A Landscape Assessment for the Southern Mt Lofty Ranges Landscape

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Executive Summary

This report presents the results of a Landscape Assessment undertaken for the southern Mt Lofty Ranges Landscape. The primary objective of a Landscape Assessment is to identify ecosystems or ecological attributes of a landscape that should be prioritised for conservation activity. The priority given to particular ecosystems is justified on the basis that these ecosystems are commonly associated with species that are in decline, but still present in the landscape. The assumption made is that the underlying cause for this common trajectory is related to historic modifications to the ecosystems that are commonly associated with these species, and that restoration activity should target these ecosystems as a matter of priority.

In the case of this Landscape Assessment, the identification of priority ecosystems was undertaken using terrestrial bird species, for two reasons: i) adequate data were available to undertaken analyses of historic trajectory and current status in the southern Mt Lofty Ranges landscape; ii) a well developed expert model of state and trajectory for terrestrial bird species exists for the southern Mt Lofty Ranges landscape, with which analyses of historic data could be compared. These two lines of evidence were combined to develop categories of exinction risk for the terrestrial birds of the southern Mt Lofty Ranges. In parallel, each bird species was classified to an 'Ecosystem Response Group' (ERG). ERGs are defined as groups of species that are commonly associated with the same ecosystem or group of ecosystems. By combining information on extinction risk with ERG membership, ecosystems (or groups of ecosystems) that are associated with terrestrial bird species at risk can be identified. These ecosystem groups were then used as the basis of conservation planning, as areas to prioritise subsequent investigations, planning and on-ground works.

On the basis of these analyses, two broad groups of ecosystems were found to be strongly associated with species at risk of extinction. These ecosystem groups were:

- Grassy ecosystems (and particularly grassy woodlands) in lower rainfall areas of the landscape, on gentle slopes. These ecosystems typically have open overstoreys dominated by *Eucalyptus odorata*, *E. leucoxylon*, *E. porosa* and/or *Allocasuarina verticillata*, with a grassy/herbaceous understorey. These ecosystems are found through the north and east of the landscape, and to a lesser extent on the western footslopes of the southern Mt Lofty Ranges near Adelaide. The bird species associated with these ecosystems include Brown Treecreeper, Hooded Robin, Restless Flycatcher and Diamond Firetail.
- Closed shrublands associated with a variety of environmental settings, with or without an overstorey. The floristics of these ecosystems are diverse, and include coastal and subcoastal mallee communities and shrublands, shrublands on aeolian sands, stringybark open forests in

higher rainfall areas with skeletal soils, and gum woodlands over shrublands. The common feature of these ecosystems is structural, in that they all support a closed sclerophyllous understorey. The birds species associated with these ecosystems include Bassian Thrush, Beautiful Firetail and Tawny Crowned Honeyeater.

Following from this preliminary outcome, more detailed analyses of these ecosystems were undertaken. In the case of the grassy ecosystem response group, landscape-scale quantitative targets were developed, based on the habitat area requirements of area-sensitive species in the response group. These analyses suggested that 51,800 ha of grassy woodland habitat is required to support viable populations of the bird species that depend on these ecosystems. Based on the extent of mapped native vegetation within the environments that support these ecosystems, a net habitat area of 37,750 ha requires reconstruction. The nature of the work required to maintain or restore these 51,800 ha will depend on the context of each patch under consideration, impacted by considerations such as management history and landscape context. These considerations have been captured within a State and Transition Model (Prescott and Rogers *in prep.*) for a portion of the priority ecosystems. In addition, for both grassy ecosystems and closed shrubland ecosystems, a preliminary analysis that identifies priority patches for restoration has been undertaken based on proximity to currently occupied remnants and the proportion of remaining native vegetation.

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1. Background: Nature Conservation Planning & Landscape Assessment

Across a range of spatial scales (global regional), the extent of conservation issues requiring attention far exceed our current capacity to address them. There is a need, therefore, to prioritise conservation activity across these spatial extents. In order to ensure that limited resources are used effectively, conservation requires planning. Ideally, such planning would be iterative and fit within an adaptive management framework. A key requirement of such planning is the establishment of clearly articulated goals, that underpin the identification, prioritisation, implementation and evaluation of conservation activities (Wilson *et al.* 2006; Bottrill *et al.* 2008). In addition, there is now widespread acknowledgement that conservation goals need to be context-specific (Failing and Gregory 2003; Hobbs 2007; Miller and Hobbs 2007), such that the goals are designed to address the conservation requirements of a particular socio-ecological setting. The need for context in goal setting is important, not only from the perspective of effective biodiversity conservation, but also to allow managers and other stakeholders to identify with conservation goals that are relevant to their patch and linked to tangible conservation outcomes.

However, landscape conservation goals are often defined poorly and in general terms. A common approach is to relate goals to generic surrogates for biodiversity. A variety of approaches to setting priorities for landscape conservation have been drawn upon, including prioritising areas of high species richness, diversity or endemism (Myers *et al.* 2000), or representativeness (Groves *et al.* 2002). Alternatively, general rules of thumb based on ecological theory (such as the Theory of Island Biogeography;(MacArthur and Wilson 1967), are used to set habitat (~native vegetation) area targets (e.g. 30% of pre-European cover). This is in spite of evidence that these generic targets fail to meet the area requirements of ecosystems in a specific context (Desmet and Cowling 2004). Generally, these approaches presume that prioritising conservation activity in areas that meet these umbrella criteria will meet the conservation requirements of most of the ecological components and processes of the landscape, and particularly those that are most at risk of deleterious and potentially irreversible change. Rather than relying on this presumption, an alternative approach would be to directly target the conservation requirements of those components and processes that are at risk, to ensure a more direct link between these and the conservation activities required to sustain them. This requires an understanding of which ecological components or processes are at risk within a landscape.

In order to conserve the biodiversity of a particular landscape, we need to understand which components of the landscape are at risk (e.g. declining and threatened species), and address the systemic issues that are responsible for these declines. In many cases, these processes are responsible for the decline of many species at risk; these common issues are often referred to as the coarse-filter (Noss 1996). However, even if we address those coarse-filter systemic issues, there will still be components of the landscape that are both declining, and whose conservation requirements are not met by addressing the coarse-filter (often referred to as fine-filters). In addition to addressing these coarse- and fine-filter systemic issues, many species will become threatened to such an extent that, even if we begin to address the systemic reasons for their decline, they are still likely to undergo regional extinction, and we will also need to address the proximate threats to these species.

Landscape Assessment

The aim of Landscape Assessment is to identify landscape-specific, coarse-filter systemic issues. It uses information on the current state and historic trend of species within a landscape, and an understanding of the processes that led to these patterns. Through the collation and synthesis of this information for a landscape, conservation priorities can be set that target those coarse-filter components that are associated with species most at risk of local (i.e. landscape) extinction. Conservation activity can then be designed to specifically meet these priority issues, and monitoring can be designed to test the effectiveness of these activities in achieving these specific goals.

2. Summary of Approach

The core of Landscape Assessment is based on a synthesis of three pieces of information:

1. An understanding of the nature (distribution, environmental-biotic relationships) of the ecosystems in a landscape;
2. An understanding of the ecological attributes (including associations with particular ecosystems) of species;
3. An understanding of the current state and historic trajectory of species

A fourth body of information that relates to current and historic land-use informs this synthesis, by supporting the interpretation of synthesised analysis.

Geographic Scope of this Assessment

The Landscape Assessment presented here focuses on identifying the priority coarse-filter issues for the southern Mt Lofty Ranges landscape. For the purposes of this assessment, the southern Mt Lofty Ranges landscape is defined as the Mt Lofty Ranges IBRA Subregion (comprising part of the Flinders-Lofty Block IBRA Region) and the Fleurieu IBRA Subregion (comprising part of the Kanmantoo IBRA Region; IBRA Version 6.2). The location of the landscape is presented in Figure 1. These subregions were combined for the purpose of this assessment as a result of a broader regional analysis of the biotic composition of IBRA associations.

