0874*				0.2525*		0.2614*	
Average LSD 5%	0.1752*				0.506*		0.5239*	

Table 32: Mean values of percent ground cover, average length of zone, and number of patches for four Landscape Function Zones (LFZ) measured at Brigalow sites. * Indicates log transformed data.

Grazing Land Condition	LFZ 0 Runoff zone with bare ground, litter and annuals		LFZ 1 Runon zone dominated by perennial forbs +/- permanent logs			LFZ 2 Runon zone dominated by perennial grass +/- shrubs+/- permanent logs			LFZ 3 Runon zone dominated with perennial grass – grass tussock or dense perennial grass patch		
	Proportion of area (%)	Length (m)	Ground cover (%)	Length (m)	Number of patches	Ground cover (%)	Length (m)	Number of patches	Ground cover (%)	Length (m)	Number of patches
A – n=27	33.7	2.48; 0.33*	2.1; −0.18*	0.79	2.2; −0.18*	40.1	4.2; 0.57*	10.4	22.9; 0.78*	6.0; 0.28*	4.3
B – n=10	46.1	3.69; 0.53*	5.0; 0.19*	1.92	3.1; 0.05*	34.6	4.2; 0.54*	9.8	9.1; 0.25*	3.5; −0.09*	3.7
C – n=15	52.8	5.00; 0.60*	2.7; 0.59*	2.22	5.0; 0.44*	25.0	4.3; 0.43*	9.3	5.4; −0.10*	1.5; −0.40*	2.9
D – n=2	92.0	9.16; 1.0*	8.8; 0.34*	0.84	4.3; 0.46*	1.5	0.7; −0.12*	2.0	0.4; −0.41*	0.1; −0.75*	3.5
Level of significance	P<0.05	P<0.05*	P<0.1*	NS	P<0.1*	P<0.05	P<0.1*	NS	P<0.05*	P<0.05*	NS
Average SE mean	13.29	0.1681*	0.53*		0.4166*	10.048	0.1932*		0.5136*	0.4216*	
Average LSD 5%	26.69	0.3376*	1.065*		0.8368*	20.18	0.388*		0.1.032*	0.8467*	

Table 33: Mean values of Landscape Function Indicators (crust disturbance, organic cover, grass tussock, annual grass and forbs, and perennial grass and forbs) and tree basal area (tba) of live trees measured at Brigalow sites. * Indicates log transformed data.

Grazing Land Condition	Crust-disturbance	Organic cover	Grass tussock	Annual forb	Annual grass	Perennial forb	Perennial grass	tba-live
A – n=27	22.2	77.1	27.9; 1.21*	0.7	0.0; −0.97*	2.4	13.5; 1.01*	6.8 (n=9)
B – n=10	29.0	66.8	8.1; 0.47*	1.3	0.3; −0.66*	4.1	9.4; 0.71*	14.3 (n=3)
C – n=15	31.5	65.1	7.0; 0.41*	2.3	0.1; −0.90*	7.1	6.6; 0.46*	2.9 (n=6)
D – n=2	37.0	52.5	0.0; −1.00*	0.3	0.0; −1.00*	1.3	0.0; −1.00*	0 (n=0)
Level of significance	NS	P<0.05	P<0.001*	NS	P<0.05*	NS	P<0.001*	P<0.05
Average SE mean		7.834	0.3952*		0.1459*		0.3005*	3.581
Average LSD 5%		15.74	0.7939*		0.2931*		0.6036*	7.633

Table 34. Mean values of percent ground cover, average length of zone, and number of patches for four Landscape Function Zones (LFZ) measured at Poplar Box on alluvial plains sites. * Indicates log transformed data.

Grazing Land Condition	LFZ 0 Runoff zone with bare ground, litter and annuals		LFZ 1 Runon zone dominated by perennial forbs +/- permanent logs			LFZ 2 Runon zone dominated by perennial grass +/- shrubs+/- permanent logs			LFZ 3 Runon zone dominated with perennial grass – grass tussock or dense perennial grass patch		
	Proportion of area (%)	Length (m)	Ground cover (%)	Length (m)	Number of patches	Ground cover (%)	Length (m)	Number of patches	Ground cover (%)	Length (m)	Number of patches
A – n=17	27.5	2.34; 0.37*	4.5	1.70	3.59	52.7	5.06; 0.69*	22.2	15.3; 0.91*	3.01; 0.32*	8.82
B – n=18	45.2	2.97; 0.45*	5.28	1.18	4.56	41.2	3.75; 0.53*	23.0	8.28; 0.30*	1.83; −0.13*	7.72
C – n=16	44.7	4.31; 0.57*	8.85	3.07	3.94	40.0	5.57; 0.60*	18.7	6.51; 0.37*	2.38; −0.04*	7.13
D – n=1	42.1	12.6; 1.10*	58.0	15.0	8.0	0.0	0.0; −1.00*	0.0	0.0; −1.00*	0.00; −1.00*	0.0
Level of sign.	P<0.1	P<0.001*	P<0.001	NS	NS	P<0.05	P<0.001*	P<0.05	P<0.05*	P<0.1*	NS
Average SE mean	14.3	0.1369*	8.083			13.48	0.1738*	5.775	0.5103*	0.4232*	
Average LSD 5%	21.48	0.2753*	16.25			27.11	0.3495*	11.61	0.1026*	0.8508*	

Table 35. Mean values of Landscape Function Indicators (crust disturbance, organic cover, grass tussock, annual grass and forbs, and perennial grass and forbs) and tree basal area (tba) of live trees measured at Poplar Box on alluvial plains sites. * Indicates log transformed data.

Grazing Land Condition	Crust-disturbance	Organic cover	Grass tussock	Annual forb	Annual grass	Perennial forb	Perennial grass	tba-live
A – n=17	26.2	73.6	18.7	2.35	0.38	0.59; −0.91*	15.7; 1.15*	8.53 (n=6)
B – n=18	29.6	70.6	16.6	2.06	2.50	0.39; −0.59*	13.7; 0.81*	9.94 (n=10)
C – n=16	36.3	69.6	20.2	5.09	1.21	0.34; −0.65*	10.5; 0.85*	5.88 (n=12)
D – n=1	62.0	27.0	34.0	2.5	1.50	11.5; −1.06*	0.0; −1.00*	0.0 (n=1)
Level of significance	P<0.05	P<0.1	NS	NS	NS	P<0.001*	P<0.05*	NS
Average SE mean	11.21	11.4				0.2948*	0.3635*	
Average LSD 5%	22.54	22.9				0.5927*	0.7309*	

4.9.3 Brigalow belt south region – poplar box on alluvial plains sites

The poplar box on alluvial plains study site (see Table 34) in D condition was significantly different from other better condition sites. This poor condition site was dominated by perennial forb LFZ 1 patches (approximately 60% of ground area) with the remainder of the site bare ground. Sites in A, B and C condition had statistically similar perennial forb and perennial grass (LFZ 2) cover, although poorer sites had higher forb cover (8%) and sites in good condition had higher (53%) LFZ 2 perennial grass patches. These LFZ 2 grass patches are either comprised of grasses other than perennial, palatable and productive (3P) grasses or the patch is sparser (inter-tussock spacing 50−100 cm) than patches in LFZ 3. Poplar box sites in A condition had significantly higher area of dense (inter-tussock spacing <50cm) 3P perennial grass patches (15%) and the lowest area of bare ground (28%).

Landscape Function Indicators (LFIs) for D condition poplar box on alluvial plains differ significantly to sites in better condition (Table 35). On the poor condition site, significantly different LFIs included crust-disturbance (62% of what? Or is this simply an index?), organic cover (27%), perennial forbs (12%) and perennial grass (0%). LFI from sites in A, B and C condition were statistically similar; however, as land condition worsened the occurrence of perennial grasses decreased and crust-disturbance to soil surface increased. Sites in good condition (A) had the lowest index for crust-disturbance of soil surface (26%) and the highest index for occurrence of perennial grasses (16%). Sites in C condition recorded the highest index for annual forbs (5%) and B condition sites had the most annual grasses (2.5%). Tree basal areas, grass tussock, annual forbs and grass LFI did not vary significantly between the land condition classes.

Ground cover and landscape function assessments have provided quantitative data that characterises the grazing ABCD land condition (Chilcott *et al*, 2005a,b) of three land types in the Mulga and Brigalow Belt South bioregions. Ground cover (LFI) and patch organisation (LFZ) at sites clearly delineated between good (A) and poor (D) land condition and provided quantitative values for the ABCD land condition continuum.

Land condition is widely recognised as being important for sustaining both production and biodiversity (James *et al*. 2000, Whitehead *et al*. 2000, Ash *et* al 2002). Land condition monitoring information is required for strategic management of grazing land, to enhance knowledge of ecosystem processes, and to support sustainable management of natural resources in rangelands (Karfs *et al* 2009). Capturing quantitative data on grazing land condition in the Mulga and Brigalow Belt south bioregions will allow for a better understanding of ecosystem processes; validation of the condition of grazing lands in these bioregions; provide support to extension activities in delivering current land condition and monitoring information; and allow calibration of remotely sensed bare ground index to inform industry and policy makers for sustainable management in rangelands.

5 Success in Achieving Objectives

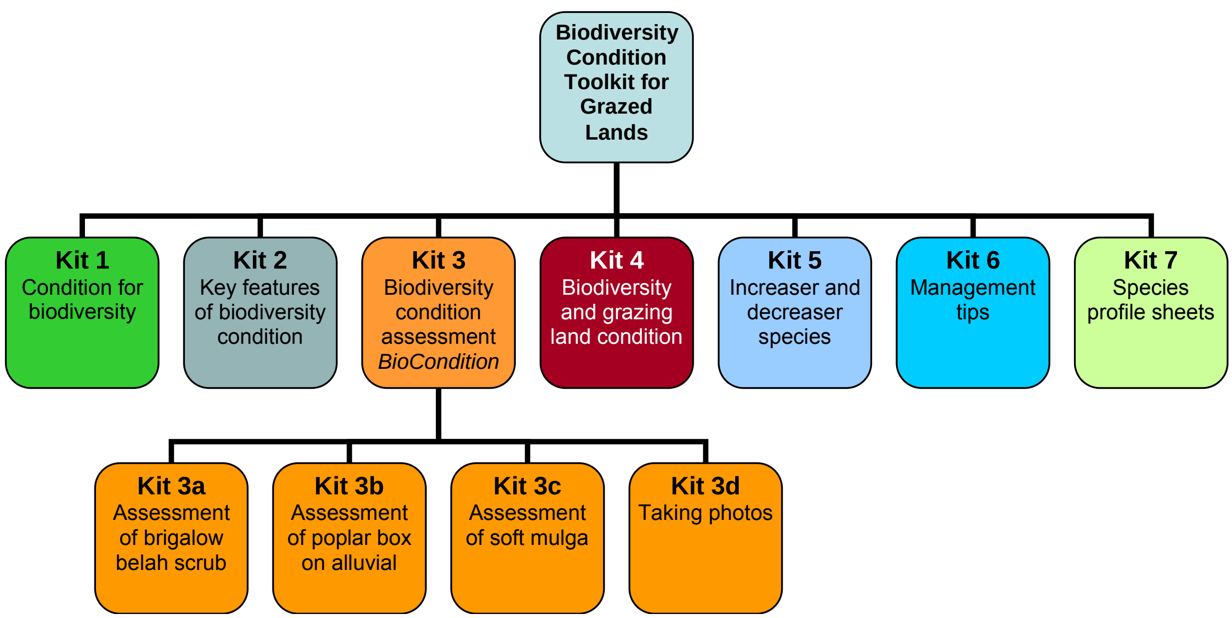
5.1 Success in Achieving Objectives

The project has achieved the objectives, as follows:

Objective 1: Provide a prototype toolkit (and corresponding set of presentations in powerpoint format), for the rapid assessment of biodiversity condition on grazing lands that is compatible with the grazing land condition (ABCD) assessment framework used in the GLM education package, and which includes materials for;

a. The rapid assessment of biodiversity condition (BioCondition);
b. Understanding biodiversity condition and its relationship to grazing land condition;
c. The significance of the BioCondition ratings for property and regional biodiversity, and;
d. Management options for maintaining or improving biodiversity in the grazed lands of southern Queensland.

- This objective has been achieved with the development of the Biodiversity Condition for Grazed Lands Toolkit. This toolkit is made up of seven separate interlinked but ultimately stand alone kits as outlined below:



- The information in theToolkit will assist with:
    - The assessment of condition of paddocks from a biodiversity perspective (BioCondition), and building on the Grazing Land Management perspective (as easy as 1234 and ABCD).

    - Understanding the relationships between flora and fauna, habitat features, pasture, woodlands and grazing land management.
    - Familiarisation with the flora and fauna that inhabit healthy (and unhealthy) grazing properties.
    - A set of educational PowerPoint presentation that could be used in conjunction with Grazing Land Management workshops, or other relevant workshops. The set of presentations follows the outline of the Toolkit.

- The Toolkit content is provided in Appendix 5. These are currently being professionally edited and desktop published.

Objective 2: Specify a set of surrogate indicators of condition for biodiversity on grazing lands, and their benchmark values, for a range of regional ecosystems occurring on grazing properties in the Southern Brigalow and Mulga regions of southern Queensland.

- Surrogate indicators of condition for biodiversity have been selected and validated for grazed regional ecosystems in the southern brigalow and mulga lands bioregions as detailed in this final report and in the peer-review (by CSIRO and David Parkes) and publication of the BioCondition document on the DERM website.
- Benchmark values for each of the validated surrogate indicators of biodiversity have been developed for poplar box, brigalow and eastern mulga regional ecosystems (see Appendix 2). These have been published on the DERM website for open access.

Objective 3: Establish relationships between the surrogate indicators and selected elements of biodiversity (e.g. persistence of identified decreaser species or species groups, for a range of flora and fauna) in the study regions.

- Relationships between the surrogate indicators selected under Objective 2, and direct measures of elements of biodiversity (e.g. species richness with taxa groups, abundance of identified increaser and decreaser species) have been established, as outlined in this report. The established relationships have been used to illustrate the importance of certain surrogate indicators for fauna and flora in the Toolkit 2 (brochure and powerpoint presentation) 'Key features for biodiversity' and Toolkit 5 (brochure and powerpoint presentation) 'Increaser and decreaser species' and brought together in within a management framework in Toolkit 6 (brochure and powerpoint presentation) 'Management Guidelines. (See Appendix 5).

Objective 4: Produce a technical BioCondition Manual relevant for the assessment of terrestrial biodiversity in Queensland.

- The BioCondition Manual has been peer-reviewed (by CSIRO and David Parkes), and has now been published on the DERM website (Appendix 6).

Miscellaneous outputs that further support the achievement of the project's objectives:

- Publications, including:

Eyre, T.J. (2010). Seven Lessons from Southern Queensland Woodlands. In: *Temperate Woodland Conservation and Management*, (Eds: David Lindenmayer, Andrew Bennett and Richard Hobbs) pp 353 – 359. CSIRO Publishing, Canberra.

Ferguson, D., Mathieson, M., and Eyre T.J. (2011). Southerly range extension of the poorly known, Queensland endemic yellow-naped snake *Furina Barnardi* (Squamata: Elapidae) into the Mulga Lands. *Memoirs of the Queensland Museum* (in press).

Kelly, A.L., Franks, A.J., and Eyre, T.J. (2011). Assessing the assessors: Quantifying observer variation in habitat and condition assessment. *Ecological Management and Restoration* 12, 144–148.

Wang, J., Eyre, T.J., Neldner, V.J., and Bean, T. (2011). Floristic composition and diversity changes over 60 years in eastern mulga communities of south central Queensland, Australia. *Biodiversity and Conservation* (in press).

- Presentations at various for a e.g. Ecological Society of Australia converences 2009 and 2010, Queensland Herbarium seminar series, NRM group seminar series, Environmental consultant collectives.

- Regular one-on-one communication with grazing land managers who participated in the project, including provision of draft Toolkit materials.

6 Impact on Meat and Livestock Industry – now and in five years time

The DEEDI Grazing Land Management and DERM Biodiversity Sciences partnership established an effective melding of grazing productivity and nature conservation knowledge and assessment skills which assisted greatly in providing effective and meaningful communication/extension between industry, grazing land science and biodiversity science.

Furthermore, given the project was undertaken by government scientists, outcomes from the project were regularly and effectively communicated with Queensland State Government policy and management. Throughout the duration of the project, and as a consequence of the work being conducted for this project, there was regular communication with Qld Govt policy and management units implementing the condition assessment component of the Delbessie Agreement and development of offset condition assessment guidelines in Vegetation Management. The immediate impact of this is that certain products that have been developed through MLA for the grazing industry (including Grazing Land Management, Stocktake, and Land Type profiles), and the products have helped new gov policy/requirements to be evidence-based and linked to practical tools and procedures.

The technical version of the BioCondition manual, as funded by MLA, is already widely used by ecological professionals in the public and private sector in Queensland. Evaluation of extent of use is difficult to measure, however the BioCondition manual has already been cited in seven peer-reviewed journal papers (Scopus, accessed July 2010) and numerous reports. It is also referred to as the Queensland standard for use in condition assessment under the Australian Vegetation Information portal (http://www.environment.gov.au/land/vegetation/nvip/standards/projects.html).

As articles and scientific papers are published, seminars, workshops and presentations are given; following from industry communication efforts in the regions (through Southwest NRM groups and delivery of GLM workshops), the future impact of the project will be significant. However, most impact will not be through uptake of the rapid assessment version of BioCondition, developed specifically for the Biodiversity in Grazed Lands Toolkit, which in reality we believe will be minimal. Rather, it will occur via the capacity building of the grazing land management network, and the incorporation of biodiversity into that program, which was only made possible through the close working relationship of the partners in this project. Key messages that were derived from the project, that have not been delivered before in Australia, include confirmation that;

- Managing for good grazing land condition does have benefits for biodiversity, particularly with the addition of a few key habitat features throughout the landscape.
- That grazing properties can and do make important contributions to the conservation of biodiversity in southern Queensland.

Overall, components of the Toolkit developed for this project can be used to systematically demonstrate sustainable management for biodiversity to benefit grazing land managers in the marketplace and when competing for relevant funding.