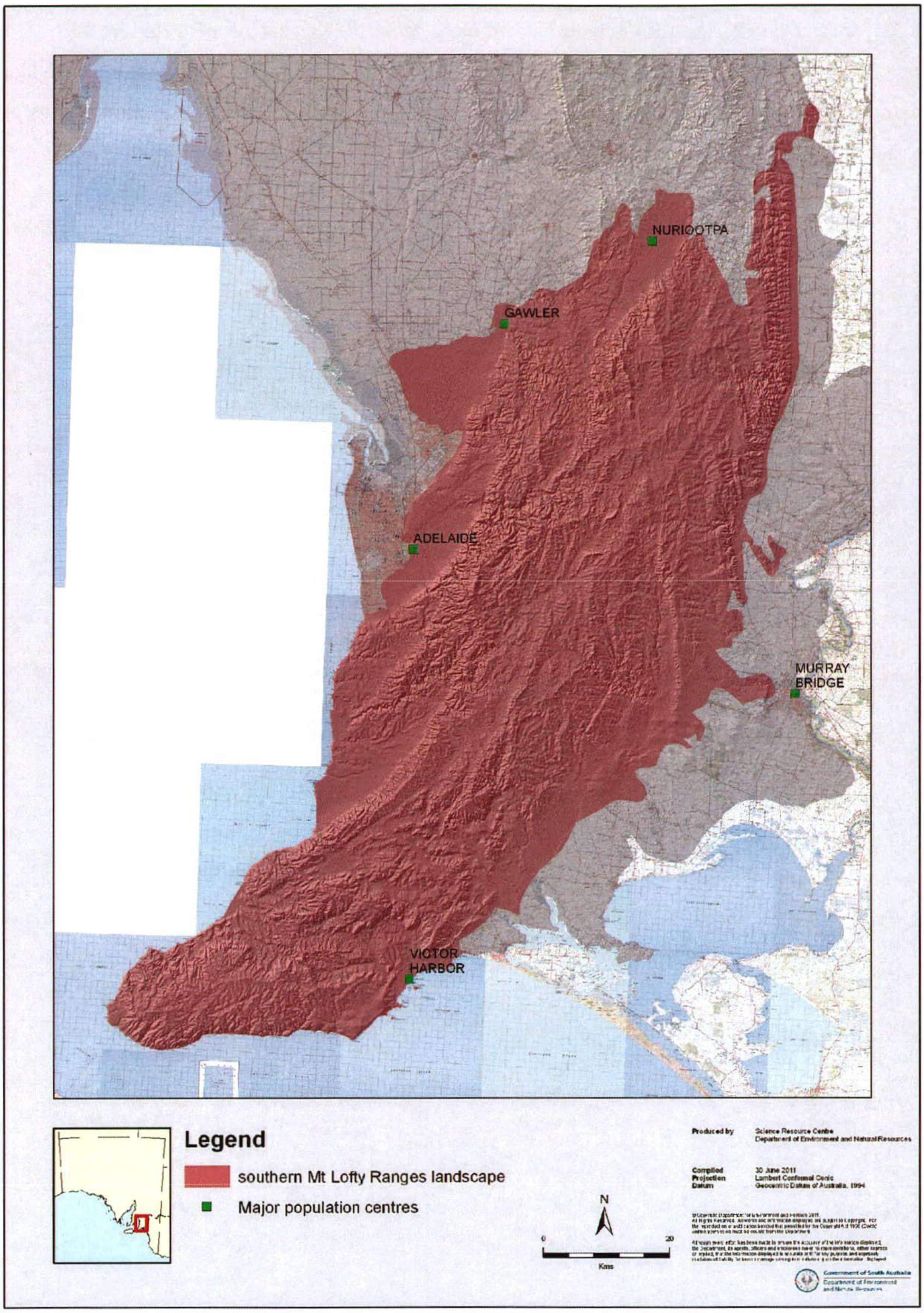


Figure 1. Location and boundary of the southern Mt Lofty Ranges landscape, upon which the Landscape Assessment presented in this report is based.

Taxonomic Scope of this Assessment

The Landscape Assessment presented here focuses on identifying priority coarse-filter issues that are associated with components of biodiversity at risk in the southern Mt Lofty Ranges landscape. This assessment is currently based on the ecological responses of terrestrial birds to environmental change within the southern Mt Lofty Ranges landscape. The initial focus on birds for the southern Mt Lofty Ranges stems from the fact that, for vertebrates, terrestrial birds form the bulk of the available data within the Biological Database of South Australia. Additionally, a robust expert model for the status and trend of terrestrial birds of the southern Mt Lofty Ranges exists.

Identifying systemic conservation issues for a landscape, based on information with such a strong taxonomic bias, will inevitably place significant caveats on the outputs, particularly with regard to how universally we can apply these results to the conservation of all species, communities and ecosystems. However, the outcomes presented here are directly relevant to the conservation of regionally threatened birds in these landscapes, and are likely to have positive outcomes for a range of other ecological components and processes for which we currently have inadequate information to undertake separate assessments.

3. Summary of Assessment Outcomes

The following presents a summary of the outcomes for a Landscape Assessment undertaken for the southern Mt Lofty Ranges landscape. This summary is presented in a number of stages, reflecting the pieces of information used to undertake the assessment, and their synthesis:

1. Understanding the nature of the ecosystems of the southern Mt Lofty Ranges (Ecological Vegetation Analysis)
2. Understanding the ecological attributes associated with terrestrial bird species of the southern Mt Lofty Ranges, including ecosystem associations (Landscape Response Groups)
3. Understanding the state and historic trajectory of terrestrial bird species of the southern Mt Lofty Ranges (Species Risk Analysis)

The summary presented here focuses on the outcomes of these analyses.

Ecosystems of the southern Mt Lofty Ranges (Ecological Vegetation Analysis)

The term ecosystems have a variety of definitions, but for the purposes of this assessment we describe ecosystems as an assemblage of species populations that occur together and are associated with a particular physical environment (Begon *et al.* 1990). An attempt to quantify the relationships between ecological communities and physical environments of the southern Mt Lofty Ranges landscape was undertaken. Floristic data were drawn from vegetation surveys undertaken by DENR and extracted from the BDBSA. Physical environmental data for each survey patch were extracted spatially (at coarse scales), and based on a reclassification of the physical descriptions collected at each patch during the survey (at fine scales). This analysis was undertaken hierarchically (Figure 2). An example output, describing the distribution of Vegetation Landscapes for the southern Mt Lofty Ranges, is presented in Figure 3.

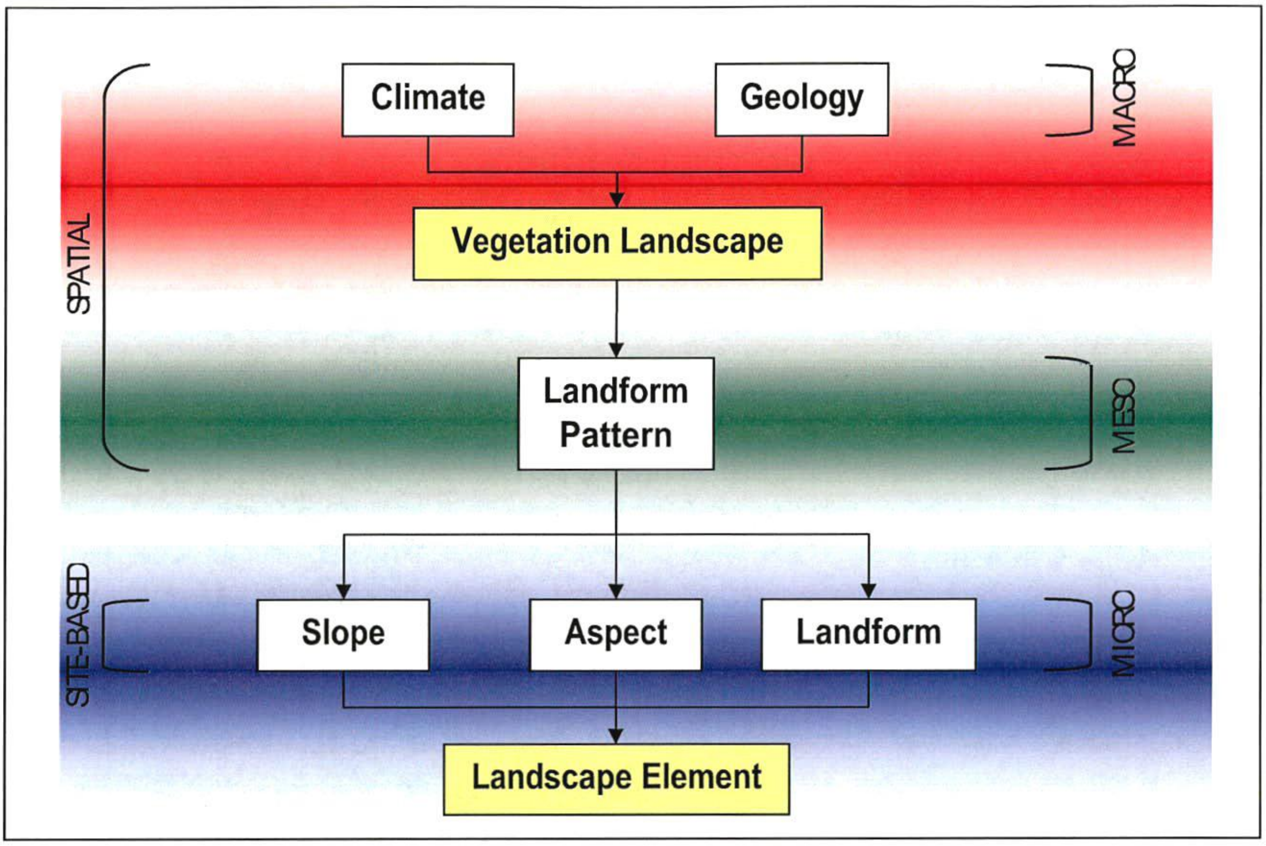


Figure 2. Conceptual diagram illustrating the hierarchical nature of the ecological analyses done to determine the distribution of ecosystems in the southern Mt Lofty Ranges landscape. The Vegetation Landscape level in the hierarchy describes landscapes within which have a common set of ecological "rules"; that is, the relationship between Landscape Element and ecological community is consistent within each Vegetation Landscape (but not necessarily between landscapes). The Landscape Element level of the hierarchy describes the finest scale of physical environment that explains variation in ecological community structure; any ecological variation that occurs below this is assumed to be explained by ecological dynamics.

The information generated from this model was used, in association with other lines of information (e.g. expert models) to help with determining Ecosystem Response Groups (groups of bird species that are commonly associated with similar suites of ecosystems – see below). More generally, these environmental models can provide information regarding the physical environmental settings that support different ecological communities. The model outputs, however, should be treated as a first iteration work in progress, and distribution of ecosystems predicted from this model should only be treated as a general guide.

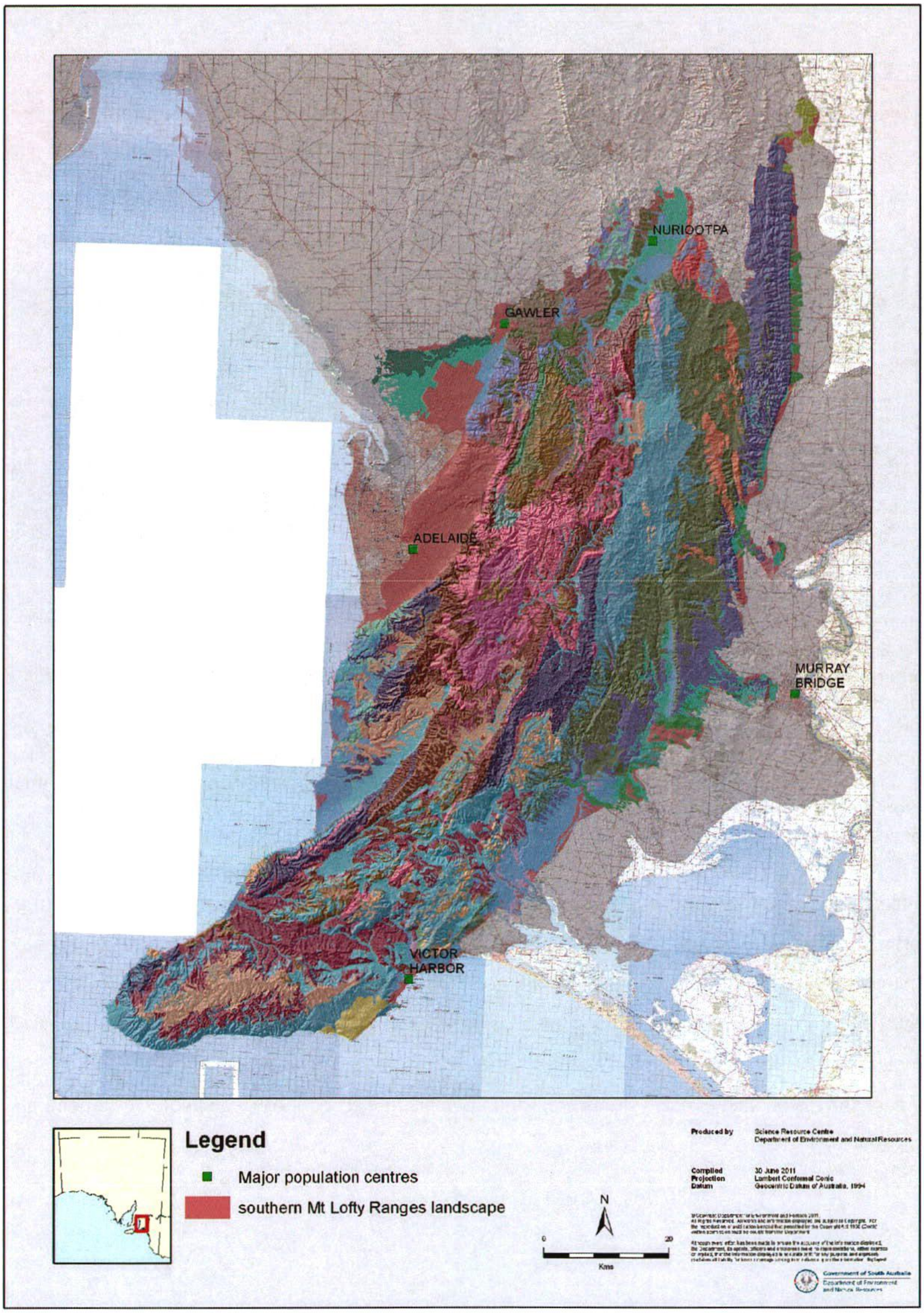


Figure 3. Vegetation Landscapes of the southern Mt Lofty Ranges. This map is based on the classification of soil landscape units (Hall *et al.* 2009) to one of four climate classes, and one of 43 geological classes.