7 Conclusions and Recommendations

- For the majority of sites – across land types, landscape types and broad condition (i.e. remnant versus non remnant), there is close alignment between grazing land condition ratings and biodiversity condition ratings. However, if grazing land condition assessment were to include woody density, then it is likely the ratings for the two different purposes would diverge.

- Grazing land condition ‘ABCD’ classification and BioCondition ‘1234’ classes differ predominantly in pasture and regrowth sites. That is, a site assessed as ‘A’ or ‘B’ grazing land condition was likely to be assessed in ‘3’ or ‘4’ BioCondition if the site had previously been cleared. For sites with remnant vegetation retained, ‘A’ or ‘B’ condition was more aligned with ‘1’ or ‘2’ condition.

- However, despite some correspondence in the ratings at sites in remant vegetation, the ABCD framework did not generally reflect variation in the species composition of native flora and fauna, specifically:
    - bird species composition did not differ between classes;
    - reptile species composition did not differ between classes;
    - grass species composition did differ between classes, but not between B and C, or C and D)

- As hoped and expected, the BioCondition framework in general did reflect variation in the species composition of native flora and fauna, specifically:
    - bird species composition does differ between classes (but not between classes 1 and 2);

  - similarly for reptile species;
  - similarly for forb and grass species.

- The biodiversity in paddocks of open pasture, which are in A or B grazing land condition, can be greatly enhanced through the retention and maintenance of scattered keystone habitat features such as clumps of shrubs/regrowth, large trees and fallen woody material.

- Mapping condition using relevant biodiversity variables requires further research and development, using new and existing site based data.

- Poplar box landscapes appear to be highly depauperate for bird species – high densities of noisy miners and predatory species, regardless of ABCD or 1234 condition. It is recommended that research is focused particularly in this land type, regarding restorative capacity and requirements.

- New information on habitat requirements for little known species e.g. yakka skink, yellow-naped snake, declining woodland birds, has been compiled for this project across three land types, two of which (soft mulga and poplar box woodlands) had limited prior knowledge.

- In the grazed lands of southern Queensland, biodiversity and grazing production need not be mutually exclusive concepts. Properties with productive grazing land management can have rich and abundant biodiversity. The following management guidelines were developed from the outputs of the project:

Top 10 guidelines: Grazing land management for biodiversity

1. Maximise and **maintain grazing land condition** in woodlands and native pasturelands
2. **Maintain keystone habitat features** throughout the property
3. **Manage impacts on key biodiversity areas, creating refuges**, such as water remote and BioCondition class 1 areas
4. **Control feral grazing animals and feral predators** (e.g. pigs, foxes and cats)
5. If possible, **restrict the extent of introduced pasture** cover to 30%
6. In fragmented landscapes, **increase and connect woodlands** to at least 30% of the landscape
7. **Maintain the property as a mosaic of pasture and retained vegetation in good condition**
8. **Get to know the 'locals';** keep an eye out for increaser and decreaser species
9. **Use your local experts**, NRM and Landcare groups, government agencies and extension officers
10. **Have a property plan** that integrates biodiversity and production values

8 Bibliography

Accad, A., Neldner, V.J., Wilson, B.A., and Niehus, R.E. (2006). Remnant Vegetation in Queensland: Analysis of Remnant Vegetation 1997-1999-2000-2001-2003, including Regional Ecosystem Information. Queensland Herbarium, Environmental Protection Agency, Brisbane. http://www.epa.qld.gov.au/nature_conservation/plants/remnant_vegetation_in_queensland/

Aisthorpe, J.L. and Paton, C.J. (2004). Stocktake - Balancing Supply and Demand, Workshop Manual. DPI&F publication QE04001, Brisbane.

Anderson, M.J., 2001. A new method for non-parametric multivariate analysis of variance. *Austral Ecology* 26, 32–46.

Anderson, M.J., Gorley, R.N., Clarke, K.R., 2008. PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods. PRIMER-E, Plymouth.

Andreasen, J.K., O'Neill, R.V., Noss, R., and Slosser, N.C. (2001). Considerations for the development of a terrestrial index of ecological integrity. *Ecological Indicators* 1: 21–35.

Ash, A., Corfield, J., and Ksiksi, T. (2002). The Ecograze Project. Developing guidelines to better manage grazing country. CSIRO Sustainable Ecosystems, Townsville.

Bailey, R.C., Norris, R.H., and Reynoldson, T.B. (2004). Bioassessment of Freshwater Ecosystems: Using a Reference Condition Approach. Kluwer Academic Publishers, USA.

Bates, G. (2001). A Duty of Care for the Protection of Biodiversity on Land, Consultancy Report. Report to the Productivity Commission. AusInfo, Canberra. http://www.pc.gov.au/research/consultancy/docpobol/

Beale, I. F. (1994). Management of Mulga (*Acacia aneura*) Scrublands in southwest Queensland. In. *Forage Tree Legumes in Tropical Agriculture*. Gutteridge, R.C., and Shelton, H.M. (Eds). Department of Agriculture, University of Queensland, Brisbane.

Bennett, A., Kimber, S. and Ryan, P. (2000). *Revegetation and Wildlife: A guide to enhancing Revegetation Habitats for Wildlife Conservation in Rural Environments*. Bushcare National and Research and Development Program Research Report 2/00. Environment Australia, Canberra.

Bostock, P., and Holland, A. E. (2007). Census of the Queensland Flora 2007. (Queensland Herbarium, Environmental Protection Agency, Brisbane.)

Buck, R.G., Armston, J., Eyre, T.,Neldner, J., Kelly, A. and Kitchen, J. (2009). Queensland Vegetation Condition Mapping Trial, Department of Environment and Resource Management, December 2009.

Catterall, C.P., Green, R.J. and Jones D.N. 1991, 'Habitat use by birds across a forest-suburb interface in Brisbane: implications for corridors', in *Nature Conservation 2: The Role of Corridors*, eds D.A. Saunders, and R.J Hobbs, Surrey Beatty and Sons, Perth, pp 247-258.

Cavaye, J.M. (1991). *The Buffel Book. A Guide to Buffel Grass Pasture Development in Queensland*. Queensland Department of Primary Industries, Brisbane.

Chilcott, C.R., Paton, C.J., Quirk, M.F., and McCallum, B.S. (2003). Grazing Land Management Education Package Workshop Notes – Burnett. Meat and Livestock Australia Limited: Sydney.

Chilcott, C.R., Hamilton, J., Whish, G., Paton, C.J., and Johnston, P.W. (2005a). Grazing Land Management – Mulga Workshop Notes. Meat and Livestock Australia (MLA).

Chilcott, C.R., Witcher, L. M., Alsemgeest, V. M. Quirk, M. F. and Paton, C.J. (2005b). Grazing Land Management – Maranoa-Balonne Workshop Notes. Meat and Livestock Australia (MLA).

Clarke, K.R., Gorley, R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth.

Collard, S., Le Brocque, A., and Zammit, C. (2008). Bird asseblages in fragmented agricultural landscapes: the role of small brigalow remnants and adjoining land uses*. Biodiversity and Conservation*.

Corfield, J.P., Abbott, B.N., Hawdon, A. and Berthelsen, S. (2006). PATCHKEY: A patch classification framework for the Upper Burdekin and beyond. CSIRO Sustainable Ecosystems, Townsville.

DERM (Department of Environment and Resource Management) (2009). Delbessie Agreement (State Rural Leasehold Land Strategy). Guidelines for determining lease land condition. Version 1.1. Queensland Department of Environment and Resource Management, Brisbane.

DPI&F (Department of Primary Industries and Fisheries) (2006). The ABCD pasture condition guide. Mulga and Mitchell Grass. Land. Water and Wool and Department of Primary Industries and Fisheries, Charleville.

ESCAVI (Executive Steering Committee for Australian Vegetation Information) (2003). Australian Vegetation Attribute Manual. National Vegetation Information System, Version 6.0, Department of the Environment and Heritage, Canberra.

ESRI (2005) ArcGIS Desktop (Version 9.1). Environmental Systems Research Institute Inc., Redlands

Eyre, T.J., Kelly, A.L., Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M. and Franks, A.J. (2011). BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Methodology Manual. Department of Environment and Resource Management, Brisbane.

Eyre, T.J., Maron, M., Mathieson, M.T., Haseler, M., (2009). Impacts of grazing, selective logging and hyper-aggressors on diurnal bird fauna in intact forest landscapes of the Brigalow Belt, Queensland. Aust. Ecol. 34, 705–716.

Fisher, A., and Kutt, A. (2007). Biodiversity and Land Condition in Tropical Savanna Rangelands Technical Report. Tropical Savannas CRC, Darwin.

Fensham, R.J., and Fairfax, R.J. (2008). Water-remoteness for grazing relief in Australian arid-lands. *Biological Conservation* 141, 1447–1460.

Freudenberger, D., and Landsberg, J.L. (2000). Management of stock watering points and grazing to maintain landscape function and biological diversity in rangelands. In Hale, P., Petrie, A., Moloney, D., and Sattler, P. (Eds.), *Management for Sustainable Ecosystems*, University of Queensland, Brisbane, pp. 71–77.

Gibbons, P., Ayers, D., Seddon, J., Doyle, S., and Briggs, S. (2008). BioMetric Version 2.0: A Terrestrial Biodiversity Assessment Tool for the NSW Property Vegetation Plan Developer Operational Manual. Department of Environment and Conservation (NSW), Canberra. http://www.nationalparks.nsw.gov.au/npws.nsf/content/biometric_tool. (accessed 26 November 2009).

Gibbons, P., and Freudenberger, D. (2006). An overview of methods to assess vegetation condition at the scale of the site. *Ecological Management and Restoration* 7, S10-S17.

Grey M. J., Clarke M. F. and Loyn R. H. (1998) Influence of the Noisy Miner Manorina melanocephala on avian diversity and abundance in remnant Grey Box woodland. Pac. Conserv. Biol. 4, 55–69.

Hannah, D., Woinarski, J.C.Z., Catterall, C.P., McCosker, J.C., Thurgate, N.Y., Fensham, R.J., 2007. Impacts of clearing, fragmentation and disturbance on the bird fauna of Eucalypt savanna woodlands in central Queensland, Australia. *Austral Ecology* 32, 261–276.

Harrington, R. (2002). *The Effects of Artificial Watering Points on the Distribution and Abundance in an Arid and Semi-arid Mallee Environment*. PhD Thesis, University of Melbourne. http://eprints.unimelb.edu.au/archive/00000738/02/02whole.pdf/

Hassett, R., Byrne, M. and Taube, C. (2004). *Ground cover recording methodology.* Internal report for Department of Natural Resources and Mines, Brisbane.

Hawke, A. (2009). Report of the independent review of the Australian Environment Protection and Biodiversity Conservation Act 1999. Department of the Environment, Water, Heritage and the Arts, Canberra. http://www.environment.gov.au/epbc/review/publications/pubs/final-report.pdf

Hobbs, R.J., and Norton, D.A. (1996). Towards a conceptual framework for restoration ecology. *Restoration Ecology* 4, 93–110.

James, C.J., Landsberg, J.L., and Morton, S. (1999). Provision of watering points in the Australian arid zone: a review of effects on biota. *Journal of Arid Environments* 41, 87–121.

James, C. D., Stafford Smith, M., Landsberg, J., Fisher, A., Tynan, R., Maconochie, J. and Woinarski, J. (2000). Biograze – melding off-reserve conservation of native species with animal production in Australian rangelands. Pages 290-300 in: *Nature Conservation in Production Environments: Managing the matrix*. EDs J. L. Craig, N. Mitchell and D. A. Saunders. Surrey Beatty and Sons, Chipping Norton, Australia.

Karfs, R., Applegate, R., Fisher, R., Lynch, D., Mullin, D., Novelly, P., Peel, L., Richardson, K., Thomas, P. and Wallace, J. (2000). *Regional Land Condition and Trend Assessment in Tropical Savannas*: *The Audit Rangeland Implementation Project Final Report* National Land and Water Resources Audit, Canberra*.*

Karfs, R.A. and Trueman, M. (2005). *Tracking Changes in the VRD Pastoral District, Northern Territory, Australia – 2004*. Report to the Australian Collaborative Rangeland Information System (ACRIS) Management Committee. NT Department of Infrastructure, Planning and Environment, Darwin.

Karfs, R. A. and Beutel, T. S. (2008). Ground cover monitoring in the Fitzroy Basin project – Final Report. Department of Primary Industries and Fisheries, Queensland.

Karfs, R., Holloway, C., Pritchard, K., and Resing, J. (2009a). Land Condition Photo Standards for the Burdekin Dry Tropics Rangelands: a guide for practitioners. Burdekin Solutions Ltd and Queensland Department of Primary Industries and Fisheries, Townsville.

Karfs, R.A., Abbott, B.N., Scarth, P.F., and Wallace, J.F. (2009). Land condition monitoring information for reef catchments: a new era. *The Rangeland Journal* 31, 69–86.

Karr, J.R., and Chu, E.W. (1999). Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington.

Keith, D., and Gorrod, E. (2006). The meanings of vegetation condition. Ecological Management and Restoration 7, S7–S9.

Kuhnell, C.A., Goulevitch, B.M., Danaher, T.J., and Harris, D.P. (1998). Mapping Woody Vegetation Cover over the State of Queensland using Landsat TM Imagery In: Proceedings of the 9th Australasian Remote Sensing and Photogrammetry Conference, Sydney. http://www.nrw.qld.gov.au/slats/.

Kutt, A.S., and Fisher, A. (2011). Increased grazing and dominance of an exotic pasture (*Bothriochloa pertusa*) affects vertebrate fauna species composition, abundance and habitat in savanna woodland. *Rangeland Journal* 33, 49-58.

Kutt, A.S., and Woinarski, J.C.Z., (2007). The effects of grazing and fire on vegetation and the vertebrate assemblage in a tropical savanna woodland in north-eastern Australia. *Journal of Tropical Ecology* 23, 95–106.

Landsberg, J., and Crowley, G. (2004). Monitoring rangeland biodiversity: Plants as indicators. *Austral Ecology* 29, 59–77.

Landsberg, J., James, C.D., and Morton, S.R. *et al.* (1999). *The Effects of Artificial Sources of Water on Rangeland Biodiversity*. Environment Australia, Canberra.

Lindenmayer, D.B., Cunningham, R.B, Pope, M.L. and Donnelly, C. F., (1999), 'The response of arboreal marsupials to landscape context: A large scale fragmentation study', *Ecological applications*, vol. 9, no. 2, pp. 594 - 611.

Lucas, R.M., Cronin, N., Moghaddam, M., Lee, A., Armston, J., Bunting, P. and Witte, C. (2006). Integration of Radar and Landsat-derived Foliage Projected Cover for Woody Regrowth Mapping, Queensland, Australia. *Remote Sensing of Environment*, 100: 407-425.

Maron, M., Kennedy, S., 2007. Roads, fire and aggressive competitors: Determinants of bird distribution in subtropical production forests. For. Ecol. Manage. 240, 24–31.

Mac Nally, R. (2000). Regression and model-building in conservation biology, biogeography and ecology: the distinction between – and reconciliation of – 'predictive' and 'explanatory' models. Biodiversity and Conservation 9, 655–671.

Mac Nally, R. (2002). Multiple regression and inference in ecology and conservation biology: further comments on identifying important predictor variables. Biodiversity and Conservation 11, 1397–1401.

MEWG (Monitoring and Evaluation Working Group) (2004). An interim approach to the native vegetation condition (indicator status: for advice). http://www.nrm.gov.au/monitoring/indicators/vegetation-condition/index.html.

Negus, P., and Marsh, N. (2006). Water Quality Condition Assessment Framework, National Action Plan – Water Quality, Report No. QLD NAP WQ02-ASS01/1. Queensland Department of Natural Resources and Mines, Indooroopilly. http://www.wqonline.info/Documents/Report_ConditionAssessmentFramework.pdf

Neldner, V.J. (2006). Why is vegetation condition important to government? A case study from Queensland. *Ecological Management and Restoration* 7, S5-S7.

Noss, R.F. (1990). Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology* 4, 355–364

Oliver, I., Smith, P.L., Lunt, I., and Parkes, D. (2002). Pre-1750 vegetation, naturalness and vegetation condition: what are the implications for biodiversity conservation. *Ecological Management and Restoration* 3, 176–178.

Oliver, I., Jones, H., and Schmoldt, D.L. (2007). Expert panel assessment of attributes for natural variability benchmarks for biodiversity. *Austral Ecology* 32, 453–475.

Parkes, D., Newell, G., and Cheal, D. (2003). Assessing the quality of native vegetation: The 'habitat hectares' approach. *Ecological Management and Restoration* 4: 29–38.

Pickup, G., Bastin, G.N., and Chewings, V.H. (1994). Remote sensing-based condition assessment for non-equilibrium rangelands under large-scale commercial grazing. *Ecological Applications* 4, 497–517.

Post, D.A., Bartley, R., Corfield, J., Nelson, B., Kinsey-Henderson, A., Hawdon, A., Gordon, I., Abbott, B., Berthelsen, S., Hodgen, M., Keen, R., Kemei, J., Vleeshouwer, J., MacLeod, N., and Webb, M. (2006). Sustainable grazing for a healthy Burdekin catchment: final report. Meat and Livestock Australia (MLA), Sydney.

Pringle, H.J.R., and Landsberg, J. (2004). Predicting the distribution of livestock grazing pressure in rangelands. *Austral Ecology* 29, 31–39.

Radford, J.Q., Bennett, A.F., and Cheers, G.J. (2005). Landscape-level thresholds of habitat cover for woodland-dependent birds. *Biological Conservation* 124, 317–337.

Seabrook, L., McAlpine, C., Fensham, R. (2006). Cattle, crops and clearing: Regional drivers of landscape change in the Brigalow Belt, Queensland, Australia, 1840-2004. *Landscape and Urban Planning* 78, 373-385

Society of American Foresters (1944). Forestry terminology, a glossary of technical terms used in forestry. Committee of Forestry Terminology, Society of American Foresters, Washington.

Smyth, A.K. (1997). *Mammals, Birds, Reptiles and Frogs of the Brigalow Belt Bioregion of Queensland. The Past, Present and Future*. Centre for Conservation Biology, University of Queensland, St Lucia.

Smyth, A.K., and James, C.D. (2004). Characteristics of Australia's rangelands and key design issues for monitoring biodiversity. *Austral Ecology* 29, 3–15.

Thackway, R. and Lesslie, R. (2006). Reporting vegetation condition using the Vegetation Assets, States and Transitions (VAST) *framework. Ecological Management and Restoration* 7, S53–S62.

Tischendorf, L., and Fahrig, L. (2000). How should we measure landscape connectivity? *Landscape Ecology* 15, 633–641.

Tongway, D. (2003). *Reading the landscape: a training course in monitoring rangelands by landscape function analysis.* CSIRO, Sustainable Ecosystems, Canberra.

Tongway, D.J and Hindley, N. L. (2004). Landscape Function Analysis: procedures for monitoring and assessing landscapes. CSIRO Sustainable Ecosystems, Brisbane.

Tongway, David J., and Hindley, N.L. (1995). Manual for Soil Condition Assessment of Tropical Grasslands . 60 p. Canberra: CSIRO Division of Wildlife and Ecology.

Walsh, C., Mac Nally, R., 2007. Hierarchical Partitioning: The Hier. Part Package, version 1.0-2. R Foundation for Statistical Computing.

Westoby, M., Walker, B., and Noy-Meir, I. (1989). Opportunistic management for rangelands not at equilibrium. *Journal of Range Management 42*, 266–274.

Whitehead, P. J., Woinarski, J., Jacklyn, P., fell, D. and Williams, D. (2000). *Defining and measuring the health of svanna landscapes: A north Australian perspective*. Tropical Savannas CRC Discussion Paper.

Wilson, B.A. (1999). Mulga Lands. In, The Conservation Status of Queensland's Bioregional Ecosystems. Sattler, P., and Williams, R., (Eds). Environmental Protection Agency, Brisbane.

With, K.A. (2004). Metapopulation dynamics: perspectives from landscape ecology. In: Hanski, I. And Gaggiotti, O. (Eds.), *Ecology, Genetics and Evolution of Metapopulations*. Elsevier, San Diego, pp.23–44.

Whish G (ed.) (2010). Land types of Queensland. Version 1.3. Prepared by the Grazing Land Management Workshop Team, Department of Employment, Economic Development and Innovation, Brisbane. PR07-3212.

Woinarski, J.C.Z., and Ash, A.J., 2002. Responses of vertebrates to pastoralism, military land use and landscape position in an Australian tropical savanna. *Austral Ecology* 27, 311–323.

Woinarski, J.C.Z., and Fisher, A. (2003). Conservation and the maintenance of biodiversity in the rangelands. *Journal of Rangeland Management* 46, 556–590.

Woinarski, J.C.Z., McCosker, J.C., Gordon, G. *et al.* (2006). Monitoring change in the vertebrate fauna of central Queensland, Australia, over a period of broad-scale vegetation clearance, 1973 – 2002. *Wildlife Ecology* 33, 263–274.

Woldendorp, G. Spencer, R.D., Keenan, R.J. and Barry, S. (2002). An analysis of sampling methods for coarse woody debris in Australian forest ecosystems. A report for the National Greenhouse strategy, Module 6.6 (Criteria and indicators of sustainable forest management). Bureau of Rural Sciences, Canberra.

Yates,C. J., Norton, D. A. and Hobbs, R. J. (2000). Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. *Austral Ecology* 25, 36–47.

Young, P.A.R, Wilson, B.A., McCosker, J.C., Fensham, R.J., Morgan, G., and Taylor, P.M. (1999). Brigalow Belt. In, *The Conservation Status of Queensland's Bioregional Ecosystems*. Sattler, P., and Williams, R., (Eds). Environmental Protection Agency, Brisbane.

Zaady, E. and Bouskila, A. (2002). Lizard burrows association with successional stages of biological soil crusts in an arid sandy region. *Journal of Arid Environments* 50, 235–246.

Appendix 1 Regional ecosystems sampled

All Bioregion 6 regional ecosystems collectively sampled ‘soft mulga’ land types.

RE	Description	Protected areas	Comments
6.5.7	*Acacia aneura, Eucalyptus populnea* ± *E. intertexta* low woodland on run-on areas	Culgoa Floodplain NP	Occurs in two main areas; most extensively in areas east of the Warrego River around the Nebine Creek and also in areas around Adavale. Highly modified structural and floristic composition. Regional ecosystem 6.5.7 has larger number of *E. populnea* trees (<100 ha) than 6.5.6 (scattered emergent).
6.5.9	*Acacia aneura*, *Eucalyptus populnea* ± *E.melanophloia* shrubby low woodland on Quaternary sediments	No representation	Confined to the north east part of the region where it often occurs in close proximity with Brigalow Belt regional ecosystems such as Acacia harpophylla woodland (11.9.11). Extensive areas of this regional ecosystem have been cleared and converted to exotic pasture. Emergent eucalypts may form open-woodland (100 trees / ha).
6.5.14	*Acacia aneura* ± *Eucalyptus populnea* ± *Eremophila gilesii* tall open shrubland on Quaternary sediments	Hell Hole Gorge NP, Mariala NP	The groving in this regional ecosystem is often diffuse, as the soils are fairly consistent throughout. Run on areas within this regional ecosystem may support *E. populnea* woodland (6.5.3).
6.5.18	*Acacia aneura* ± *Eucalyptus populnea* ± *E. melanophloia* ± *Eremophila mitchellii* low open woodland on plains	Mariala NP	Northern areas subject to clearing and associated introduction of exotic pastures. This regional ecosystem was described in Sattler and Williams (1999) under 6.4.5 but has now been allocated to land zone 5 following re-assessment.
6.5.1	*Acacia aneura*, *Eucalyptus populnea, E. melanophloia* open forest on undulating lowlands	Chesterton Range NP, Thrushton NP, Tregole NP	Extensively cleared. Remaining extent has highly modified structural and floristic composition. The vegetation structure of this regional ecosystem may overlap 6.5.2, which is generally Eucalyptus dominated and has no gravel in the soil. This regional ecosystem is dominated by A. aneura woodland (10-14 m) while 6.5.13 is dominated by an A. aneura low woodland (8-10m), occurs on shallower soils.

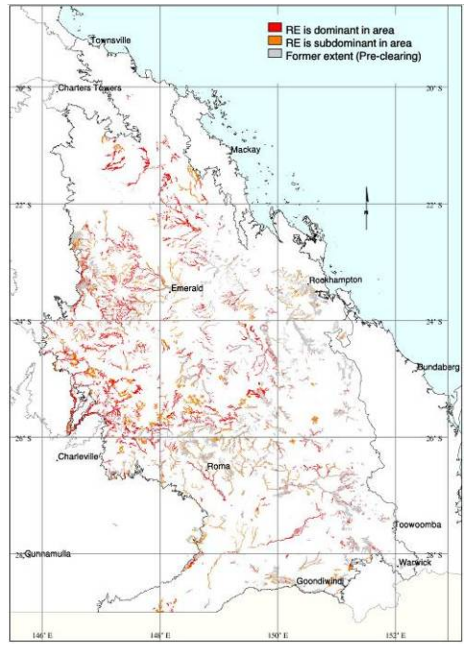
6.5.10	*Acacia aneura* ± *Eucalyptus populnea* ± *Grevillea striata, A. excelsa, Hakea ivoryi* low woodland on sand plains	No representation.	East of the Warrego River floodplain, from Charleville to south of Cunnamulla. Some areas severely degraded, showing highly modified ground layer species composition associated with topsoil loss. A dense Acacia aneura low tree layer develops in areas that have been previously cleared, thinned or severely disturbed by grazing.
6.5.11	*Acacia aneura* ± *Eucalyptus populnea* low woodland on sand plains	No representation.	East of the Warrego River.
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Alton NP, Blackdown Tableland NP, Carnarvon NP, Chesterton Range NP, Dawson River CP, Dipperu NP (Scientific Reserve), Expedition NP, Expedition RR, Homevale NP, Homevale RR, Isla Gorge NP, Lake Murphy CP, Narrien Range NP, Nuga Nuga NP, Taunton NP (Scientific Reserve).	Extensively cleared or modified by grazing. There are unmapped patches of low Acacia harpophylla (11.3.1) or grassland (11.3.21) associated with this regional ecosystem in some areas.
11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	Carnarvon NP, Carraba CP, Chesterton Range NP, Expedition NP, Homevale NP, Homevale RR, Irongate CP, Isla Gorge NP, Lake Murphy CP, Roundstone CP, Taunton NP (Scientific Reserve), Tregole NP	Extensively cleared for cropping and pasture.

Appendix 2: Benchmark documents

Brigalow Belt Bioregion

Regional Ecosystem: 11.3.2

Photo: Teresa Eyre



Vegetation Management Act class (Nov 2009):	Of concern
Biodiversity status:	Of concern
Subregion:	26, 31, 24, 11, 21, (8), (32), (27), (13), (20), (7), (6), (15), (25), (16), (36), (18), (35), (9), (22), (14), (19)
Estimated extent:	In December 2006, remnant extent was > 10,000 ha and 10-30% of the pre-clearing area remained
Extent in reserves:	Low
Wetland:	Contains palustrine wetland (e.g. in swales).

Short Description: *Eucalyptus populnea* woodland on alluvial plains

Regional Ecosystem Description: *Eucalyptus populnea* woodland to open-woodland. *E. melanophloia* may be present and locally dominant. There is sometimes a distinct low tree layer dominated by species such as *Geijera parviflora, Eremophila mitchellii, Acacia salicina, Acacia pendula, Lysiphyllum* spp., *Cassia brewsteri, Callitris glaucophylla* and *Acacia excelsa.* The ground layer is grassy dominated by a range of species depending on soil and management conditions. Species include *Bothriochloa decipiens, Enteropogon acicularis, Aristida ramosa* and *Tripogon loliiformis*. Occurs on Cainozoic alluvial plains with variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays.

Habitat: There are unmapped patches of low *Acacia harpophylla* (11.3.1) or grassland (11.3.21) associated with this regional ecosystem in some areas. This regional ecosystem may include small areas dominated by *Acacia pendula* (Neldner 1984, Association 41).

Protected Areas: Carnarvon NP, Expedition (Limited Depth) NP, Dipperu NP(S), Homevale RR, Chesterton Range NP, Homevale NP, Expedition RR, Taunton NP(S), Nuga Nuga NP, Isla Gorge NP, Blackdown Tableland NP, Alton NP, Dawson River CP, Narrien Range NP, Bouldercombe Gorge RR, Epping Forest NP(S), Lake Murphy CP, Carraba CP, Lake Broadwater CP, [Highworth Bend CP], [Lake Broadwater RR]

Values: Habitat for rare and threatened flora species including *Homopholis belsonii.*

Condition: Extensively cleared or modified by grazing.

1. Native plant species richness:

Tree	2
Shrub	2
Grass	9
Forbs	14
Other species	3

2. Trees:

Tree height range (m)		
Median canopy height (m):	18	
Canopy cover (%):	40	
Density (stems per hectare):		
Basal area per hectare (m^2):		
Large tree* dbh threshold (cm):	40	(Eucalypts etc.)
		(non-Eucalypts)
Number of large trees* per hectare:	22	(Eucalypts etc.)
		(non-Eucalypts)

Typical species:

poplar box	*Eucalyptus populnea*
silver-leaved ironbark	*Eucalyptus melanophloia*

3. Shrubs:

Median canopy height (m):	
Canopy cover (%):	2
Density (stems per hectare):	

Typical species:

wilga	*Geijera parviflora*
false sandalwood	*Eremophila mitchelii*

4. Ground cover:

Median canopy height (m):	
Total ground cover (%):	44
Native perennial grass cover (%):	35
Native perennial forbs and other species cover (%):	9
Native annual grass, forb and other species cover (%):	0

Typical species:

Purple lovegrass	*Eragrostis lacunaria*
Slender Chloris	*Chloris divaricata*
Lovegrass	*Eragrostis alveiformis*
Kangaroo Grass	*Themeda triandra*
Tall Windmill Grass	*Chloris ventricosa*
Hairy Panic	*Panicum effusum*
Purple Wiregrass	*Aristida personata*

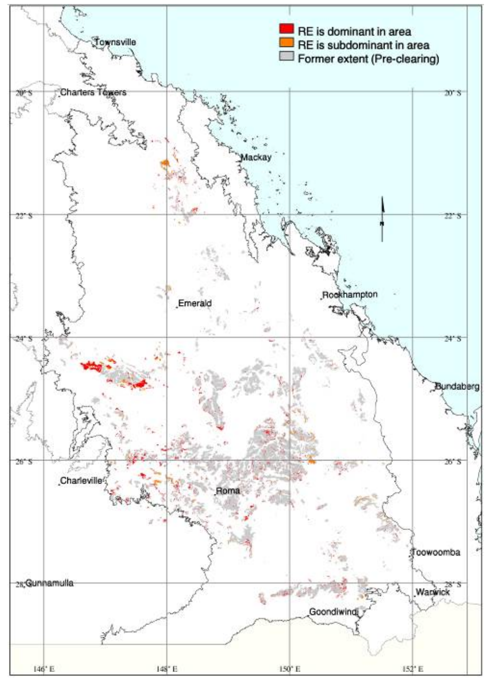
5. Fallen woody material:

Total length (m) of logs ≥ 10cm diameter per hectare:	307	or
Number of logs ≥ 10cm diameter per hectare:	160	

6. Organic litter cover (%): 30

*Eyre *et al*. (2006) Methodology for the establishment and survey of reference sites for BioCondition

Photo: Don Butler



Vegetation Management Act class (Nov 2009):	Endangered
Biodiversity status:	Endangered
Subregion:	26, 25, 21, 20, 27, 15, (33), (32), (6), (11), (31), (29), (28), (19), (24)
Estimated extent:	In December 2006, <10% of the pre-clearing area remained.
Extent in reserves:	Low

Short Description: *Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks.

Regional Ecosystem Description: Open-forest dominated by *Acacia harpophylla* and/or *Casuarina cristata* (10-20m). Open-forest dominated by *C. cristata* is more common in southern parts of the bioregion. A prominent low tree or tall shrub layer dominated by species such as *Geijera parviflora* and *Eremophila mitchellii*, and often with semi-evergreen vine thicket species is often present. The latter include *Flindersia dissosperma, Brachychiton rupestris, Excoecaria dallachyana, Macropteranthes leichhardtii* and *Acalypha eremorum* in eastern areas, and species such as *Carissa ovata, Owenia acidula, Croton insularis, Denhamia oleaster* and *Notelaea microcarpa* in south-western areas. *Melaleuca bracteata* may be present along watercourses. Occurs on fine-grained sediments. The topography includes gently undulating plains, valley floors and undulating foot slopes and rarely on low hills. The soils are generally deep texture-contrast and cracking clays. The cracking clays are usually black or grey to brown or reddish-brown in colour, often self mulching and sometimes gilgaied in flatter areas. Some texture contrast soils are shallow to only moderately deep.

Protected Areas: Carnarvon NP, Palmgrove NP(S), Expedition (Limited Depth) NP, Chesterton Range NP, Isla Gorge NP, Precipice NP, Roundstone CP, Homevale NP, Lake Murphy CP, Nuga Nuga NP, Carraba CP, Taunton NP(S), Irongate CP, Homevale RR, Bunya Mountains NP

Values: Habitat for rare and threatened flora species including *Jalmenus eubulus*, pale imperial hairstreak butterfly (Eastwood et al. 2008)

Condition: Extensively cleared for cropping and pasture.

1. Native plant species richness:

Tree	4
Shrub	5
Grass	5
Forbs	7
Other species	3

2. Trees:

Tree height range (m)		
Median canopy height (m):	16-25 (gradient from west to east of bioregion)	
Canopy cover (%):	60	
Density (stems per hectare):		
Basal area per hectare (m^2):		
Large tree* dbh threshold (cm):		(Eucalypts etc.)
	30	(non-Eucalypts)
Number of large trees* per hectare:		(Eucalypts etc.)
	22	(non-Eucalypts)

Typical species:

brigalow	*Acacia harpophylla*
belah	*Casuarina cristata*

3. Shrubs:

Median canopy height (m):	
Canopy cover (%):	21
Density (stems per hectare):	

Typical species:

wilga	*Geijera parviflora*
python tree	*Austromyrtus bidwillii*
false sandalwood	*Eremophila mitchellii*
ellangowan poison bush	*Eremophila deserti*

4. Ground cover:

Median canopy height (m):	
Total ground cover (%):	35
Native perennial grass cover (%):	30
Native perennial forbs and other species cover (%):	5
Native annual grass, forb and other species cover (%):	0

Typical species:

Brigalow grass	*Paspalidium caespitosum*

5. Fallen woody material:

Total length (m) of logs ≥ 10cm diameter per hectare:	688	or
Number of logs ≥ 10cm diameter per hectare:	520	

6. Organic litter cover (%): 50

*Eyre *et al*. (2006) Methodology for the establishment and survey of reference sites for BioCondition

Photo: Teresa Eyre

Regional Ecosystems: 6.5.1, 6.5.7, 6.5.9, 6.5.10, 6.5.14, 6.5.18

Landform:* Flat to gently undulating plains (slopes <1%).

Woody vegetation:* Mulga low open woodlands to tall woodlands; often associated with poplar box, ironwood, bloodwood and sandalwood east of the Grey Range, and with western bloodwood and beefwood to the west. Patches with a spinifex understorey are found throughout on very acidic soils.