Assigning ecological attributes to species (including Ecosystem Response Groups)

A key step in this Landscape Assessment is to identify ecological attributes that are commonly associated with groups of species. Together with assessments of species' trends, these two pieces of information can be brought together to identify ecological attributes that are commonly associated with decline (and are therefore a priority for conservation planning).

One of the key ecological attributes used to identify coarse filter issues in a landscape is the assignment of species to Ecosystem Response Groups (ERGs). This assignment was done through a combination of quantitative spatial analysis (spatially comparing the distribution of species records with the predicted distribution of ecosystems from the Ecological Vegetation Analysis), literature and expert opinion. ERGs are defined as groups of species that are commonly associated specifically with the same ecosystems or groups of ecosystems. The ERGs defined for the southern Mt Lofty Ranges landscape are presented in Box 1.

Box 1 Ecosystem Response Groups – southern Mt Lofty Ranges Landscape

ERG 1 – Generalists. Includes Australian Magpie, Galah, Rainbow Lorikeet.
ERG 2 – High rainfall forest species. Includes Buff-rumped Thornbill, Scarlet Robin, Yellow-faced Honeyeater.
ERG 3 – Grassy woodland generalists. Includes Varied Sittella, Brown-headed Honeyeater, Weebill.
ERG 5 – Grassy woodland & mallee specialists. Includes Brown Treecreeper, Hooded Robin, Diamond Firetail.
ERG 6 – Moderate rainfall woodland species. Comprised of Black-chinned Honeyeater, Elegant Parrot & Crested Shrike-Tit.
ERG 8 – Open grassy woodland specialists. Includes Stubble Quail, Southern Whiteface, Restless Flycatcher.
ERG 11 – Closed shrubland specialists. Includes Bassian Thrush, Chestnut-rumped Heathwren, Beautiful Firetail.

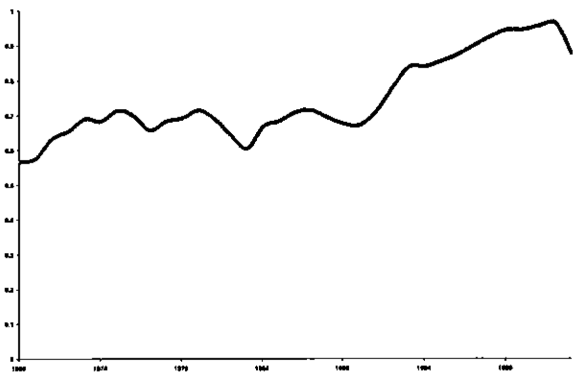
Ecological attributes were also generated (for the same set of bird species) for foraging mode, foraging substrate, food preferences, nest habitat and social structure (based on literature and expert opinion), such that the combination of different groupings could be used to identify which combinations of ecological attributes were most strongly associated with declining species.

Determining Historic Trends for Terrestrial Birds

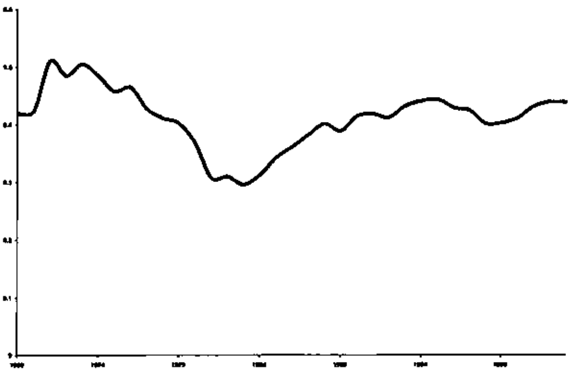
For each of the species used to define the ecosystem response groups described above (Box 1), an assessment of the current state and trend was undertaken. The foundations of Landscape Assessment lie in the synthesis of these state and trend assessments and response group definitions, with the premise being that, where species with common ecological requirements also show similar historic trends, these historic trends are related to change in the nature of these common requirements.

Time series of relative distribution were undertaken for 89 species, for the time period 1964-2004. Examples of these time series are presented in Figure 4. A series of statistics were then generated for each time series, in order to classify each species to one of seven trend categories. These classifications, in association with the time series graphs, were compared to the assessment made by (Cale 2005) . With very few exceptions, the outcomes of the data analysis matched the expert model of trend for each species.

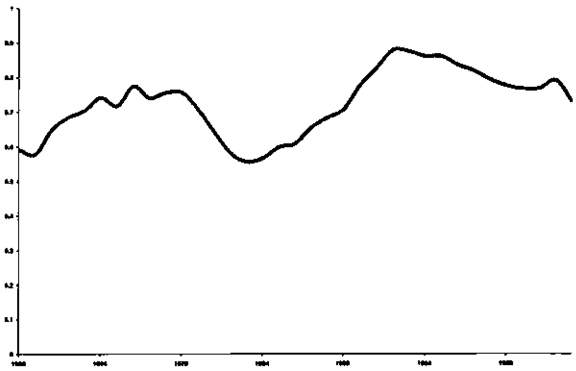
i. Crested Pigeon



ii. Galah

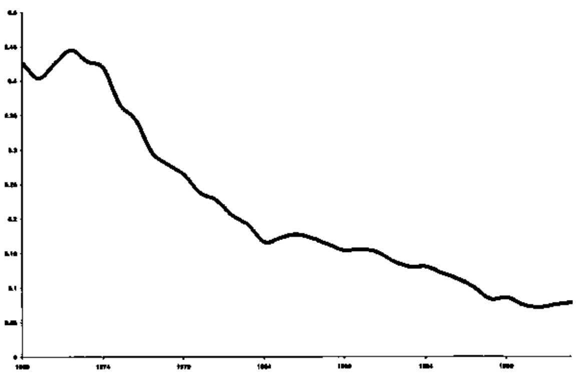


iii. Buff-rumped Thornbill



iv. Superb Fairy-wren

v. Bassian Thrush



vi. Restless Flycatcher

Figure 4. Example trend analyses for woodland birds of the southern Mt Lofty Ranges. These analyses, that span the time period 1965-2005, are based on changes in the relative distribution of a species, standardised against survey effort and relative to the most widely distributed species in any year.

Synthesis – Defining Priority Coarse-Filters

In order to identify systemic issues associated with decline within the southern Mt Lofty Ranges landscape, species' trend categories were related to each combination of ecological attributes using a Classification and Regression Tree analysis. This analysis was used to identify the combination of ecological attributes that were most commonly associated with each a species trend category.

This analysis suggested that, above all else, the ecosystem response group to which a species was classified was the strongest determinant for the trend category to which it was classified (Figure 5), that is, changes to ecosystems in the Mt Lofty Ranges appear to be the systemic issue associated with species decline in this landscape. In particular, declining trend categories were most strongly associated with ERGs 5, 6, 8 and 11 (see Box 1). Among those Ecosystem Response Groups that were not generally associated with decline (ERGs 1, 2, 3 and 4), a weak decline was also associated with ERGs 2 and 3 (high rainfall forest species, and grassy woodland generalists respectively; Box 1), in those cases where the preferred foraging mode was Pouncing or Snatching (compared with Gleaning, Probing or Generalist foraging modes). This relates primarily to the presence of ground- and bark-foraging insectivores in these Ecosystem Response Groups (e.g. Scarlet Robin and Varied Sittella).