* sourced from DPI (Mulga land zone sheets)

Benchmarks soft mulga

1. Native plant species richness:

- Tree 2
- Shrub 1
- Grass 13
- Forbs 10
- Other species 2

2. Trees:

- Tree height range (m)
- Median canopy height (m): 13
- Canopy cover (%): 52
- Density (stems per hectare):
- Basal area per hectare (m^2):
- Large tree* dbh threshold (cm): 40 (Eucalypts etc.)
  30 (non-Eucalypts)
- Number of large trees* per hectare: 60 (Eucalypts etc.)
  80 (non-Eucalypts)

Typical species:

Mulga	*Acacia aneura*
Sandlebox	*Eremophila mitchellii*
Poplar box	*Eucalyptus populnea*

3. Shrubs:

- Median canopy height (m):
- Canopy cover (%): 1
- Density (stems per hectare):

Typical species:

Charleville turkey bush	*Eremophila gilesii*
silver turkey bush	*Eremophila bowmanii*
silver cassia	*Senna artemisioides*

4. Ground cover:

- Median canopy height (m):
- Total ground cover (%): 26.6
- Native perennial grass cover (%): 18
- Native perennial forbs and other species cover (%): 7.8
- Native annual grass, forb and other species cover (%): 0.8

Typical species:

mulga Mitchell grass	*Thyridolepis mitchelliana*
Jericho wiregrass	*Aristida jerichoensis*
mulga oats	*Monachather paradoxus*
woollybutt	*Eragrostis eriopoda*
long grey-beard grass	*Amphipogon caricinus* var. *caricinus*

5. Fallen woody material:

- Total length (m) of logs ≥ 10cm diameter per hectare: 116

  or
- Number of logs ≥ 10cm diameter per hectare: 220

6. Organic litter cover (%): 33

*Eyre *et al*. (2006) Methodology for the establishment and survey of reference sites for BioCondition

Appendix 3: Fauna species by land type

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental#
Frogs (*Amphibia*)						
Crinia deserticola	chirping froglet, desert froglet	LC				20
Limnodynastes fletcheri	barking frog, long thumbed frog	LC	3	4	5	4
Limnodynastes salmini	salmon striped frog	LC	2	8		
Limnodynastes tasmaniensis	spotted marshfrog, spotted grassfrog	LC	33	88		35
Limnodynastes terraereginae	scarlet sided pobblebonk, northern banjo frog	LC	3	1		8
Neobatrachus sudelli	eastern metal-eyed frog, meeowing frog	LC			13	7
Notaden bennettii	holy cross frog, crucifix toad	LC			15	5
Opisthodon ornatus	ornate burrowing frog	LC	13	42		54
Uperoleia laevigata	eastern gungan, smooth toadlet	LC		13		
Uperoleia rugosa	chubby gungan, wrinkled toadlet	LC		200	2	18
Cyclorana alboguttata	striped burrowing frog, greenstripe frog	LC				3
Cyclorana brevipes	superb collared frog, short footed frog	LC			1	
Cyclorana cultripes	grassland collared frog, desert collared frog	LC			4	4
Cyclorana novaehollandiae	eastern snapping frog, New Holland frog	LC	1	1	3	72
Litoria caerulea	common green treefrog, green treefrog	LC	36	60	1	24
Litoria latopalmata	broad-palmed rocketfrog	LC		26	5	232
Litoria peronii	emerald spotted treefrog, Peron's treefrog	LC	8	9		35
Litoria rubella	naked treefrog, desert treefrog	LC	3	10	25	52
Rhinella (formerly *Bufo*)*marinus*	cane toad	I	12	45		30
Reptiles (*Reptilia*)						
Chelodina longicollis	eastern long-necked turtle	LC				18
Wollumbinia latisternum	saw-shelled turtle	LC				1
Diplodactylus conspicillatus	fat-tailed gecko	LC			26	9
Diplodactylus tessellatus	tessellated gecko	LC	14	3		4
Diplodactylus vittatus	wood gecko, eastern stone gecko	LC	19	3	11	1
Gehyra catenata	chain-backed tree dtella (gecko)	LC	147	11		9
Gehyra dubia	common dtella, house dtella (gecko)	LC	145	73	1	26
Gehyra variegata	tree dtella (gecko)	LC	33	9	689	158
Heteronotia binoei	Bynoe's gecko	LC	216	105	238	63
Lucasium steindachneri	box-patterned gecko	LC	21	33	138	32

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental[#]
Oedura marmorata	marbled velvet gecko	LC			68	25
Oedura monilis	ocellated velvet gecko	LC	161	11		10
Oedura robusta	robust velvet gecko	LC		8		
Rhynchoedura ornata	beaked gecko	LC	2	6	191	53
Strophurus krisalys	spiny-tailed gecko	LC			3	
Strophurus taenicauda	golden-tailed gecko	NT	7			
Strophurus williamsi	eastern spiny-tailed gecko, soft-spined gecko	LC	27	9	17	8
Underwoodisaurus milii	thick-tailed gecko, barking gecko	LC	3			8
Delma plebeia	leaden delma (legless lizard)	LC	1	2		
Delma tincta	northern delma, excitable delma (legless lizard)	LC	1			
Delma sp.	unidentified legless lizard	-		1		
Lialis burtonis	Burton's legless lizard	LC	1	3	4	4
Paradelma orientalis	brigalow scaly-foot	V	11			1
Pygopus schraderi	eastern hooded scaly-foot	LC	4	1	4	1
Anomalopus leuckartii	two-clawed worm-skink	LC		1		
Anomalopus verreauxii	Verraux's worm-skink, three-clawed worm-skink	LC	1	1		
Carlia foliorum	Burnett's skink	LC	22	21		3
Carlia pectoralis	open-litter rainbow skink	LC	226	34		22
Carlia vivax	lively rainbow skink, tussock rainbow skink	LC		24		1
Cryptoblepharus australis		LC			12	3
Cryptoblepharus pannosus	Ragged snake-eyed skink	LC	94	93	223	35
Cryptoblepharus pulcher pulcher		LC	39	71		4
Ctenotus allotropis	brown-blazed wedgesnout ctenotus (striped skink)	LC	10		12	10
Ctenotus allotropis/strauchii	a striped skink	LC			91	30
Ctenotus brachyonyx	short-clawed ctenotus (striped skink)	LC			1	
Ctenotus hebetior	stout ctenotus (striped skink)	LC			21	41
Ctenotus ingrami	Ingram's striped skink, unspotted yellow-sided ctenotus	LC	58	7	22	5
Ctenotus leonhardii	Leonhardi's ctenotus (striped skink)	LC			3	11
Ctenotus pantherinus	leopard ctenotus (skink)	LC			2	10
Ctenotus robustus	eastern striped skink, robust striped skink	LC	35	90	19	22
Ctenotus schomburgkii	barred wedge-snout ctenotus (striped skink)	LC				2
Ctenotus strauchii	short-legged ctenotus (striped skink)	LC			4	
Ctenotus taeniolatus	copper-tailed skink	LC	5	2		4
Ctenotus sp.	unidentified striped skink species	-			18	11

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental#
Liopholis modesta	eastern ranges rock-skink	LC		20		
Egernia rugosa	yakka skink	V	3	22	11	6
Egernia striolata	tree skink	LC	123	36	53	13
Eremiascincus fasciolatus	narrow-banded sand swimmer	LC			14	6
Eremiascincus richardsonii	broad-banded sand swimmer	LC	3	32	23	8
Lerista fragilis	eastern mulch-slider (burrowing skink)	LC	11	21		11
Lerista muelleri	wood mulch-slider (burrowing skink)	LC	24	33	406	93
Lerista punctatovittata	speckled short-limbed slider (burrowing skink)	LC	34	6	10	5
Menetia greyii	grey dwarf skink	LC	11	35	31	6
Menetia timlowi	Low's litter skink, forest dwarf skink	LC	3	1		
Morethia boulengeri	Boulenger's skink	LC	165	186	142	33
Tiliqua rugosa	shingle-back, bobtail, stumpy-tail	LC	2		4	6
Tiliqua scincoides	eastern blue-tongued lizard	LC	1	4	1	6
Amphibolurus burnsi	Burns' dragon	LC	87	6	4	12
Amphibolurus nobbi	nobbi dragon	LC	14		2	
Pogona barbata	common bearded dragon	LC	25	36	4	12
Pogona vitticeps	central bearded dragon	LC			20	13
Varanus gouldii	sand monitor, sand goanna	LC	3	5	4	7
Varanus panoptes	yellow-spotted monitor, sand goanna	LC	4	8	1	3
Varanus tristis	black-headed monitor, freckled monitor, black-tailed monitor	LC	4	4	7	1
Varanus varius	lace monitor	LC	7	3		12
Varanus sp.	unidentified monitor species, goanna	-	8	2	2	4
Ramphotyphlops sp.	unidentified blind snake	-			1	1
Antaresia maculosus	spotted python	LC				2
Antaresia stimsoni	Stimson's python	LC				2
Aspidites melanocephalus	black-headed python	LC				2
Aspidites ramsayi	woma, bilby snake	NT				4
Morelia spilota	carpet python, diamond python	LC	1			2
Tropidonophis mairii	freshwater snake, keelback	LC				1
Brachyurophis australis	Australian coral snake	LC	2	1	3	1
Brachyurophis incinctus	unbanded shovel-nosed snake	LC			1	
Cryptophis boschmai	Carpentaria whip snake	LC	1	1		1
Cryptophis nigrescens	eastern small-eyed snake	LC	1			4
Demansia psammophis	yellow-faced whip snake	LC	5	12		5
Denisonia devisi	De Vis' banded snake, mud adder	LC				1
Furina barnardi	yellow-naped snake	NT				1
Furina diadema	red-naped snake	LC	2	3	1	

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental#
Hoplocephalus bitorquatus	pale-headed snake	LC	1	3		
Parasuta dwyeri	Dwyer's snake	LC	4	7	5	5
Pseudechis australis	mulga snake, king brown snake	LC	2	3	4	3
Pseudonaja modesta	ringed brown snake	LC			2	
Pseudonaja nuchalis	western brown snake, gwardar	LC		1	2	3
Pseudonaja textilis	eastern brown snake, common brown snake	LC	12	4		3
Pseudonaja sp.	unidentified "brown" snake	LC		1		
Suta suta	myall snake, curl snake	LC	4	6	11	5
Vermicella annulata	bandy-bandy	LC	2		1	1
Birds (*Aves*)						
Dromaius novaehollandiae	emu	LC	21	67	92	70
Coturnix pectoralis	stubble quail	LC		1		1
Coturnix ypsilophora	brown quail	LC	24	26		28
Pavo cristatus	Indian peafowl	I		1		4
Dendrocygna eytoni	plumed whistling-duck	LC				54
Stictonetta naevosa	freckled duck	NT				18
Cygnus atratus	black swan	LC				10
Chenonetta jubata	Australian wood duck	LC				81
Anas superciliosa	Pacific black duck	LC	2			48
Anas rhynchotis	Australasian shoveler	LC				9
Anas gracilis	grey teal	LC				100
Malacorhynchus membranaceus	pink-eared duck	LC				41
Aythya australis	hardhead	LC				78
Tachybaptus novaehollandiae	Australasian grebe	LC				118
Poliocephalus poliocephalus	hoary-headed grebe	LC				3
Anhinga novaehollandiae	Australasian darter	LC				24
Phalacrocorax melanoleucos	little pied cormorant	LC				4
Phalacrocorax sulcirostris	little black cormorant	LC				40
Pelecanus conspicillatus	Australian pelican	LC				9
Egretta novaehollandiae	white-faced heron	LC		7		5
Egretta garzetta	little egret	LC				2
Ardea pacifica	white-necked heron	LC	1	2		27
Ardea modesta	Eastern great egret	LC				23
Ardea intermedia	intermediate egret	LC				3
Nycticorax caledonicus	nankeen night heron	LC		1		6
Threskiornis molucca	Australian white ibis	LC				1
Threskiornis spinicollis	straw-necked ibis	LC				493
Platalea regia	royal spoonbill	LC				1
Platalea flavipes	yellow-billed spoonbill	LC		1		13
Aviceda subcristata	Pacific baza	LC				2
Elanus axillaris	black-shouldered kite	LC	15	12		7
Lophoictinia isura	square-tailed kite	NT				3
Milvus migrans	black kite	LC		4	1	21

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental[#]
Haliastur sphenurus	whistling kite	LC			2	14
Haliaeetus leucogaster	white-bellied sea-eagle	LC				1
Circus assimilis	spotted harrier	LC			1	11
Circus approximans	swamp harrier	LC	1	3		1
Accipiter fasciatus	brown goshawk	LC	3	3	4	13
Accipiter cirrhocephalus	collared sparrowhawk	LC			1	2
Aquila audax	wedge-tailed eagle	LC	35	50	25	36
Hieraaetus morphnoides	little eagle	LC				2
Falco berigora	brown falcon	LC	11	13	26	30
Falco longipennis	Australian hobby	LC	3	4	2	5
Falco subniger	black falcon	LC				1
Falco peregrinus	peregrine falcon	LC			1	2
Falco cenchroides	nankeen kestrel	LC	21	24	17	34
Grus rubicunda	brolga	LC				13
Porphyrio porphyrio	purple swamphen	LC				7
Tribonyx tenebrosa	dusky moorhen	LC				7
Tribonyx ventralis	black-tailed native-hen	LC				9
Fulica atra	Eurasian coot	LC				31
Ardeotis australis	Australian bustard	LC	12	22	4	26
Turnix velox	little button-quail	LC	27	14	46	45
Turnix pyrrhothorax	red-chested button-quail	LC	8	1	1	1
Turnix varius	painted button-quail	D	25	16		9
Turnix sp.	unidentified button-quail	-	3			
Gallinago hardwickii	Latham's snipe	LC				2
Tringa stagnatilis	marsh sandpiper	LC				2
Tringa nebularia	common greenshank	LC				9
Burhinus grallarius	bush stone-curlew	LC	1	2		13
Himantopus himantopus	black-winged stilt	LC				15
Recurvirostra novaehollandiae	red-necked avocet	LC				3
Elseyornis melanops	black-fronted dotterel	LC				20
Erythrogonys cinctus	red-kneed dotterel	LC				4
Vanellus tricolor	banded lapwing	LC	9	5	4	42
Vanellus miles novaehollandiae	masked lapwing (southern subspecies)	LC		9		32
Chlidonias hybridus	whiskered tern	LC			1	43
Phaps chalcoptera	common bronzewing	LC	11	26	49	92
Phaps histrionica	flock bronzewing	LC				70
Ocyphaps lophotes	crested pigeon	LC	144	103	125	203
Geophaps scripta scripta	squatter pigeon (southern subspecies)	V	21	36		157
Geopelia cuneata	diamond dove	LC		2	293	218
Geopelia striata	peaceful dove	LC	30	4	16	59
Geopelia humeralis	bar-shouldered dove	LC	87	3		44
Calyptorhynchus banksii	red-tailed black-cockatoo	LC	5			6
Calyptorhynchus funereus	yellow-tailed black-cockatoo	LC	7	4		11
Eolophus roseicapillus	galah	LC	103	358	342	231
Cacatua sanguinea	little corella	LC			2	66
Lophochroa leadbeateri	Major Mitchell's cockatoo	LC			58	53

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental#
Cacatua galerita	sulphur-crested cockatoo	LC	7	46	1	51
Nymphicus hollandicus	cockatiel	LC	68	129	387	356
Trichoglossus haematodus	rainbow lorikeet	LC	36	28		12
Trichoglossus chlorolepidotus	scaly-breasted lorikeet	LC	6	12		22
Alisterus scapularis	Australian king-parrot	LC	15	16		7
Aprosmictus erythropterus	red-winged parrot	LC	45	65	60	49
Platycercus adscitus	pale-headed rosella	LC	82	202		81
Barnardius zonarius barnardi	Australian ringneck (mallee form)	LC	13	48	152	105
Northiella haematogaster	blue bonnet	LC	10	38	2	36
Psephotus haematonotus	red-rumped parrot	LC		3		
Psephotus varius	mulga parrot	LC			15	36
Melopsittacus undulatus	budgerigar	LC	47	40	2045	1877
Cacomantis pallidus	pallid cuckoo	LC	30	8	10	10
Cacomantis variolosus	brush cuckoo	LC	1			
Chalcites osculans	black-eared cuckoo	LC	7		3	4
Chalcites basalis	Horsfield's bronze-cuckoo	LC	20	1	15	16
Chalcites lucidus	shining bronze-cuckoo	LC	25	2		5
Chalcites minutillus	little bronze-cuckoo	LC		1		
Eudynamys orientalis	Eastern koel	LC				2
Scythrops novaehollandiae	channel-billed cuckoo	LC	10	17	1	16
Centropus phasianinus	pheasant coucal	LC	21	28		11
Ninox connivens	barking owl	LC				7
Ninox novaeseelandiae	southern boobook	LC	4	10	51	30
Tyto novaehollandiae	masked owl	LC				1
Tyto javanica	Eastern barn owl	LC	11	10	2	20
Tyto longimembris	eastern grass owl	LC	2			
Podargus strigoides	tawny frogmouth	LC	18	15	9	31
Eurostopodus mystacalis	white-throated nightjar	LC	3	4		3
Eurostopodus argus	spotted nightjar	LC	1	1	7	9
Aegotheles cristatus	Australian owlet-nightjar	LC	71	107	49	51
Hirundapus caudacutus	white-throated needletail	LC	7			2
Apus pacificus	fork-tailed swift	LC	2			
Dacelo novaeguineae	laughing kookaburra	LC	48	92	19	56
Todiramphus macleayii	forest kingfisher	LC	1			1
Todiramphus pyrrhopygia	red-backed kingfisher	LC	1	1	75	24
Todiramphus sanctus	sacred kingfisher	LC	2		55	30
Merops ornatus	rainbow bee-eater	LC	37	35	144	103
Eurystomus orientalis	dollarbird	LC	1	7		10
Cormobates leucophaeus	white-throated treecreeper	LC	39			
Climacteris affinis	white-browed treecreeper	D			325	64
Climacteris picumnus	brown treecreeper	D	3		218	59
Malurus cyaneus	superb fairy-wren	LC	185	67		13
Malurus splendens melanotis	splendid fairy-wren (black-backed subspecies)	LC			60	52
Malurus lamberti	variegated fairy-wren	LC	63		20	23
Malurus leucopterus	white-winged fairy-wren	LC	9	29		3
Malurus melanocephalus	red-backed fairy-wren	LC	3	1		

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental[#]
Malurus sp.	unidentified fairy-wren	-		4		
Pardalotus rubricatus	red-browed pardalote	LC	3	1	9	7
Pardalotus striatus	striated pardalote	LC	110	200	272	155
Sericornis frontalis	white-browed scrubwren	LC	1			5
Chthonicola sagittata	speckled warbler	D	101	1	1	10
Smicrornis brevirostris	weebill	LC	364	245	465	183
Gerygone fusca	western gerygone	LC	9		113	24
Gerygone olivacea	white-throated gerygone	LC		5		7
Acanthiza apicalis	inland thornbill	LC	177	2	133	61
Acanthiza uropygialis	chestnut-rumped thornbill	D	43	2	899	235
Acanthiza robustirostris	slaty-backed thornbill	LC			2	
Acanthiza reguloides	buff-rumped thornbill	LC	3			11
Acanthiza chrysorrhoa	yellow-rumped thornbill	LC	145	31	382	119
Acanthiza nana	yellow thornbill	LC	170		246	53
Aphelocephala leucopsis	southern whiteface	D			13	2
Acanthagenys rufogularis	spiny-cheeked honeyeater	LC	110	10	226	163
Plectorhyncha lanceolata	striped honeyeater	LC	292	125	364	120
Philemon corniculatus	noisy friarbird	LC	79	32	87	96
Philemon citreogularis	little friarbird	LC	48	44	178	91
Entomyzon cyanotis	blue-faced honeyeater	LC	30	102	2	29
Manorina melanocephala	noisy miner	LC	911	2793		339
Manorina flavigula	yellow-throated miner	LC			489	188
Meliphaga lewinii	Lewin's honeyeater	LC	20			5
Lichenostomus chrysops	yellow-faced honeyeater	LC	122			12
Lichenostomus virescens	singing honeyeater	LC	34		19	24
Lichenostomus leucotis	white-eared honeyeater	LC	30	5		17
Lichenostomus penicillatus	white-plumed honeyeater	LC			235	154
Melithreptus gularis	black-chinned honeyeater	NT			1	
Melithreptus brevirostris	brown-headed honeyeater	LC	2	3		
Melithreptus albogularis	white-throated honeyeater	LC				12
Lichmera indistincta	brown honeyeater	LC	116	1	16	8
Grantiella picta	painted honeyeater	V	4		3	1
Sugomel niger	black honeyeater	LC	5		30	7
Epthianura tricolor	crimson chat	LC		66	273	84
Microeca fascinans	jacky winter	D	61	29	260	64
Petroica goodenovii	red-capped robin	D	41	1	325	71
Petroica rosea	rose robin	LC	1			
Melanodryas cucullata	hooded robin	D	4		116	48
Eopsaltria australis	eastern yellow robin	D	89	1		5
Pomatostomus temporalis	grey-crowned babbler	D	147	153	250	208
Pomatostomus superciliosus	white-browed babbler	D	27			
Pomatostomus halli	Hall's babbler	LC			57	36
Psophodes cristatus	chirruping wedgebill	LC				1
Cinclosoma castaneothorax	chestnut-breasted quail-thrush	LC			10	8
Daphoenositta chrysoptera	varied sittella	D	97		144	44
Oreoica gutturalis	crested bellbird	D	16		246	103
Pachycephala pectoralis	golden whistler	LC	14			1

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental[#]
Pachycephala rufiventris	rufous whistler	D	310	13	570	143
Colluricincla harmonica	grey shrike-thrush	LC	146	9	154	45
Myiagra rubecula	leaden flycatcher	LC	48	1		9
Myiagra inquieta	restless flycatcher	D			11	11
Grallina cyanoleuca	magpie-lark	LC	67	140	54	84
Rhipidura fuliginosa	grey fantail	LC	169	3	24	9
Rhipidura leucophrys	willie wagtail	LC	134	31	362	151
Dicrurus bracteatus	spangled drongo	LC	3	1		
Coracina novaehollandiae	black-faced cuckoo-shrike	LC	73	28	96	67
Coracina papuensis	white-bellied cuckoo-shrike	LC	2	3		8
Coracina tenuirostris	cicadabird	LC	10			1
Coracina maxima	ground cuckoo-shrike	LC	12	34	9	19
Lalage sueurii	white-winged triller	LC	42	24	239	120
Lalage leucomela	varied triller	LC	1			3
Oriolus sagittatus	olive-backed oriole	LC	38	3	11	9
Sphecotheres vieilloti	Australasian figbird	LC	2			
Artamus leucorynchus	white-breasted woodswallow	LC	20	24	1	76
Artamus personatus	masked woodswallow	LC	94	144	971	658
Artamus superciliosus	white-browed woodswallow	D	52	60	936	393
Artamus cinereus	black-faced woodswallow	LC	6	25	40	57
Artamus cyanopterus	dusky woodswallow	D	4	1		4
Artamus minor	little woodswallow	LC	11		69	58
Cracticus torquatus	grey butcherbird	LC	464	537	262	158
Cracticus nigrogularis	pied butcherbird	LC	254	378	378	170
Gymnorhina tibicen dorsalis	Australian magpie (black-backed form)	LC	258	457	228	178
Strepera graculina	pied currawong	LC	307	125	12	41
Corvus coronoides	Australian raven	LC	67	70	198	233
Corvus orru	Torresian crow	LC	374	533	11	154
Corcorax melanorhamphos	white-winged chough	LC	35	137	49	88
Struthidea cinerea	apostlebird	LC	294	978	643	565
Ptilonorhynchus maculata	spotted bowerbird	LC	18		7	21
Mirafra javanica	Horsfield's bushlark	LC	14	14		2
Anthus novaeseelandiae	Australasian pipit	LC	94	87	6	27
Taeniopygia guttata	zebra finch	LC	7	33	89	126
Taeniopygia bichenovii	double-barred finch	LC	131	9	14	76
Neochmia modesta	plum-headed finch	LC				103
Dicaeum hirundinaceum	mistletoebird	LC	105	9	46	13
Hirundo neoxena	welcome swallow	LC		4	2	3
Cheramoeca leucosternus	white-backed swallow	LC		2		2
Petrochelidon nigricans	tree martin	LC	77	9	35	27
Petrochelidon ariel	fairy martin	LC	109	1		204
Acrocephalus stentoreus	clamorous reed-warbler	LC				2
Megalurus timoriensis	tawny grassbird	LC	1			
Megalurus gramineus	little grassbird	LC				1
Cincloramphus mathewsi	rufous songlark	LC	59	22	31	45
Cincloramphus cruralis	brown songlark	LC	9	8	1	3
Cisticola exilis	golden-headed cisticola	LC	16	5		

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental#
Zosterops lateralis	silvereye	LC	179			4
Mammals (*Mammalia*)						
Tachyglossus aculeatus	short-beaked echidna	LC	16	15	51	18
Antechinomys laniger	kultarr	NT			1	5
Planigale maculata	common planigale	LC	2	2		
Planigale tenuirostris	narrow-nosed planigale	LC	9	3		
Sminthopsis crassicaudata	fat-tailed dunnart	LC			4	1
Sminthopsis macroura	stripe-faced dunnart	LC	37	25	11	8
Sminthopsis murina	common dunnart	LC	3	3		1
Isoodon sp.	unidentified bandicoot (Isoodon sp.)	-				1
Phascolarctos cinereus	koala	LC		1	1	4
Trichosurus vulpecula	common brushtail possum	LC	10	5	1	5
Petaurus australis australis	yellow-bellied glider (southern subspecies), fluffy glider	LC				1
Petaurus breviceps	sugar glider	LC	3	17		11
Petauroides volans	greater glider	LC				1
Aepyprymnus rufescens	rufous bettong, rufous rat-kangaroo	LC	3	15		17
Macropus dorsalis	black-striped wallaby, scrub wallaby	LC	79			9
Macropus fuliginosus	western grey kangaroo	LC			5	4
Macropus giganteus	eastern grey kangaroo	LC	113	93	116	113
Macropus parryi	whiptail wallaby, pretty face wallaby	LC	2	29		13
Macropus robustus	common wallaroo, euro	LC	20	7	67	38
Macropus rufogriseus	red-necked wallaby, Bennett's wallaby	LC	29	51		20
Macropus rufus	red kangaroo, blue-flier	LC	13	10	60	75
Wallabia bicolor	swamp wallaby, black wallaby	LC	8	3		25
Pteropus scapulatus	little red flying-fox	LC				1
Saccolaimus flaviventris	yellow-bellied sheathtail bat	LC	19	17	3	18
Mormopterus sp. no. 3.	inland freetail bat	LC				1
Mormopterus eleryi	hairy-nosed freetail bat, bristle-faced freetail bat	LC				1
Tadarida australis	white-striped freetail bat	LC	48	25		25
Chalinolobus gouldii	Gould's wattled bat	LC		2		205
Chalinolobus picatus	little pied bat	NT	7	2		18
Miniopterus schreibersii oceanensis	eastern bent-winged bat	LC				10
Nyctophilus geoffroyi	lesser long-eared bat	LC	13	1	1	15
Nyctophilus gouldi	Gould's long-eared bat	LC	5	1	1	7
Nyctophilus corbeni	eastern long-eared bat	V	1			2
Scotorepens balstoni	inland broad-nosed bat	LC				3
Scotorepens greyii	little broad-nosed bat	LC	15	1	1	49
Scotorepens sp.	unidentified broad-nosed bat	-				1

Species	Common Name	Status*	Brigalow	Poplar box	Soft Mulga	Incidental#
Vespadelus troughtoni	eastern cave bat	LC				13
Vespadelus vulturnus	little forest bat	LC	16	1	2	35
Mus musculus	house mouse	I	189	176	2	12
Pseudomys delicatulus	delicate mouse	LC	4	19	2	1
Pseudomys hermannsburgensis	sandy inland mouse, Hermannsburg mouse	LC			4	2
Pseudomys sp.	unidentified native mouse (Pseudomys sp.)	-			1	
Canis familiaris	dog	I	16	2	2	15
Canis lupus dingo	dingo	LC	2	4		12
Vulpes vulpes	red fox	I				4
Felis catus	cat	I	6	3	1	5
Capra hircus	goat	I			25	20
Sus scrofa	pig	I	3	9	5	21
Lepus capensis	brown hare	I	5	3		3
Oryctolagus cuniculus	rabbit	I	12	19	5	22

*Status: E=endangered, V=vulnerable, NT=near threaten, D=declining[1] LC=least concern, and I=introduced.

[1]Used to indicate declining woodland birds as recognised by Reid (1999) – note that all these species may not be declining in Queensland; however they are definitely ones to keep an eye on.

#Incidental: records of species within the study area (typically the study properties), not on project sites but may have been collected using a standardised technique or be incidentally encountered.

Appendix 4: Plant species by life form by land type

Scientific Name	Exotic	Common Name	Family	Brigalow	Poplar box	Mulga
Ferns						
Cheilanthes distans		hairy mulga fern, bristly cloak fern	Adiantaceae	X	X	
Cheilanthes sieberi subsp. *sieberi*		rock fern, mulga fern	Adiantaceae	X	X	X
Marsilea drummondii		common nardoo	Marsileaceae		X	X
Marsilea exarata		sway-back nardoo	Marsileaceae		X	
Sedges						
Bulbostylis barbata		dainty sedge	Cyperaceae			X
Cyperus sp.			Cyperaceae	X	X	
Cyperus bifax		western nutgrass, downs nutgrass	Cyperaceae		X	
Cyperus castaneus			Cyperaceae			X
Cyperus fulvus			Cyperaceae	X	X	X
Cyperus gracilis		slender sedge	Cyperaceae	X	X	X
Cyperus laevis			Cyperaceae	X	X	
Fimbristylis dichotoma		common fringe-rush	Cyperaceae		X	X
Scleria mackaviensis			Cyperaceae		X	
Vines						
Cayratia clematidea		slender grape	Vitaceae	X		
Cissus opaca		slender grape, small-leaf water vine	Vitaceae	X		
Jasminum didymum subsp. *lineare*		desert jasmine, native jasmine	Oleaceae	X	X	
Jasminum didymum subsp. *racemosum*		slender jasmine, small-leaf jasmine	Oleaceae	X	X	
Marsdenia australis		doubah, native pear, cogola bush	Apocynaceae		X	X
Marsdenia microlepis			Apocynaceae	X		
Marsdenia viridiflora subsp. *viridiflora*		native pear	Apocynaceae	X	X	
Pandorea pandorana		wonga vine	Bignoniaceae		X	
Parsonsia sp.			Apocynaceae	X		X
Parsonsia eucalyptophylla		gargaloo	Apocynaceae	X	X	X
Parsonsia lanceolata		northern silkpod	Apocynaceae	X		
Rhyncharrhena linearis			Apocynaceae	X		X
Sarcostemma viminale		pencil caustic, caustic vine, caustic bush	Apocynaceae	X		
Forbs						
Abutilon fraseri subsp. *fraseri*		dwarf lantern flower	Malvaceae	X	X	X
Abutilon leucopetalum		desert chinese lantern, lantern bush	Malvaceae	X		X
Abutilon otocarpum			Malvaceae	X	X	X
Abutilon oxycarpum		straggy lantern-bush, flannel weed	Malvaceae	X	X	
Abutilon oxycarpum var.		flannel weed	Malvaceae		X	

Scientific Name	Exotic	Common Name	Family	Brigalow	Poplar box	Mulga
subsagittatum						
Achyranthes aspera		chaff-flower	Amaranthaceae	X	X	
Ajuga australis		Australian bugle	Lamiaceae		X	
Alternanthera angustifolia			Amaranthaceae	X	X	
Alternanthera denticulata		lesser joyweed	Amaranthaceae	X	X	X
Alternanthera nana		hairy joyweed	Amaranthaceae		X	
Alternanthera nodiflora		common joyweed, joyweed	Amaranthaceae			X
Amaranthus mitchellii		Boggabri weed	Amaranthaceae	X	X	
Arabidella eremigena		yellow cress, priddiwalkatji, priddiwarrukatji	Brassicaceae	X	X	
Asperula conferta		common woodruff	Rubiaceae		X	
Asperula subulifolia			Rubiaceae		X	
Atriplex sp.			Chenopodiaceae	X	X	
Atriplex muelleri		Mueller's saltbush, green saltbush, annual saltbush	Chenopodiaceae	X	X	
Atriplex semibaccata		creeping saltbush	Chenopodiaceae	X	X	
Boerhavia sp.			Nyctaginaceae		X	
Boerhavia dominii		tar vine	Nyctaginaceae	X	X	X
Brachyscome ciliaris var. *ciliaris*		variable daisy, fringed daisy	Asteraceae	X	X	X
Brachyscome curvicarpa			Asteraceae	X		
Brunonia australis		blue pincushion	Goodeniaceae	X		X
Brunoniella acaulis subsp. *ciliata*			Acanthaceae		X	
Brunoniella australis		blue trumpet	Acanthaceae	X	X	X
Bulbine alata		native leek	Asphodelaceae	X	X	
Calandrinia sp.			Portulacaceae	X		
Calandrinia balonensis		broad-leaved parakeelya, parakeelya	Portulacaceae			X
Calandrinia pickeringii			Portulacaceae	X		
Calandrinia stagnensis			Portulacaceae			X
Calotis cuneata		blue burr daisy	Asteraceae		X	X
Calotis cuneifolia		burr daisy, purple daisy burr	Asteraceae		X	X
Calotis dentex		white burr daisy	Asteraceae	X	X	
Calotis hispidula		bogan flea, bindy eye, burr daisy	Asteraceae	X		
Calotis lappulacea		yellow burr daisy	Asteraceae	X	X	X
Calotis scabiosifolia var. *scabiosifolia*		rough burr daisy	Asteraceae	X		
Calotis scapigera		tufted burr daisy	Asteraceae		X	X
Calotis xanthosioidea			Asteraceae			X
Camptacra barbata			Asteraceae	X	X	
Centaurium erythraea	*	common centaury	Gentianaceae		X	
Centaurium tenuiflorum	*	spike centaury	Gentianaceae			X
Centipeda minima var. *minima*		spreading sneezeweed	Asteraceae		X	
Centipeda thespidioides		desert sneezeweed	Asteraceae			X
Chamaesyce dallachyana		mat spurge, caustic-weed	Euphorbiaceae	X	X	
Chamaesyce drummondii		mat spurge, caustic-weed, creeping spurge	Euphorbiaceae	X	X	X

Scientific Name	Exotic	Common Name	Family	Brigalow	Poplar box	Mulga
Chenopodium album	*	fat-hen, white goosefoot	Chenopodiaceae		X	
Chenopodium carinatum		green crumbweed	Chenopodiaceae	X	X	
Chenopodium cristatum		crested goosefoot	Chenopodiaceae	X	X	
Chenopodium desertorum		desert goosefoot	Chenopodiaceae			X
Chenopodium desertorum subsp. *anidiophyllum*			Chenopodiaceae	X	X	
Chenopodium desertorum subsp. *microphyllum*		gidyea saltbush	Chenopodiaceae	X	X	
Chenopodium melanocarpum		black crumbweed	Chenopodiaceae	X	X	X
Chenopodium pumilio		small crumbweed	Chenopodiaceae		X	
Chrysocephalum apiculatum		yellow buttons	Asteraceae	X	X	
Cirsium vulgare	*	spear thistle, scotch thistle	Asteraceae		X	
Citrullus colocynthis	*	colocynth, vine of sodom	Cucurbitaceae			X
Commelina diffusa		wandering jew	Commelinaceae	X	X	
Commelina ensifolia		scurvy grass, wandering jew	Commelinaceae	X		
Commelina lanceolata		wandering jew	Commelinaceae	X	X	
Convolvulus arvensis	*	European bindweed, bindweed	Convolvulaceae		X	
Convolvulus clementii			Convolvulaceae		X	X
Convolvulus erubescens		blushing bindweed, Australian bindweed	Convolvulaceae		X	
Convolvulus graminetinus			Convolvulaceae		X	
Conyza bonariensis	*	flaxleaf fleabane	Asteraceae	X	X	
Crassula sieberiana		native crassula	Crassulaceae		X	
Crotalaria incana subsp. *incana*	*	wooly rattlepod	Fabaceae	X	X	
Cucumis myriocarpus subsp. *myriocarpus*	*	prickly pademelon	Cucurbitaceae			X
Cullen tenax		emu-foot	Fabaceae		X	
Cyanthillium cinereum		vernonia, woolly vernonia	Asteraceae	X	X	
Daucus glochidiatus		Australian carrot	Apiaceae	X	X	
Desmodium sp.			Fabaceae	X		
Desmodium brachypodum		large ticktrefoil. tropical speedwell	Fabaceae	X		
Desmodium gunnii			Fabaceae	X		
Desmodium rhytidophyllum			Fabaceae		X	
Desmodium varians		slender tick trefoil	Fabaceae	X	X	X
Dianella sp.			Hemerocallidaceae		X	
Dianella caerulea		blue flax lily, blueberry lily	Hemerocallidaceae		X	X
Dianella longifolia		smooth flax-lily	Hemerocallidaceae	X	X	X
Dipteracanthus australasicus subsp. *corynothecus*			Acanthaceae	X	X	X
Dysphania kalpari			Chenopodiaceae			X
Dysphania littoralis		red crumbweed	Chenopodiaceae			X
Einadia nutans		climbing saltbush	Chenopodiaceae			X
Einadia nutans subsp. *linifolia*		climbing saltbush	Chenopodiaceae	X	X	
Einadia nutans subsp. *nutans*		climbing saltbush, nodding saltbush	Chenopodiaceae	X	X	X