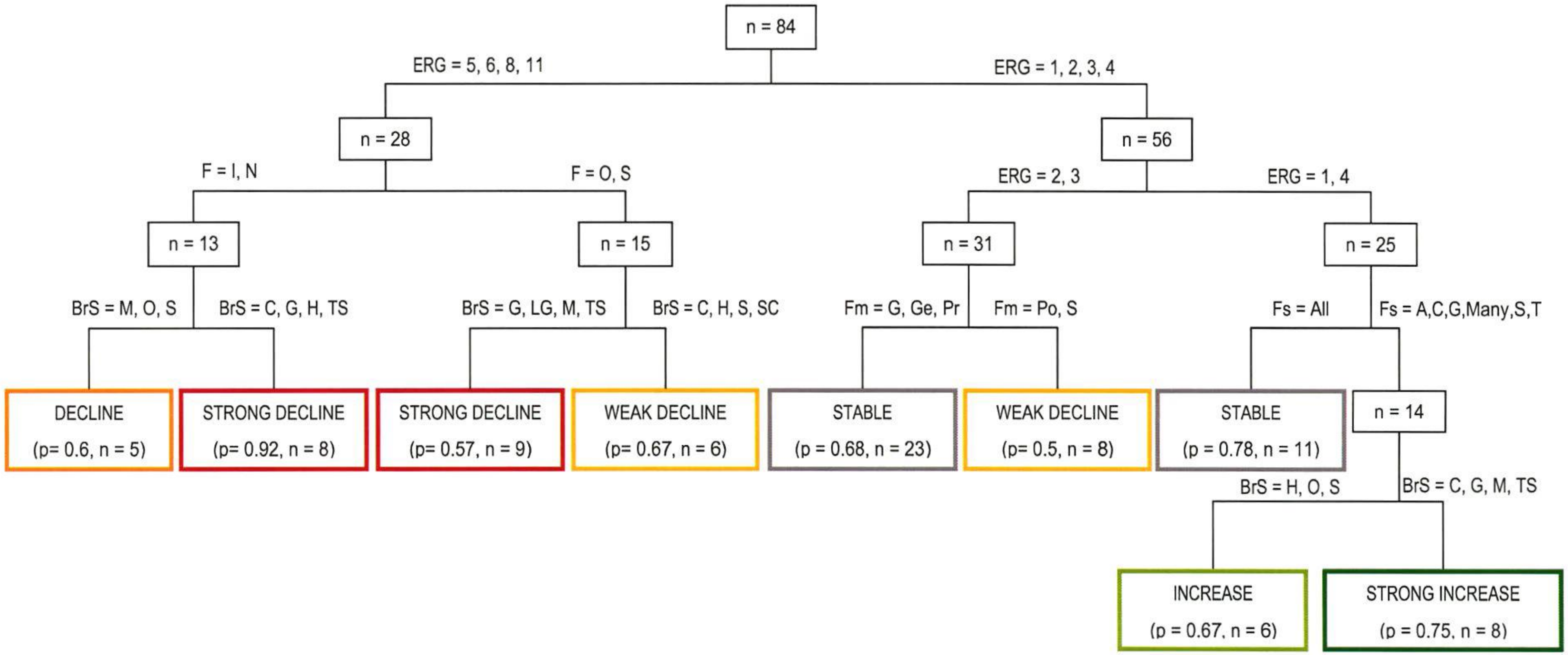


Figure 5. Classification Tree relating trend category to a species' ecological attributes. n refers to the number of species within the branch or node, p refers to the proportion of these species that were correctly classified to the trend category of that node. Refer to Box 1 and Table 1 for descriptions of Ecosystem Response Groups and other ecological attributes.

Response Group	Strong Decline	Decline	Weak Decline	Stable/Noisy	Weak Increase	Increase	Strong Increase
ERG 1				7	2	4	8
ERG 2			1	10	4	2	
ERG 3		3	2	9			
ERG 4			1	3			
ERG 5	3	1	1	1			
ERG 6	2		1				
ERG 8	9	3	1	1			
ERG 11	3	1		1			

Table 1. Number of terrestrial bird species in each ecosystem response group that were classified to each trend category. Ecosystem response groups are described in Box 1. The trend categories are based on the trend analyses described above.

This classification analysis, that identified which combinations of ecological attributes were associated with each trend category, found that Ecosystem Response Group membership was the strongest determinant of historic trend. As demonstrated in

Table 1, declining species were not distributed evenly across the different Ecosystem Response Groups, with ERGs 5, 8 and 11 containing a high proportion of declining of strongly declining species.

The ecosystems that were most strongly associated with ERGs 5 and 8 showed a high degree of overlap, and so much of the discussion around the priorities for these species will be combined (with some additional discussion around those systems that were unique to the two response groups). ERG 11, however, was significantly different from these two and will largely be treated separately.

The ecosystems (or combinations of ecosystems) that were most strongly associated with these priority response groups were :

- **Grassy ecosystems on lower rainfall flats and gentle slopes.** These support open woodlands with an overstorey dominated by *Eucalyptus porosa, Eucalyptus odorata, E. leucoxylon, E. microcarpa* and/or *Allocasuarina verticillata* with grassy and/or herbaceous understoreys (ERG5, ERG8)
- **Closed shrubland ecosystems.** These ecosystems are supported by a variety of environmental settings, particularly coastal & aeolian sands (that support mallee shrublands with or without an ovestorey of *Eucalyptus diversifolia*), and high rainfall skeletal rangelands (that support open forests with an overstorey of *Eucalyptus baxteri* or *Eucalyptus obliqua*) (ERG 11).

Given the strong relationship between decline and ecosystem response groups, the priority conservation issues identified for the Southern Mt Lofty Ranges landscape are primarily related to the conservation and restoration of those ecosystems associated with declining species. These are described below (Table 2).

Declining species covered by grassy ecosystem coarse filter	*Declining species covered by the heathland coarse filter*
Brown Treecreeper	Bassian Thrush
Diamond Firetail	Beautiful Firetail
Hooded Robin	Tawny-crowned Honeyeater
Peaceful Dove	Southern Emu-wren
Rainbow Bee-eater	Chestnut-rumped Heathwren
White-winged Chough	
Jacky Winter	
Australian Owlet-nightjar	
Restless Flycatcher	
Rufous Songlark	
Brown Songlark	
Southern Whiteface	
White-winged Triller	
Zebra Finch	
Varied Sittella[1]	
White-browed Babbler[1]	
Crested Shrike-tit[1]	
Sacred Kingfisher[1]	
Black-chinned Honeyeater[1]	
Declining species not covered by priority coarse filters	
Scarlet Robin	
Fairy Martin	
White-fronted Chat	

Table 2. Declining terrestrial bird species whose conservation requirements are likely to be met by the priority coarse-filters identified in this assessment, and those whose requirements are unlikely to be met by the priority coarse-filters (and will require the identification of species-specific conservation requirements). Note those species that are associated with higher rainfall gum woodlands whose decline may also be associated with the ecosystems they are commonly associated with (i.e. a potential additional coarse-filter).

Based on this assessment, two broad groups of ecosystems were identified as requiring conservation activity as a priority, in order to arrest the declines in species associated with these ecosystems. These priorities can now be validated and incorporated into broader planning processes being undertaken in the Adelaide & Mt Lofty Ranges NRM region and South Australian Murray-Darling Basin NRM region.

[1] These species belong to a sub-set that are more strictly associated with higher rainfall grassy woodlands components of this group of ecosystems

4. Conservation Planning for Priority Ecosystems

The Landscape Assessment informs a Situation Appraisal of a landscape – that is, it helps in identifying the conservation issues of a landscape. The identification of these issues is a necessary first step in the development of conservation goals and targets, and the activities required to meet these. However, Landscape Assessment is only one step in the broader conservation planning cycle.

Conservation planning requires a diverse range of stakeholder and expert input, with different expertise providing appropriate input at different steps in the process. In the next sections, analyses have been undertaken to provide input into these next planning steps (particularly regarding Issue Model Development, Goal & Target Setting, and spatial prioritisation on where to undertake activity to meet these goals and targets). This information can then be incorporated into the conservation planning process in association with the range of other required inputs.