Scientific Name	Exotic	Common Name	Family	Brigalow	Poplar box	Mulga
Einadia polygonoides		knotweed goosefoot	Chenopodiaceae	X	X	
Einadia trigonos subsp. *stellulata*		fishweed	Chenopodiaceae	X		
Epaltes australis		spreading nutheads, epalates	Asteraceae		X	X
Epilobium billardierianum subsp. *cinereum*			Onagraceae		X	
Erodium crinitum		blue crowfoot	Geraniaceae	X	X	X
Euchiton sphaericus		cudweed	Asteraceae	X	X	
Euphorbia tannensis subsp. *eremophila*		desert spurge, bottle-tree caustic	Euphorbiaceae	X		
Evolvulus alsinoides		baby blue eyes, tropical speedwell	Convolvulaceae	X	X	X
Galium migrans			Rubiaceae	X	X	
Galium propinquum			Rubiaceae		X	
Gamochaeta pensylvanica	*	cudweed	Asteraceae		X	
Geranium solanderi var. *solanderi*		native geranium	Geraniaceae		X	
Glossocardia bidens		native cobbler's pegs	Asteraceae	X	X	X
Glycine canescens		silky glycine	Fabaceae		X	X
Glycine clandestina		twining glycine	Fabaceae	X	X	X
Glycine clandestina var. *sericea*		twining glycine	Fabaceae		X	
Glycine tabacina		glycine pea	Fabaceae	X	X	
Glycine tomentella		woolly glycine, rusty glycine	Fabaceae		X	X
Gnephosis tenuissima			Asteraceae			X
Gomphocarpus physocarpus	*	balloon cottonbush	Asclepiadaceae	X	X	
Gomphrena celosioides	*	gomphrena weed, soft khakiweed	Amaranthaceae	X	X	
Goodenia sp.			Goodeniaceae		X	
Goodenia delicata			Goodeniaceae		X	
Goodenia fascicularis		silky goodenia, fan flower, malle goodenia	Goodeniaceae	X	X	
Goodenia glabra		smooth goodenia	Goodeniaceae	X	X	X
Goodenia havilandii			Goodeniaceae		X	X
Haloragis odontocarpa forma *rugosa*		mulga nettle	Haloragaceae			X
Harmsiodoxa brevipes var. *major*			Brassicaceae		X	
Harmsiodoxa puberula		scented cress, mauve candytuft	Brassicaceae		X	
Helichrysum rupicola			Asteraceae	X		
Heliotropium cunninghamii			Boraginaceae			X
Heliotropium moorei			Boraginaceae			X
Hibiscus brachysiphonius			Malvaceae	X	X	
Hibiscus krichauffianus			Malvaceae	X		X
Hibiscus sturtii		hill hibiscus	Clusiaceae			X
Hibiscus trionum var. *vesicarius*		bladder ketmia	Malvaceae	X	X	
Hybanthus stellarioides		spade flower	Violaceae		X	
Hydrocotyle peduncularis		pennywort	Apiaceae		X	
Hypericum gramineum		small St Johns wort	Clusiaceae			X

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Hypoestes floribunda		blue tongue	Acanthaceae	X		
Indigastrum parviflorum		smallflower indigo	Fabaceae	X	X	
Indigofera linnaei		nine-leaved indigo, Birdsville indigo	Fabaceae		X	
Ipomoea lonchophylla		cow vine	Convolvulaceae	X		
Ipomoea plebeia		bellvine	Convolvulaceae	X		
Isoetopsis graminifolia		grass cushion	Asteraceae			X
Juncus usitatus		common rush	Juncaceae		X	
Lagenophora gracilis		blue-bottle daisy	Asteraceae		X	
Leiocarpa panaetioides			Asteraceae		X	X
Lepidium sp.			Brassicaceae	X	X	
Lepidium africanum	*	common peppercress	Brassicaceae	X	X	
Lepidium bonariense	*	Argentine peppercress	Brassicaceae	X	X	
Lobelia darlingensis		matted pratia, darling pratia	Campanulaceae			X
Lomandra leucocephala subsp. *leucocephala*		iron grass, woolly matrush	Laxmanniaceae		X	
Lomandra longifolia		long-leaved matrush, spinyhead matrush, longleaf matrush	Laxmanniaceae	X	X	
Lomandra multiflora subsp. *multiflora*		many-flowered matrush	Laxmanniaceae	X	X	
Macgregoria racemigera		carpet-of-snow	Stackhousiaceae			X
Maireana coronata			Chenopodiaceae		X	
Maireana dichoptera			Chenopodiaceae		X	
Maireana enchylaenoides		wingless fissure-weed	Chenopodiaceae	X	X	X
Malvastrum americanum var. *americanum*	*	spiked mallow, malvastrum	Malvaceae	X	X	
Malvastrum coromandelianum	*	prickly malvastrum	Malvaceae	X	X	X
Mentha diemenica		native pennyroyal, native mint	Lamiaceae	X		
Minuria integerrima		smooth minuria	Asteraceae		X	
Moluccella laevis	*	molucca balm	Lamiaceae		X	
Muelleranthus trifoliolatus		spinifex pea	Fabaceae			X
Neptunia gracilis forma *gracilis*		native sensitive plant, low sensitive plant, sensitive plant, selenium weed	Mimosaceae	X	X	
Nicotiana megalosiphon		wild tobacco, long-flowered tobacco	Solanaceae	X	X	X
Nyssanthes erecta			Amaranthaceae	X	X	
Oenothera affinis	*	long-flowered evening primrose	Onagraceae			X
Oenothera indecora subsp. *bonariensis*	*	small-flowered evening primrose	Onagraceae		X	
Oldenlandia mitrasacmoides subsp. *trachymenoides*			Rubiaceae		X	X
Opuntia aurantiaca	*	tiger pear	Cactaceae	X	X	
Oxalis chnoodes			Oxalidaceae		X	
Oxalis perennans			Oxalidaceae	X	X	X
Oxalis radicosa			Oxalidaceae	X	X	X
Parthenium hysterophorus	*	parthenium weed, ragweed	Asteraceae	X	X	
Phyllanthus fuernrohrii		sand spurge	Euphorbiaceae			X

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Phyllanthus similis			Euphorbiaceae	X		
Phyllanthus virgatus			Euphorbiaceae		X	X
Physalis minima	*	wild gooseberry	Solanaceae	X		
Pimelea trichostachya		flaxweed, spiked riceflower	Thymelaeaceae		X	X
Plantago cunninghamii		sago weed, lamb's tongue	Plantaginaceae	X	X	
Plantago debilis		shade plantain	Plantaginaceae	X	X	X
Plantago turrifera			Plantaginaceae	X	X	
Plectranthus parviflorus		native coleus	Lamiaceae	X	X	
Podolepis arachnoidea		clustered copper-wire daisy	Asteraceae		X	
Podolepis longipedata		tall copper-wire daisy	Asteraceae		X	
Polycarpaea corymbosa			Caryophyllaceae		X	
Polygala linariifolia		native milkwort	Polygalaceae		X	X
Portulaca filifolia		slender pigweed	Portulacaceae	X	X	X
Portulaca oleracea	*	pigweed, common pigweed, munyeroo	Portulacaceae	X	X	X
Pratia concolor		white root, poison pratia	Campanulaceae		X	
Pseuderanthemum variabile		pastel flower, loveflower	Acanthaceae	X	X	
Pterocaulon sphacelatum		applebush, fruit salad plant	Asteraceae	X	X	X
Ptilotus sp.			Amaranthaceae		X	
Ptilotus exaltatus var. *semilanatus*		Prince-of-Wales feather, fox brush, lamb's tail	Amaranthaceae	X	X	
Ptilotus leucocoma		small purple foxtail	Amaranthaceae			X
Ptilotus macrocephalus		green pussytails, square-headed foxtail	Amaranthaceae		X	
Ptilotus polystachyus forma *polystachyus*		long-tails	Amaranthaceae			X
Ptilotus sessilifolius var. *sessilifolius*		crimson foxtail, silvertails	Amaranthaceae			X
Rhodanthe diffusa subsp. *leucactina*			Asteraceae	X	X	
Rhodanthe floribunda		white paper daisy, common white sunray	Asteraceae			X
Rhodanthe polyphylla			Asteraceae	X	X	
Rhynchosia minima var. *minima*		rhynchosia	Fabaceae	X	X	
Rorippa eustylis		river cress	Brassicaceae		X	
Rostellularia adscendens		dwarf justicia	Acanthaceae	X	X	
Rumex brownii		swamp dock	Polygonaceae		X	
Rumex crispus	*	curled dock	Polygonaceae		X	
Salsola kali		soft roly-poly, buckbush, tumbleweed	Chenopodiaceae	X	X	
Salsola tragus	*		Chenopodiaceae	X	X	
Salvia plebeia		common sage	Lamiaceae	X		
Salvia reflexa	*	mintweed	Lamiaceae	X	X	
Scaevola parvibarbata			Goodeniaceae			X
Schkuhria pinnata	*	curious weed	Asteraceae		X	
Senecio brigalowensis			Asteraceae	X	X	
Seringia corollata			Sterculiaceae	X		

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Sida sp.			Malvaceae	X	X	
Sida corrugata		corrugated sida	Malvaceae	X	X	
Sigesbeckia orientalis		Indian weed	Asteraceae	X		X
Sisymbrium thellungii	*	African turnip-weed	Brassicaceae	X	X	
Solanum sp.			Solanaceae	X		
Solanum americanum	*	night-shade, glossy nightshade	Solanaceae	X		
Solanum ammophilum			Solanaceae			X
Solanum cleistogamum			Solanaceae	X	X	X
Solanum ellipticum		potato bush, potato weed, hillside flannel bush	Solanaceae	X	X	X
Solanum esuriale		quena, potato weed	Solanaceae	X	X	
Solanum ferocissimum		narrow-leaved gin's whisker	Solanaceae	X		X
Solanum furfuraceum			Solanaceae			X
Solanum innoxium			Solanaceae	X		
Solanum jucundum			Solanaceae	X	X	
Solanum mitchellianum		western prickly nightshade	Solanaceae	X		
Solanum nemophilum			Solanaceae	X		
Solanum parvifolium		small-leaved nightshade	Solanaceae	X		X
Solanum versicolor			Solanaceae			X
Solenogyne bellioides			Asteraceae		X	
Soliva anthemifolia	*	dwarf jo jo weed, hairy jo jo weed	Asteraceae			X
Sonchus oleraceus	*	common sowthistle	Asteraceae	X	X	
Spermacoce brachystema			Rubiaceae		X	
Spermacoce multicaulis			Rubiaceae	X		
Stackhousia viminea		slender stackhousia	Stackhousiaceae		X	
Stemodia glabella		smooth bluerod	Scrophulariaceae			X
Stenopetalum lineare var. *lineare*			Brassicaceae		X	
Stenopetalum nutans			Brassicaceae	X	X	
Stenopetalum velutinum			Brassicaceae		X	
Swainsona affinis			Fabaceae			X
Swainsona luteola		dwarf Darling pea	Fabaceae	X	X	
Swainsona microphylla		small-leaved Darling pea	Fabaceae		X	
Swainsona phacoides		dwarf swainsona	Fabaceae			X
Synaptantha tillaeacea var. *tillaeacea*			Rubiaceae			X
Tagetes minuta	*	stinking roger	Asteraceae		X	
Tephrosia dietrichiae			Fabaceae		X	
Tephrosia rufula			Fabaceae	X		
Tetragonia tetragonioides		New Zealand spinach	Aizoaceae	X	X	
Trachymene ochracea		white parsnip				X
Trianthema triquetra		red spinach	Aizoaceae	X	X	
Tribulus sp.			Zygophyllaceae	X		
Tribulus eichlerianus		bull head	Zygophyllaceae			X
Tribulus micrococcus		yellow vine	Zygophyllaceae	X	X	
Tribulus terrestris		caltrop, goathead burr, yellow vine, puncture vine	Zygophyllaceae	X	X	X
Tricoryne elatior		yellow autumn lily, rush lily	Hemerocallidaceae		X	X
Velleia glabrata		smooth velleia, pee-the-bed	Goodeniaceae			X

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Verbena africana			Verbenaceae	X	X	
Verbena aristigera	*	Mayne's pest	Verbenaceae	X	X	
Verbena officinalis	*	common verbena	Verbenaceae	X		
Verbesina encelioides	*	crownbeard, wild sunflower	Asteraceae	X	X	X
Vigna sp.			Fabaceae		X	
Vittadinia sp.			Asteraceae	X	X	
Vittadinia cuneata var. *hirsuta*			Asteraceae	X	X	
Vittadinia dissecta var. *dissecta*			Asteraceae	X	X	X
Vittadinia dissecta var. *hirta*			Asteraceae		X	
Vittadinia pterochaeta		rough fuzzweed	Asteraceae	X	X	
Vittadinia pustulata			Asteraceae	X	X	X
Vittadinia sulcata		native daisy	Asteraceae	X	X	X
Wahlenbergia sp.			Campanulaceae		X	
Wahlenbergia gracilis		sprawling bluebell, Australian bluebell, native bluebell	Campanulaceae	X	X	
Wahlenbergia graniticola		granite bluebell	Campanulaceae	X	X	X
Waltheria indica		waltheria	Sterculiaceae		X	
Wedelia spilanthoides		creeping sunflower	Asteraceae		X	
Xanthium occidentale	*	Noogoora burr, cockleburr	Asteraceae		X	
Xanthium spinosum	*	Bathurst burr	Asteraceae		X	
Xerochrysum bracteatum		golden everlasting, yellow everlasting daisy, everlasting daisy, paper daisy	Asteraceae		X	
Zaleya galericulata subsp. *galericulata*		hogweed	Aizoaceae	X	X	
Zinnia peruviana	*	wild zinnia	Asteraceae		X	
Zornia muriculata		upright zornia	Fabaceae		X	
Zornia muriculata subsp. *angustata*		upright zornia	Fabaceae			X
Zornia muriculata subsp. *muriculata*		upright zornia	Fabaceae		X	
Zygophyllum apiculatum		gall weed, common twinleaf	Zygophyllaceae	X		
Grasses						
Alloteropsis semialata		cockatoo grass	Poaceae		X	
Amphipogon caricinus var. *caricinus*		long grey-beard grass, grey-beard grass	Poaceae	X	X	X
Ancistrachne uncinulata		hooky grass	Poaceae	X		X
Aristida sp.		wiregrass, three-awn speargrass	Poaceae	X	X	
Aristida calycina var. *calycina*		dark wiregrass, three-awns	Poaceae	X	X	X
Aristida caput-medusae		many-headed wiregrass, three-awns	Poaceae	X		
Aristida contorta		bunched kerosene grass, wind grass, kerosene grass, three-awns	Poaceae			X
Aristida echinata			Poaceae	X	X	
Aristida holathera var. *holathera*		erect kerosene grass, large silvergrass	Poaceae		X	X

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Aristida jerichoensis var. *jerichoensis*		Jericho wiregrass, three-awns	Poaceae	X	X	X
Aristida jerichoensis var. *subspinulifera*		Jericho wiregrass, three-awns	Poaceae		X	X
Aristida latifolia		feathertop wiregrass, curly wiregrass, three-awns	Poaceae	X	X	
Aristida leptopoda		white speargrass, three-awns	Poaceae		X	
Aristida personata		purple wiregrass	Poaceae	X	X	X
Aristida ramosa		purple wiregrass, three-awns	Poaceae	X	X	X
Arundinella nepalensis		reedgrass	Poaceae		X	
Astrebla elymoides		hoop Mitchell grass, weeping Mitchell	Poaceae	X	X	
Astrebla lappacea		Curly Mitchell grass, wheat Mitchellgrass	Poaceae	X	X	
Astrebla squarrosa		Bull Mitchell grass	Poaceae		X	
Austrodanthonia sp.			Poaceae	X		
Austrodanthonia tenuior			Poaceae	X		
Austrostipa ramosissima		bamboo grass	Poaceae	X	X	
Austrostipa scabra subsp. *scabra*		speargrass, rough speargrass	Poaceae		X	
Austrostipa setacea		corkscrew grass	Poaceae		X	
Austrostipa verticillata		slender bamboo grass	Poaceae	X	X	
Bothriochloa bladhii subsp. *bladhii*		forest bluegrass, forest Mitchell grass, Burnett River bluegrass	Poaceae		X	
Bothriochloa decipiens var. *decipiens*		pitted bluegrass	Poaceae	X	X	X
Brachyachne ciliaris		hairy native couch	Poaceae			X
Chloris sp.			Poaceae		X	
Chloris divaricata		slender chloris, small chloris	Poaceae	X	X	X
Chloris pectinata		comb chloris, comb windmill grass	Poaceae	X	X	X
Chloris truncata		windmill grass	Poaceae		X	
Chloris ventricosa		tall chloris, tall windmil grass	Poaceae	X	X	X
Chloris virgata	*	feathertop Rhodes grass	Poaceae		X	
Chrysopogon fallax		golden beard grass, ribbon grass	Poaceae		X	X
Cymbopogon refractus		barbed-wire grass	Poaceae	X	X	
Cynodon sp.			Poaceae	X		
Cynodon dactylon		couch, green couch, Bermuda grass	Poaceae		X	
Dactyloctenium radulans		button grass	Poaceae	X		X
Dichanthium sericeum subsp. *sericeum*		slender Queensland bluegrass	Poaceae	X	X	X
Digitaria sp.			Poaceae		X	
Digitaria ammophila		silky umbrella grass	Poaceae	X		
Digitaria breviglumis		short-glumed umbrella grass	Poaceae	X		X
Digitaria brownii		cotton panic grass	Poaceae	X	X	X
Digitaria coenicola		finger panic	Poaceae	X	X	
Digitaria divaricatissima		umbrella grass, spreading umbrella grass	Poaceae	X	X	
Digitaria hystrichoides		umbrella grass	Poaceae	X	X	X

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Digitaria parviflora		small-flower fingergrass	Poaceae	X		
Echinopogon ovatus var. *ovatus*		forest hedgehog	Poaceae	X	X	
Enneapogon avenaceus		common bottlewashers, ridge grass, bottle washers	Poaceae		X	
Enneapogon gracilis		slender nineawn, slender bottlewashers	Poaceae	X	X	
Enneapogon lindleyanus		wiry nineawn, bottle washer grass, prickly couch	Poaceae	X	X	
Enneapogon polyphyllus		leafy nineawn, limestone bottlewashers	Poaceae	X	X	X
Enteropogon acicularis		curly windmill grass	Poaceae	X	X	X
Enteropogon ramosus		twirly windmill grass, curly windmill grass	Poaceae	X	X	
Enteropogon unispiceus			Poaceae	X		
Entolasia stricta		wiry panic	Poaceae	X		
Eragrostis sp.			Poaceae		X	X
Eragrostis alveiformis			Poaceae	X	X	
Eragrostis australasica		cane grass, swamp cane grass, a lovegrass	Poaceae			X
Eragrostis brownii		Brown's lovegrass	Poaceae	X	X	
Eragrostis cilianensis	*	stinkgrass	Poaceae		X	
Eragrostis elongata		clustered love grass	Poaceae		X	
Eragrostis eriopoda		wollybutt, a lovegrass	Poaceae			X
Eragrostis lacunaria		purple lovegrass	Poaceae	X	X	X
Eragrostis microcarpa		dainty lovegrass	Poaceae			X
Eragrostis minor	*	smaller stinkgrass	Poaceae		X	
Eragrostis parviflora		weeping lovegrass	Poaceae			X
Eragrostis sororia		woodland lovegrass	Poaceae		X	X
Eragrostis spartinoides			Poaceae		X	
Eragrostis tenellula		delicate lovegrass	Poaceae	X	X	X
Eragrostis tenuifolia	*	elastic grass	Poaceae	X	X	
Eriachne helmsii		Helm's wanderrie grass, woollybutt wanderrie, buck wanderrie	Poaceae			X
Eriachne mucronata		mountain wanderrie grass	Poaceae			X
Eriachne pulchella subsp. *pulchella*		pretty wanderrie	Poaceae			X
Eriochloa crebra		spring grass, tall cupgrass	Poaceae		X	
Eriochloa pseudoacrotricha		spring grass. cup grass, early spring grass	Poaceae		X	
Eulalia aurea		silky browntop	Poaceae		X	X
Heteropogon contortus		black speargrass, bunch speargrass	Poaceae	X	X	
Iseilema membranaceum		small Flinders grass	Poaceae		X	
Iseilema vaginiflorum		red Flinders grass	Poaceae		X	
Leptochloa decipiens subsp. *asthenes*		slender canegrass	Poaceae	X		
Leptochloa decipiens subsp. *decipiens*		slender canegrass	Poaceae	X	X	X

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Leptochloa decipiens subsp. *peacockii*		slender canegrass	Poaceae	X	X	
Leptochloa digitata		umbrella canegrass	Poaceae		X	
Leptochloa fusca subsp. *fusca*		beetle grass	Poaceae	X		
Monachather paradoxus		bandicoot grass, mulga oats	Poaceae	X		X
Oplismenus aemulus		creeping shade grass	Poaceae	X	X	
Panicum sp.			Poaceae		X	
Panicum buncei		native panic	Poaceae		X	
Panicum decompositum var. *decompositum*		native millet, stargrass, wild millet, australian millet	Poaceae	X	X	
Panicum effusum		hairy panic	Poaceae	X	X	X
Paspalidium sp.			Poaceae	X	X	
Paspalidium caespitosum		brigalow grass	Poaceae	X	X	X
Paspalidium constrictum		knottybutt grass, box grass	Poaceae		X	
Paspalidium distans		shotgrass	Poaceae		X	
Paspalidium globoideum		sago grass, shotgrass	Poaceae		X	
Paspalidium gracile		slender panic	Poaceae	X	X	
Paspalidium jubiflorum		Warrego grass, Warrego summer grass	Poaceae			X
Paspalidium rarum		rare paspalidium, rare panic	Poaceae	X	X	X
Paspalum dilatatum	*	paspalum	Poaceae		X	
Paspalum notatum	*	bahia grass	Poaceae		X	
Pennisetum ciliare	*	buffel grass	Poaceae	X	X	X
Perotis rara		comet grass	Poaceae		X	X
Schizachyrium fragile		firegrass, red spathe grass	Poaceae			X
Setaria			Poaceae	X		
Sorghum halepense	*	Johnson grass	Poaceae			X
Sporobolus sp.			Poaceae	X		
Sporobolus actinocladus		katoora grass, ray grass	Poaceae		X	
Sporobolus australasicus		Australian dropseed grass	Poaceae	X		X
Sporobolus caroli		fairy grass, yakka grass, small pepper grass	Poaceae	X	X	X
Sporobolus creber		slender ratstail grass, western rat's-tail grass	Poaceae	X	X	
Sporobolus elongatus		slender rat's-tail grass	Poaceae		X	
Sporobolus mitchellii		rat's tail couch, river couch	Poaceae	X	X	
Thellungia advena		coolibah grass	Poaceae	X	X	
Themeda triandra		kangaroo grass	Poaceae	X	X	X
Thyridolepis mitchelliana		mulga mitchell grass, mulga grass	Poaceae			X
Thyridolepis xerophila		small mulga mitchell grass	Poaceae	X		X
Tragus australianus		small burr grass, sock grass	Poaceae	X	X	X
Tripogon loliiformis		five-minute grass	Poaceae	X	X	X
Triraphis mollis		purple plumegrass, needlegrass	Poaceae		X	X
Urochloa sp.			Poaceae		X	
Urochloa gilesii		hairy-edged arm grass	Poaceae	X	X	X
Urochloa piligera		hairy armgrass	Poaceae	X	X	X
Urochloa pubigera			Poaceae	X	X	

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Walwhalleya subxerophila		gilgai grass	Poaceae		X	X

Shrubs						
Abutilon malvifolium		bastard marshmallow	Malvaceae	X		
Acacia decora		pretty wattle	Mimosaceae		X	
Acalypha eremorum		soft acalypha	Euphorbiaceae	X		
Alectryon connatus		grey birds-eye	Sapindaceae	X		
Alectryon diversifolius		scrub boonaree, hollybush	Sapindaceae	X	X	
Amyema quandang		grey mistletoe	Loranthaceae	X		
Apophyllum anomalum		broom bush, warrior bush	Capparaceae	X	X	
Bridelia leichhardtii		small-leaved brush ironbark, small-leaved scrub ironbark	Euphorbiaceae	X	X	
Bursaria spinosa subsp. *spinosa*		sweet bursaria, prickly pine, blackthorn	Pittosporaceae	X		
Capparis sp.			Capparaceae		X	
Capparis lasiantha		nipan, splitjack, wait-a-while	Capparaceae	X	X	
Capparis mitchellii		wild orange, bimbil, native pomegranate, bumblebush	Capparaceae	X	X	
Carissa ovata		blackberry, kunkerberry, currantbush	Apocynaceae	X		
Citrus glauca		desert lime, wild lime, limebush	Rutaceae	X	X	
Croton insularis		native cascarilla bark, Queensland cascarilla, silver croton	Euphorbiaceae	X		
Croton phebalioides		narrow-leaved croton, white croton	Euphorbiaceae	X		
Denhamia oleaster		stiff denhamia	Celastraceae	X	X	
Dodonaea boroniifolia		hop bush	Sapindaceae			X
Dodonaea viscosa subsp. *angustissima*		narrow-leaf hopbush, sticky hopbush	Sapindaceae		X	X
Dodonaea viscosa subsp. *spatulata*		sticky hop bush	Sapindaceae	X	X	
Enchylaena tomentosa		ruby saltbush, barrier saltbush	Chenopodiaceae	X	X	X
Eremophila bowmanii subsp. *bowmanii*		silver turkey bush, flannel bush	Myoporaceae			X
Eremophila debilis		winter apple, creeping boobialla	Myoporaceae		X	
Eremophila deserti		Ellangowan poison bush, turkey bush	Myoporaceae	X	X	X
Eremophila gilesii		Charleville turkey bush, green turkey bush, desert fuchsia	Myoporaceae			X
Eremophila glabra subsp. *glabra*		tar bush, poverty bush, black fuchsia bush, black fuchsia, fuchsia	Myoporaceae			X
Eremophila longifolia		berrigan, long-leaf emubush, weeping emubush	Myoporaceae	X	X	X
Eremophila maculata subsp. *maculata*		spotted emubush, native fuchsia, spotted fuchsia	Myoporaceae			X
Everistia vacciniifolia forma *vacciniifolia*		small-leaved canthium, spiny canthium	Rubiaceae	X		
Geijera parviflora		wilga	Rutaceae	X	X	

Scientific Name	Exotic	Common Name	Family	Brigalow	Poplar box	Mulga
Hibbertia stricta var. *stricta*			Dilleniaceae	X		
Indigofera brevidens var. *brevidens*		desert indigo	Fabaceae	X		
Maireana sp.			Chenopodiaceae	X		
Maireana decalvans		black cottonbush	Chenopodiaceae		X	
Maireana microphylla		small-leaved cottonbush, saltbush, eastern cottonbush	Chenopodiaceae	X	X	
Maireana villosa		silky bluebush	Chenopodiaceae	X	X	X
Maytenus cunninghamii		yellow berry bush	Celastraceae	X	X	
Melhania oblongifolia		velvet hibiscus	Sterculiaceae	X		
Micromyrtus hexamera			Myrtaceae			X
Myoporum acuminatum		boobialla, waterbush, coastal boobialla	Myoporaceae		X	
Notelaea microcarpa var. *microcarpa*		native olive	Oleaceae	X	X	
Olearia sp.			Asteraceae	X		
Olearia subspicata		shrubby daisy-bush, turkey-bush, emubush, spiked daisy-bush	Asteraceae	X		X
Opuntia stricta	*	prickly pear. common pest pear, spiny pest pear	Cactaceae	X	X	X
Pittosporum spinescens		large-fruited orange thorn, wallaby apple, orange thorn	Pittosporaceae	X	X	
Prostanthera suborbicularis		mind bush, mountain saltbush	Lamiaceae			X
Psydrax johnsonii		brigalow canthium	Rubiaceae	X	X	
Psydrax oleifolia		myrtle tree, wild lemon	Rubiaceae	X	X	
Rhagodia parabolica		berry saltbush	Chenopodiaceae	X	X	
Rhagodia spinescens		thorny saltbush, spiny saltbush	Chenopodiaceae	X	X	
Santalum lanceolatum		true sandalwood, plumbush	Santalaceae	X		
Sclerolaena sp.			Chenopodiaceae	X	X	
Sclerolaena anisacanthoides		yellow copperburr, yellow burr	Chenopodiaceae	X	X	
Sclerolaena bicornis		goathead burr, bull's head	Chenopodiaceae	X	X	
Sclerolaena birchii		galvanised burr, blueburr	Chenopodiaceae	X	X	X
Sclerolaena convexula		copper burr, buck bush	Chenopodiaceae	X	X	X
Sclerolaena diacantha		grey copper burr	Chenopodiaceae	X	X	
Sclerolaena muricata		prickly roly-poly, black roly-poly, electric burr	Chenopodiaceae	X		
Sclerolaena muricata var. *muricata*		prickly roly-poly, black roly-poly	Chenopodiaceae	X	X	
Sclerolaena tetracuspis		brigalow burr	Chenopodiaceae	X	X	
Sclerolaena tricuspis		giant red burr	Chenopodiaceae	X	X	
Senna sp.			Caesalpiniaceae		X	
Senna artemisioides subsp. *artemisioides*		silver cassia, dense cassia, puntee	Caesalpiniaceae	X		X
Senna artemisioides subsp. *zygophylla*		butter bush, desert cassia, silver cassia	Caesalpiniaceae	X		
Senna barclayana		pepper leaf senna	Caesalpiniaceae	X		
Senna coronilloides			Caesalpiniaceae	X		
Sida aprica			Malvaceae			X

Scientific Name	Exotic	Common Name	Family	Brigalow	Poplar box	Mulga
Sida brachypoda			Malvaceae			X
Sida cunninghamii		ridge sida	Malvaceae		X	X
Sida fibulifera		pin sida, silver sida	Malvaceae	X	X	X
Sida filiformis		fine sida, fire sida	Malvaceae	X	X	X
Sida hackettiana		spiked sida	Malvaceae	X	X	
Sida rhombifolia	*	sida retusa, common sida	Malvaceae		X	
Sida rohlenae subsp. *rohlenae*		shrub sida	Malvaceae	X	X	
Sida trichopoda		high sida, narrow-leaf sida	Malvaceae	X	X	
Spartothamnella juncea		native broom	Lamiaceae	X	X	
Spartothamnella puberula		red-berried stick-plant	Lamiaceae	X		X
Teucrium micranthum			Lamiaceae	X		

Trees						
Acacia sp.			Mimosaceae		X	X
Acacia aneura		mulga	Mimosaceae			X
Acacia crassa subsp. *crassa*		thick-leaved black wattle	Mimosaceae	X	X	
Acacia deanei subsp. *deanei*		green wattle	Mimosaceae	X		
Acacia excelsa subsp. *excelsa*		ironwood wattle, falcate wattle	Mimosaceae	X	X	X
Acacia harpophylla		brigalow	Mimosaceae	X	X	
Acacia oswaldii		miljee, nelia	Mimosaceae		X	
Acacia pendula		myall	Mimosaceae	X	X	
Acacia salicina		doolan, cooba, sally wattle, willow wattle	Mimosaceae		X	
Alectryon oleifolius subsp. *elongatus*		boonaree	Sapindaceae	X	X	
Alstonia constricta		bitterbark, quinine tree	Apocynaceae	X		
Atalaya hemiglauca		whitewood	Sapindaceae	X	X	
Atalaya salicifolia		whitewood	Sapindaceae		X	
Brachychiton australis		broad-leaved bottle tree, bottle tree	Sterculiaceae	X		
Brachychiton populneus subsp. *trilobus*		kurrajong	Sterculiaceae			X
Brachychiton rupestris		narrow-leaved bottle tree, bottle tree, Queensland bottle tree	Sterculiaceae	X		
Callitris glaucophylla		white cypress pine	Cupressaceae	X	X	
Casuarina cristata		belah	Casuarinaceae	X	X	
Codonocarpus cotinifolius		bellfriut-tree	Gyrostemponaceae			X
Ehretia membranifolia		peach bush, weeping koda	Boraginaceae	X	X	
Elaeodendron australe var. *integrifolium*		narrow-leaved red olive palm	Celastraceae	X		
Eremophila mitchellii		false sandalwood. sandalwood box, budda, bastard sandalwood	Myoporaceae	X	X	X
Erythroxylum sp. (Splityard Creek L.Pedley 5360)		southern erythroxylum	Erythroxylaceae	X		
Eucalyptus camaldulensis		river red gum	Myrtaceae		X	
Eucalyptus chloroclada		Baradine red gum, barradine gum	Myrtaceae		X	

Scientific Name	Exotic	Common Name	Family	Brigalow	Poplar box	Mulga
Eucalyptus exserta		Queensland peppermint, bendo	Myrtaceae		X	
Eucalyptus melanophloia		silver-leaved ironbark, silver ironbark	Myrtaceae	X	X	X
Eucalyptus microcarpa		inland grey box, brown box, grey box	Myrtaceae	X		
Eucalyptus populnea		poplar box, bimble box	Myrtaceae	X	X	X
Grevillea striata		beefwood, beef oak, silvery honeysuckle	Proteaceae		X	X
Hakea leucoptera subsp. *sericipes*		needlewood, needle hakea, watertree	Proteaceae			X
Lysiphyllum carronii		ebony tree	Caesalpiniaceae	X		
Opuntia tomentosa	*	velvety tree pear	Cactaceae	X	X	
Owenia acidula		emu apple, gruie	Meliaceae		X	
Pittosporum angustifolium		wild apricot, butterbush, meemeei	Pittosporaceae	X	X	
Ventilago viminalis		vine tree, supplejack	Rhamnaceae	X	X	X

Appendix 5: Biodiversity Condition Toolkit for Grazed Lands

NOTE: the various components of the Toolkit are provided in separate documents. The following is the summary introduction of the Toolkit. The Toolkit has also been prepared as a series of relatable presentations in powerpoint.

Biodiversity Condition Toolkit for Grazed Lands

Introduction

The flora and fauna of the Brigalow Belt and Mulga Lands bioregions of southern Queensland are incredibly diverse and contain many endemic species, which are species that are found no where else. Extensive grazing by sheep and cattle is the predominant land use, so pastoral lands therefore make an important contribution to biodiversity and its conservation in these bioregions. Conserving native plants and animals in a region can also help provide 'services', such as nutrient cycling which can benefit grazing enterprises now and in the future. This toolkit will help land managers to better assess the capacity of their land to contribute to conservation of native plants and animals, and to identify ways to improve or maintain this capacity over time.

The ABCD Grazing Land Condition Framework provides an indication of the health of grazing lands for production. Having pastures and soils in good condition ensures they are producing to their potential and this is the first step in catering for biodiversity. But there are other components or measures to consider to fully gauge biodiversity condition.

This toolkit has been developed as a result of a large, field-based project funded by Meat & Livestock Australia and the Queensland Government. The project aimed to develop a practical and systematic approach for the assessment of condition of grazing lands for biodiversity. This involved collaboration with more than 20 grazing land properties in the Mulga Lands and Brigalow Belt bioregions, and their contribution to this project is warmly acknowledged.