Priority 1. Grassy woodland and grassland ecosystems associated with lower rainfall on gentle slopes

Addressing the conservation requirements of these ecosystems will contribute to the conservation and restoration of habitats that support bird species belonging to the grassy ecosystem response groups (Ecosystem Response Groups 5 and 8 above), two thirds of which are thought to be both rare and declining in the region. The predicted distribution (based on the ecosystem model described above) of priority ecosystems for this objective are presented in Figure 6.

As suggested above, the ecosystems associated with ERG 5 and ERG 8 respectively overlap. Both response groups are primarily associated with woodlands dominated by *Eucalyptus odorata*, *E. porosa*, *E. leucoxylon* and *Allocasuarina verticillata*, or communities for which these three species are co-dominant. Some of the species considered declining are more typically associated with grasslands (rather than grassy woodlands), that are often found . On the western slopes of the Mt Lofty Ranges, these response groups were additionally associated with *Eucalyptus microcarpa* grassy woodlands.

Adjacent to the Mt Lofty Ranges landscape, these species groups are associated with a number of mallee communities that are found at the margins of this landscape, particularly *E. gracilis* / *E. socialis* mallee on calcareous loam plains. DENR are currently undertaking work to assess the landscape priorities for this western Murray mallee landscape (Nigel Willoughby, SA MDB region).

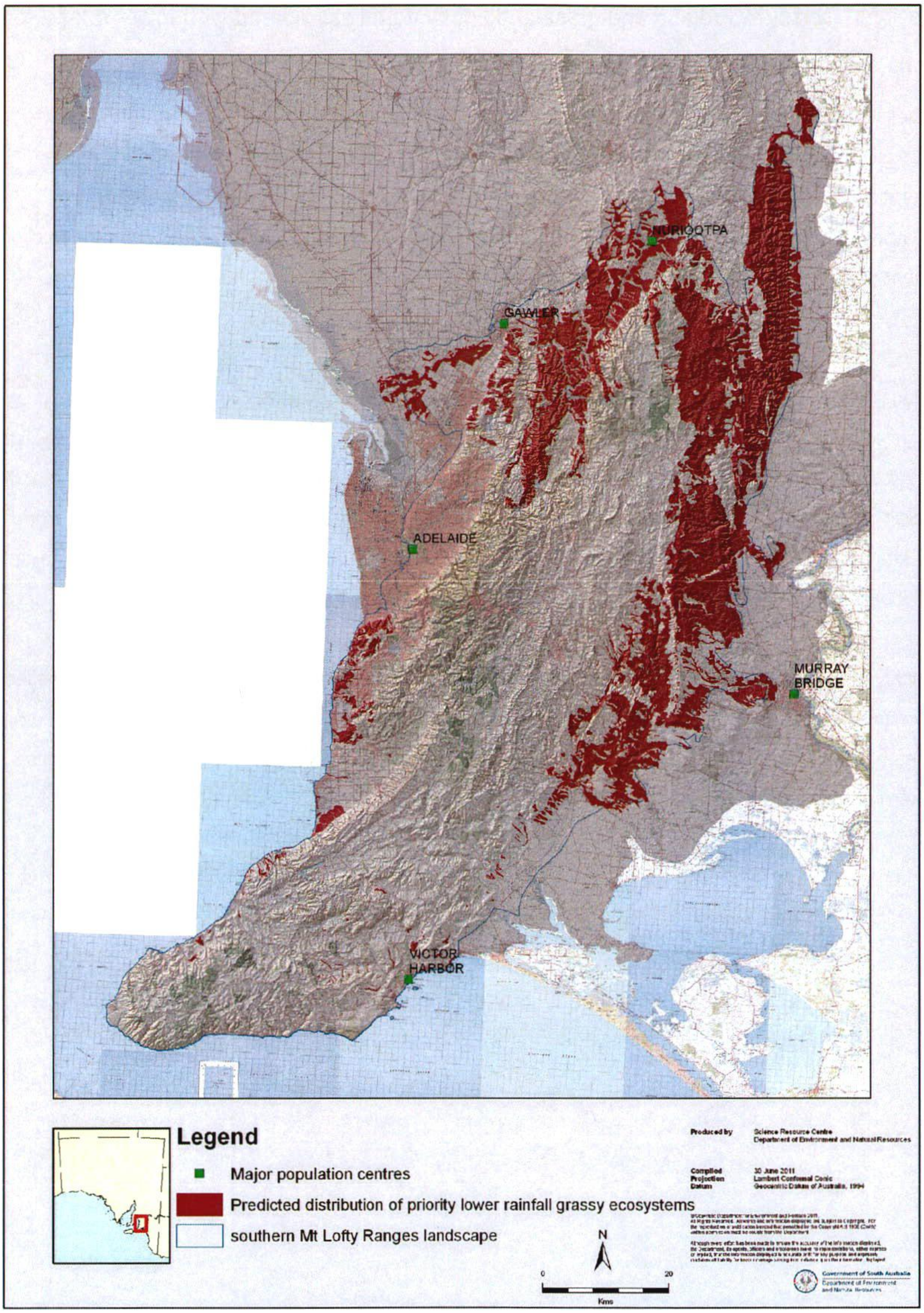


Figure 6. Predicted distribution of vegetation landscapes associated with lower rainfall grassy woodlands ecosystem response group.

Issue Model Development – Identifying What's Wrong with Lower Rainfall Grassy Ecosystems in the southern Mt Lofty Ranges

As a default hypothesis, the primary issue that we currently consider commonly responsible for the decline in species associated with lower rainfall grassy woodlands is the historic removal of these grassy ecosystems for agricutural development. There is some evidence for this hypothesis, based on the remnancy of the Vegetation Landscapes associated with these ecosystems. The total remnancy of these Vegetation Landscapes in the southern Mt Lofty Ranges is 5%; this compares with the total remnancy for the entire southern Mt Lofty Ranges (18%). Of equal significance, however, is an estimate of the habitat area required to support a minimum viable population of the most area-sensitive species in the response group. This analysis, for Diamond Firetail, found that a minimum viable population (estimated at 2,590 for the southern Mt Lofty Ranges landscape) requires 51,800 hectares of habitat (based on an estimated area requirement of 20 $ha.individual^{-1}$). The area that is predicted to support lower rainfall grassy woodlands currently have 14,050 ha of mapped remnant vegetation. The difference between current habitat available and estimated area required to support a minimum viable (37,750 ha) provides reasonably strong evidence that the bird species associated with lower rainfall grassy woodlands are currently habitat area limited.

A Goal for Lower Rainfall Grassy Ecosystems in the southern Mt Lofty Ranges

As inadequate area of habitat has been identified as the primary systemic issue affecting lower grassy woodland ecosystems, a goal for this ecosystem needs to incorporate the need to increase the area of suitable habitat. A first iteration goal that reflects this issue for this ecosystem, therefore, is:

'Reinstate adequate grassy woodland ecosystems on appropriate environmental settings to support viable populations of declining birds associated with these ecosystems'

This goal, however, will require additional iterations in association with input from other stakeholders.

Setting Quantitative Targets for Lower Rainfall Grassy Ecosystems of the southern Mt Lofty Ranges

Again, the primary systemic issue related to the decline of species associated with lower rainfall grassy woodlands is inadequate habitat area. The goals and targets required to meet the conservation requirements of these ecosystems thus need to primarily reflect this issue of area requirements.