Who is this toolkit for?

This toolkit has been produced to support facilitators, extension officers and Natural Resource Management groups who work with land managers involved in the management of grazing land production and biodiversity conservation. The toolkit can also be used directly by grazing land managers interested in biodiversity conservation, particularly those familiar with the concepts used in the EDGE*network* Grazing Land Management (GLM) and Stocktake education and training packages.

The aim of the toolkit is to provide capacity for land managers to build on existing knowledge of sustainable grazing land management, and in doing so encourage enthusiasm for caring about biodiversity on their properties. The toolkit also aims to provide some knowledge and insights on what we have learnt about the plants and animals that cohabit with grazing stock in healthy grazing lands. Local examples from research and managers' own experiences have been used to ensure relevance to the south west Queensland region.

The information within this toolkit will help with:

- The assessment of condition of paddocks from a biodiversity perspective (BioCondition), and building on the Grazing Land Management perspective (as easy as 1234 and ABCD).

- Understanding the relationships between flora and fauna, habitat features, pasture, woodlands and grazing land management.

- Familiarisation with the flora and fauna that inhabit healthy (and unhealthy) grazing properties

What can this toolkit be used for?

This toolkit can be used for education purposes on aspects of biodiversity in grazing lands of southern Queensland. Components in this kit can be used to guide paddock-scale assessment and monitoring of grazing land condition for biodiversity, and provide some insights on how to maintain or improve condition for biodiversity in the paddock and across the property. It can be used to demonstrate sustainable management for biodiversity to benefit grazing land managers in the marketplace and when competing for relevant funding.

What is biodiversity?

In short, 'biodiversity' is the variety of life. It includes the variation in plant and animal species, and within their populations and gene pools, the variety of environments in which they live, and the natural processes such as nutrient and water cycling that sustains them.

Species interact within and between each other and the environment at a range of scales, from a few millimetres (such as microscopic soil organisms) through to 100's of kilometres (such as migratory birds and flying foxes). From a grazing land perspective, this means that biodiversity is functioning in the paddock, and across the property, and also across neighbouring properties.

Why is biodiversity important?

A healthy, functioning biodiversity provides a number of natural services for everyone, including:

Ecosystem services (the benefits that natural elements of the landscape provide, such as maintaining a sustainable grazing enterprise) including:

- Protection of water resources
- Soils formation and protection
- Nutrient storage and recycling
- Pollution breakdown and absorption
- Contribution to climate stability
- Shelter and forage for stock
- Control of diseases, parasitic organisms and pests
- Increased resilience, or capacity of country to recover from unpredictable events such as fire, floods and drought.

Biological resources, such as:

- Food
- Medicinal resources and pharmaceutical drugs
- Wood products
- Ornamental plants
- Breeding stocks, population reservoirs

And **social benefits**, including:

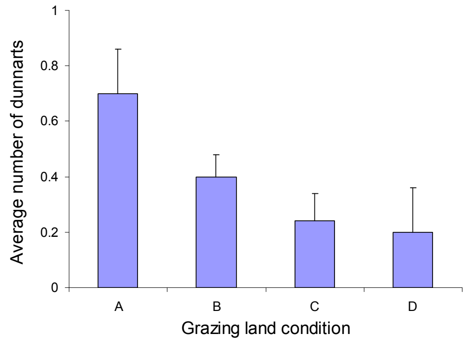
- Research and education
- Recreation and tourism
- Cultural values

Willing workers

Biodiversity provides a multitude of services. There is a strong link between increased native species diversity and a resilient and productive grazing enterprise.

Insect Eaters

Carnivorous marsupials like **dunnarts** and **planigales** eat vast quantities of insects every year and help control plaguing insects such as locusts. In the Brigalow region stripe-face dunnarts are strongly linked to grazing pastures in good or 'A' grazing land condition. This is because increased cover of perennial grasses and good soil condition provide important dunnart food and shelter. **Insectivorous birds** also help control pest insects, keeping in balance populations and preventing excessive damage to trees, shrubs and grasses from insect damage, as well as crops, whilst **insectivorous bats** consume vast quantities of crop and fodder insects every night



Ecosystem engineers

Burrowing insects and animals provide a significant service by aerating and mixing the soil and assisting with water capture and infiltration. Burrows can also collect and store plant seeds for germination under suitable conditions when seeds fall or are blown in and are protected from seed-eaters like ants. **Burrowing frogs**, lizards such as **skinks**, **dragons** and **goannas**, small ground mammals such as **native mice**, **echidnas**, **bandicoots** and **bilbies** all dig or burrow to a greater or lesser extent . **Burrowing spiders**, as well as consuming huge numbers of pest insects, also help significantly with soil water infiltration and nutrient cycling by virtue of their vast numbers and consequently the vast numbers of burrows.

Pasture and soil health

Seed eating birds (**granivores**) help germinate and spread perennial grass seeds through topsoil and litter disturbance, and help prevent single species dominance by feeding on the more prolific seeding species such as annuals and sedges. **Bettongs**, **bandicoots**, **small wallabies** and even **native rats** dig in soil for fungi and help spread fungal spores essential to soil health. These mycorrihzal fungi assist with water and mineral uptake, and can even assist plants with disease and drought resistance. Some fungi also need to pass through the animal's gut in order to germinate. **Termites** are nature's recyclers and create soil, increase soil fertility and enhance water infiltration and reduce erosion; they are also a critical food source for many species.

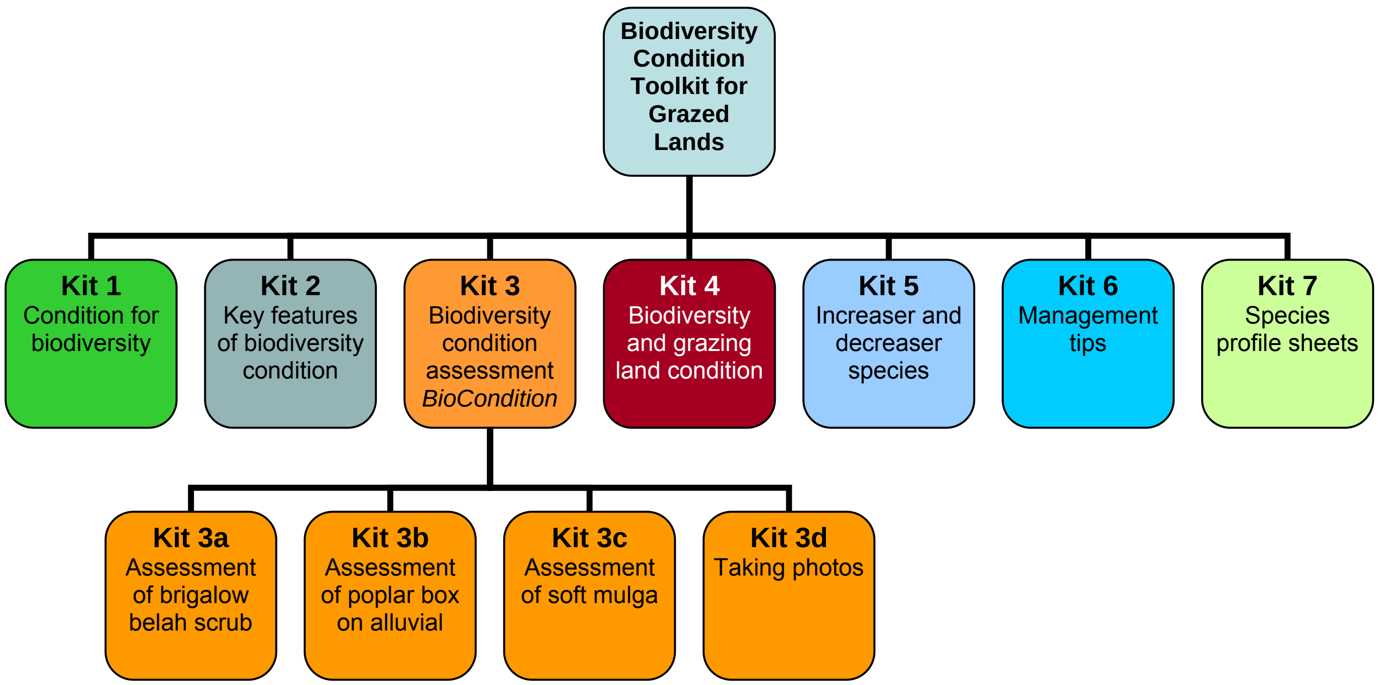
Native predators

The dingo dilemma: **dingos** can help moderate populations of kangaroos and wallabies to reduce total grazing pressure, and also prey on feral cats, foxes and pigs which all have a detrimental impact on our native fauna and ecosystems. **Goannas** feed on rotting carcasses, snakes, vermin and a wide variety of insects. Their large and deep burrows aid in water infiltration. Birds of prey such as **eagles**, **hawks** and **kites**, as well as **owls** can help to regulate seasonal fluctuations of ground mammals, especially rats and mice. They can fly vast distances to quickly move into areas experiencing rodent population booms (sometimes called plagues). They can disappear just as quickly when their food source lessens, unlike feral predators which tend to hang around and put extra on the rest of the local fauna.

Support your workers and they will support you!

What is in the toolkit?

The Toolkit is made up of seven 'stand alone', but interlinking kits. Each kit is made up of a brochure or set of brochures that provides information or resources relevant to biodiversity in the grazed lands of southern Queensland. The kits are colour-coded for easy referencing. A glossary of terms and a page of useful resources are also included.

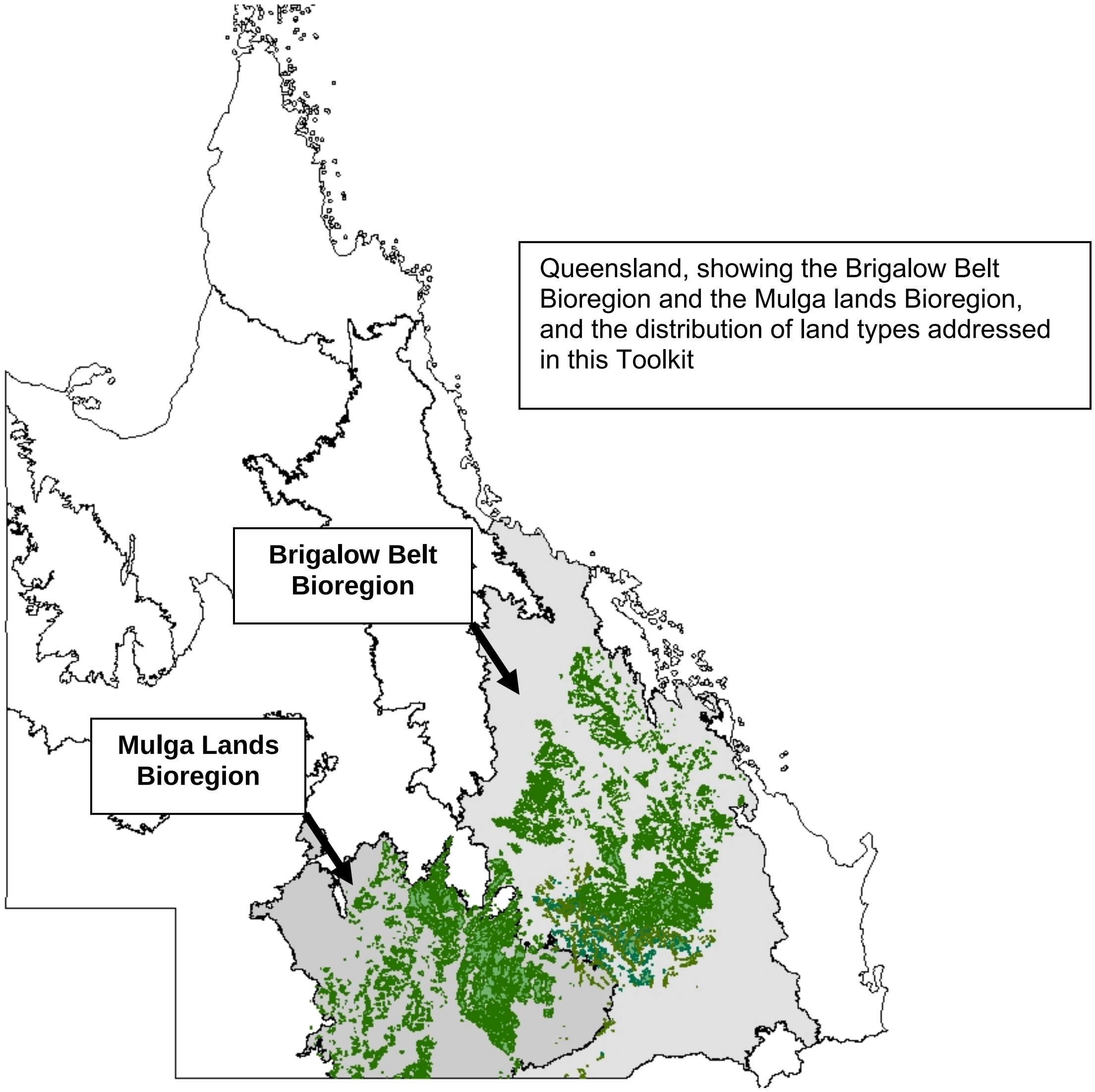


Where is the toolkit relevant?

The information and condition assessment resources presented in this toolkit are primarily relevant to land types in southern Queensland, specifically in the Mulga Lands and Brigalow Belt Bioregions. At this stage, the score sheets and guides provided in Kit 3 are specific to the following land types;

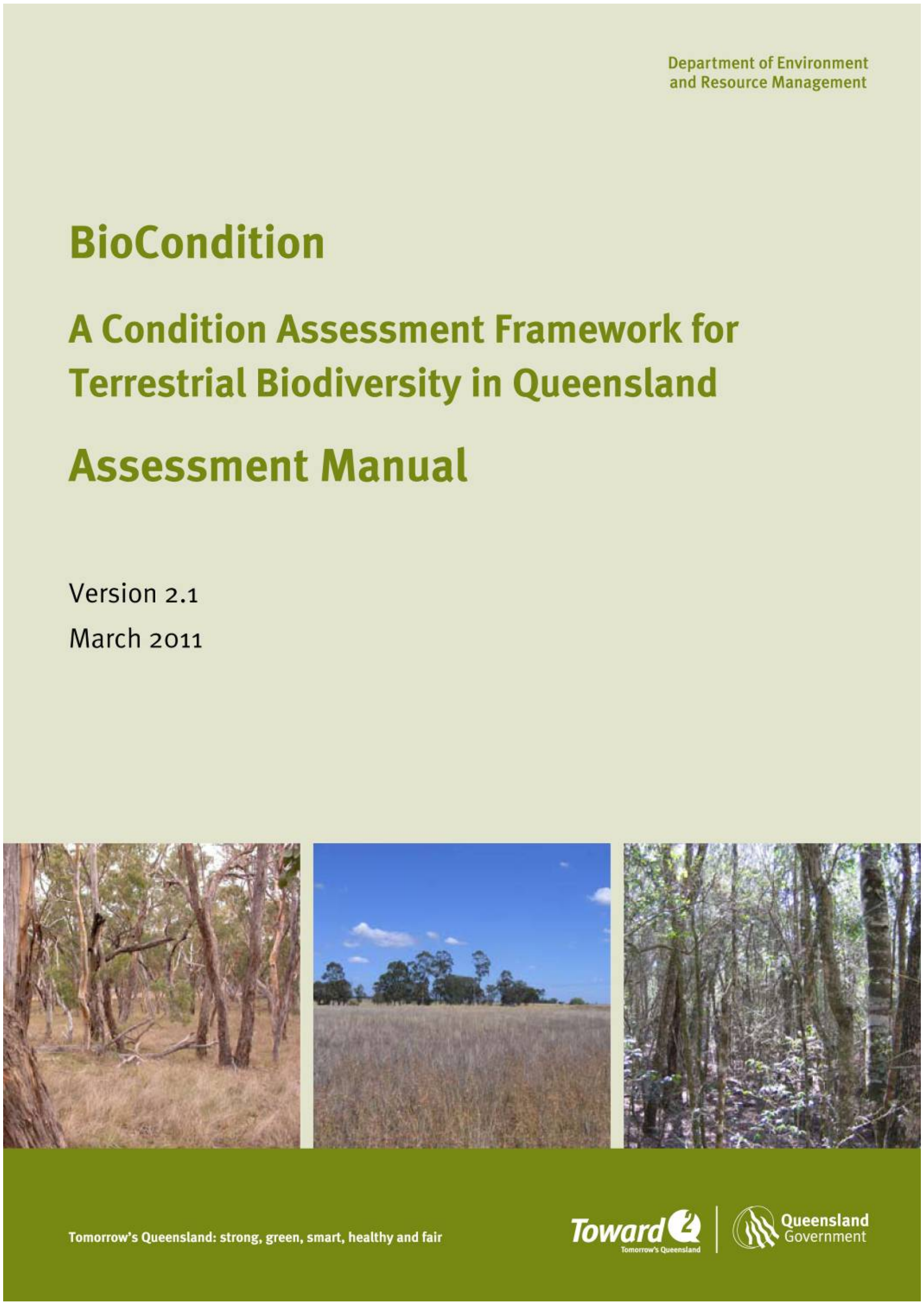
- Soft mulga
- Poplar box woodlands on alluvial plains; and
- Brigalow belah scrub

The distribution of these land types is shown as green on the map. Other land types can be easily incorporated in future if there is a requirement.


Queensland, showing the Brigalow Belt Bioregion and the Mulga lands Bioregion, and the distribution of land types addressed in this Toolkit
Brigalow Belt Bioregion
Mulga Lands Bioregion

Appendix 6: BioCondition Manual

Note: Only the cover is presented here – the latest version of the document BioCondition can be downloaded from the DERM website: http://www.derm.qld.gov.au/



Department of Environment and Resource Management

BioCondition

A Condition Assessment Framework for Terrestrial Biodiversity in Queensland

Assessment Manual

Version 2.1

March 2011

Tomorrow's Queensland: strong, green, smart, healthy and fair

Toward Q2 Tomorrow's Queensland

Queensland Government