As outlined above, an analysis of the habitat area required to support a minimum viable population of the most area sensitive species within the ecosystem response group found that a total of 51,800 ha of lower rainfall grassy woodland are required to meet this goal. Based on the area currently mapped as native vegetation, the net increase in woodland reinstatement required to meet this goal is 37,750 ha. However, the former of these values should perhaps be treated as our primary target for this ecosystem, for two reasons. First, mapped native vegetation does not necessarily reflect the true extent of remnant vegetation (due to technical mapping issues), particular in grassy woodland and grassland ecosystems. Second, we need to acknowledge the total area of grassy woodland required to support populations of the species in the response group, as we need to encompass the restoration requirements of both those areas that are not mapped as native vegetation (that we might consider need to be reconstructed) and those areas mapped as native vegetation (that might require other restoration activities besides revegetation). Ultimately, a target could be framed in terms of **51,800 ha of grassy woodlands occurring in a state that supports the habitat requirements of woodland birds associated with these ecosystems.** What is actually required to achieve this target will depend on how much of the ecosystem is currently in a state that supports the requirements of response group species (based on the area of mapped native vegetation, we have estimated 14,050 ha), and the nature and extent of the alternate states (that do not support these requirements). This requires the development of a state and transition model for these ecosystems. Such a model is currently being developed for the grassy woodland ecosystems of the eastern slopes of the southern Mt Lofty Ranges landscape.

Prioritising Areas for Restoration

Within those areas that are predicted to support the priority ecosystems for restoration, additional spatial prioritisation was undertaken. This spatial prioritisation refined those planning units that are most likely to provide the greatest benefit to the bird species associated with these ecosystems, should they be restored in such a way that they support habitat for these species. This prioritisation was undertaken using Marxan By Zones (Ardron *et al.* 2010). Marxan was originally developed as a tool for prioritising planning units to be incorporated into a conservation reserve system, based on their current conservation value. However, here this tool is being used in a slightly different manner, as a way of identifying planning units that should be prioritised for restoration. The mechanism by which this restoration is undertaken will depend on factors such as current tenure and land-use, but acquisition into the reserve system is only one of a number of possible mechanisms that are potentially available to meet this goal.

In this instance, a spatial prioritisation was developed using two parameters:

1. Distance from occupied planning unit. This parameter was chosen to maximise the probability that declining species would be able to make use of restored areas, as they are in close proximity to extant groups of the species of concern
2. Percent remnancy of planning unit. This parameter was chosen such that mapped remnant vegetation was captured within the area to be considered for conservation activity, with the premise being that those areas mapped as native vegetation are likely to be those areas that we either need to maintain, or will be the easiest to restore to a desirable state.

As the parameters used to undertake this prioritisation focussed on ecological principles (rather than incorporating, for example socio-economic inputs), the outputs from this analysis are limited to an ecological interpretation of priority planning units. Socio-economic considerations, while obviously critical to the success of landscape conservation, should be incorporated into the process as a next step, using these ecological considerations to focus landowner engagement.

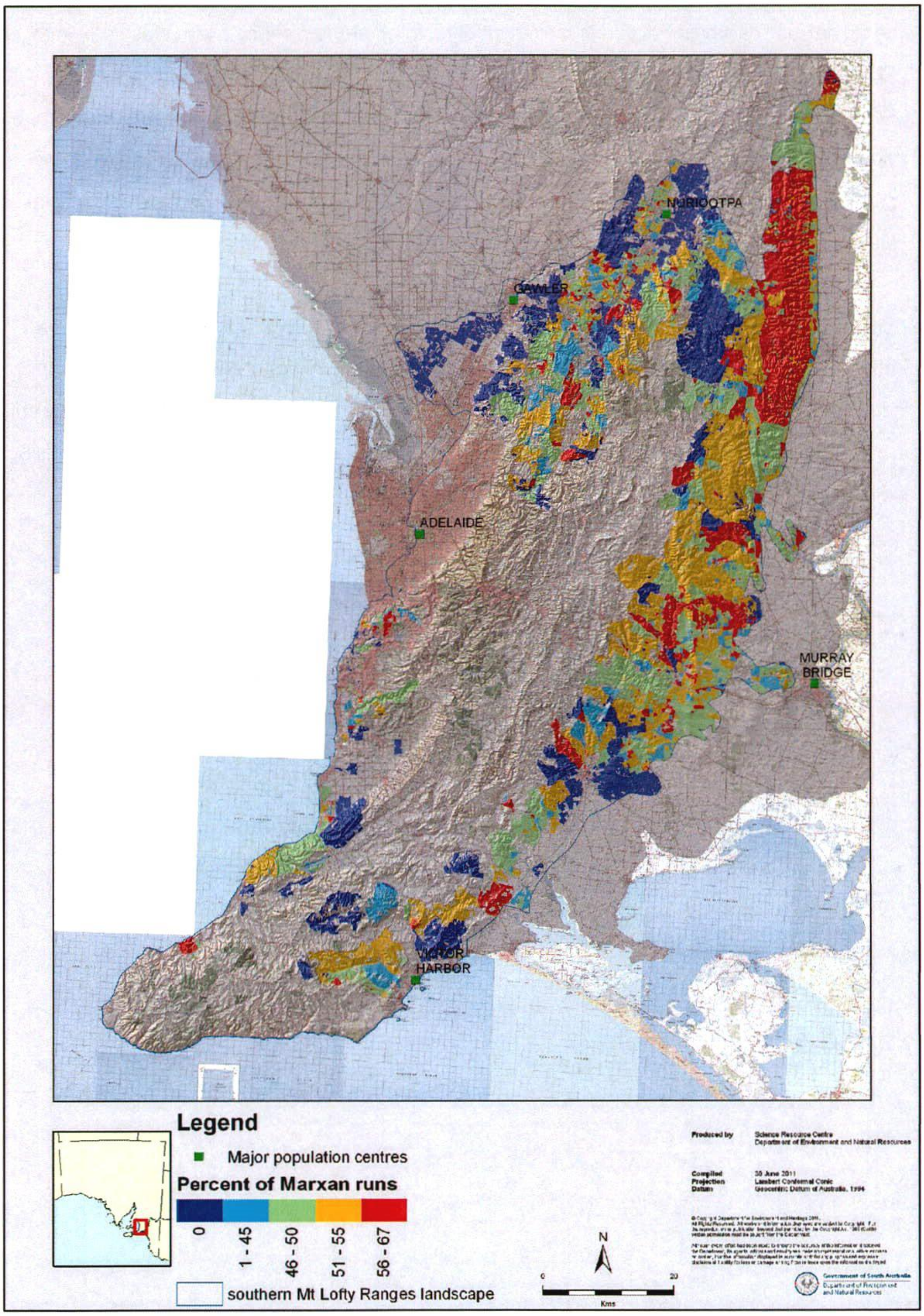


Figure 7. Prioritised planning units for the restoration of lower rainfall grassy ecosystems in the southern Mt Lofty Ranges landscape. Colour scale reflects the percent of Marxan simulations in which the planning unit was included in the solution.

Priority 2. Closed shrubland ecosystems associated with a range of environmental settings and overstorey species.

Identifying and undertaking conservation activity in closed shrubland ecosystems will contribute to the conservation and restoration of habitats that support bird species belonging to the closed shrubland ecosystem response group (ERG 11 above), 66% (4 of 6 species) of which are thought to be both rare and declining in the region. The predicted distribution (based on the ecosystem model described above) of vegetation landscapes associated with this response group is presented in Figure 8.

The ecosystems that were most strongly associated with this response group can be categorised into three broad groups:

- coastal and subcoastal mallee/shrublands, dominated by *Eucalyptus diversifolia* overstorey and *Olearia axillaris/ Leucopogon parviflorus* understorey
- moderately cool and wet forests with overstoreys dominated by either *Eucalyptus baxteri, E obliqua* or *E. goniocalyx*
- woodlands with shrubland understorey with overstoreys dominated by *E. leucoxylon* and/or *E. fasciculosa*.

Refinement of the priority ecosystems was required, in order to better identify those ecosystems that are both associated with this response group, and that historic changes to have led to the observed declines in the member species of the response group. This refinement was required both because of the diverse nature of the ecosystems associated with this bird group, and because some of the ecosystems associated with this response group are also associated with ERG 2 (high rainfall forest species), which are generally considered to be stable (Table 1).

Priority ecosystems for this response group were thus inferred from two pieces of information for each of the vegetation landscapes associated with the group. First, the remnancy of each associated vegetation landscape was calculated, with the assumption that vegetation landscapes with relatively high remnancy were less likely to be associated with the common patterns of decline observed for these species. Second, a change in area of occupancy within each vegetation landscape, for the species in the response group, was calculated, with the assumption that landscapes with relatively small declines in area of occupancy were again less likely to be associated with observed decline.

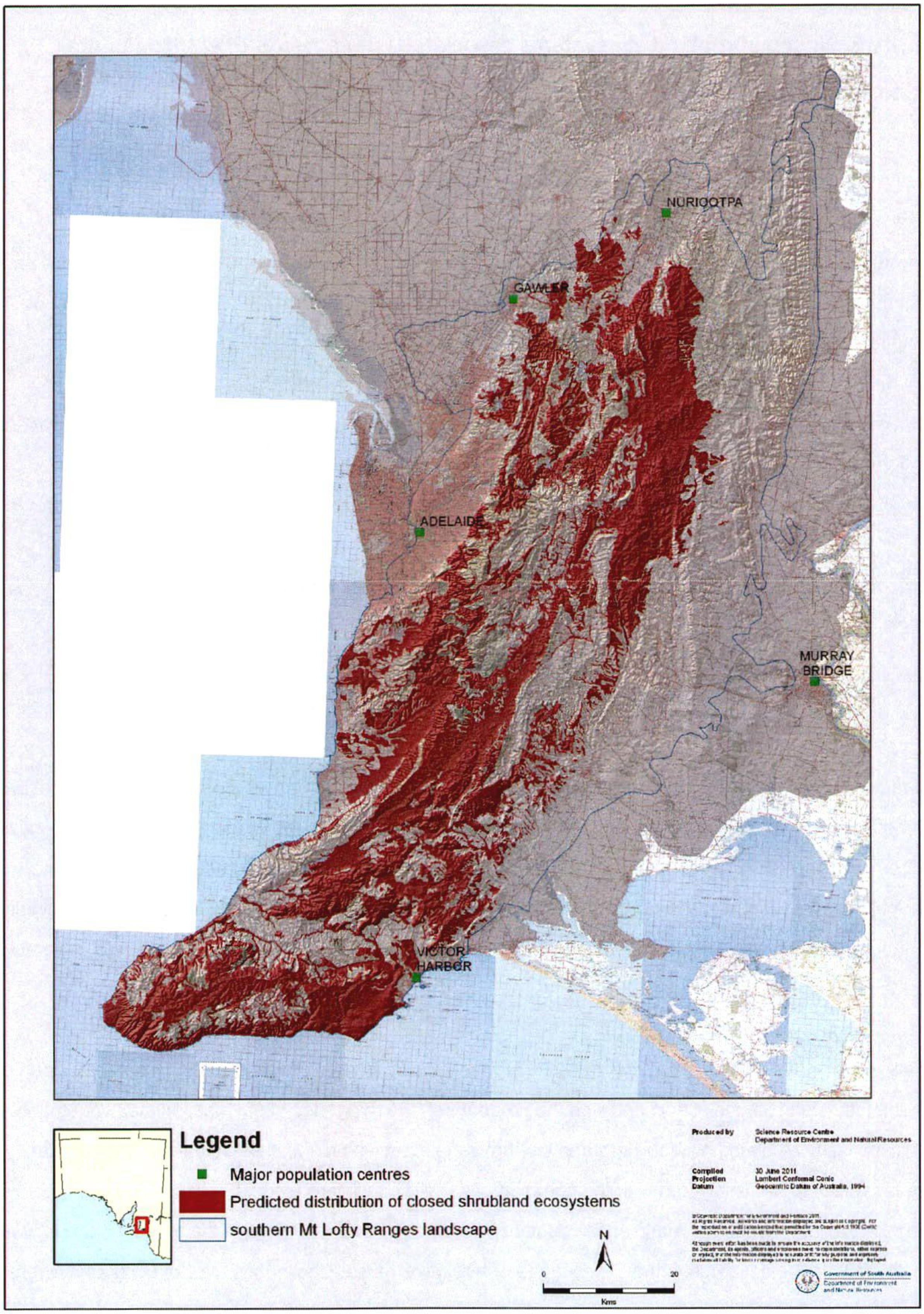


Figure 8. Predicted distribution of vegetation landscapes associated with closed shrublands ecosystem response group.

Thirteen vegetation landscapes were associated with the closed shrubland response group (Table 3). A significant inverse linear relationship existed between the remnancy and reduction in area of occupancy, suggesting that, within this group of vegetation landscapes, declines in this ecosystem response group are associated with the clearance of particular ecosystems. The hypothesis, therefore, is that the declines observed in these species within the southern Mt Lofty Ranges landscape relate to the clearance of particular ecosystems with a closed shrubland understorey that have been preferentially cleared. The distribution of these preferentially cleared vegetation landscapes is presented in . However, preferential clearance of particular closed shrubland habitats has most likely occurred within these vegetation landscapes on finer scale environmental settings (that, at this stage, cannot be mapped at the scale at which they occur). This prioritisation thus identifies those vegetation landscapes that are likely to contain priority ecosystems; however, particular settings within these landscapes that support closed shrubland communities still need to be identified using available vegetation information.

Based on this analysis, a subset of the vegetation landscapes, where a greater than 50% reduction in the area of occupancy of response group species has been detected, were selected as priority vegetation landscapes for restoration (Figure 9).

Vegetation Landscape	*'Typical' ecological communities*	*Remnancy (% of area mapped as native vegetation)*	*Reduction in Area of Occupancy (AOO > 2000 v AOO all records)*
Cold, Wet landscapes (rain 550-1050mm, CV_{rain} 43-54, T°C 12-15°C)			
Cambrian igneous acid materials		62.7	84%
Cambrian sedimentary sandstone	*E. fasciculosa / E. baxteri / E. obliqua / E. cosmophylla* open forests on steeper slopes, to *E. leucoxylon* / E. *fasciculosa* woodlands on gentler slopes	17.0	69%
Holocene Aeolian materials	*E. diversifolia* +/- *E. cosmophylla* low mallee	53.8	17%
Proterozoic metamorphic materials	*E. fasciculosa / E. baxteri / E. obliqua / E. cosmophylla* open forests on steeper slopes, to *E. leucoxylon* / E. *fasciculosa* woodlands on gentler slopes	40.5	28%
Proterozoic metamorphic quartzite	*E. baxteri* forests, *E. leucoxylon* woodlands on lower slopes	35.2	16%
Proterozoic sedimentary limestone	Few samples – *E. fasciculosa / E. leucoxylon* woodlands (poorly sampled)	26.2	84%
Proterozoic sedimentary mudstone	*E. leucoxylon* woodlands, also *E. obliqua* forests	19.1	70%
Proterozoic sedimentary sandstone	*E fasciculosa* woodland, *E. baxteri / E. obliqua* forests	40.7	31%
Pleistocene plain materials	*E. fasciculosa / E. leucoxylon* woodlands, also *E. porosa / E. microcarpa* woodlands (more grassy)	9.6	73%
Tertiary terrestrial materials	*E. obliqua* forests on moderate slopes, *E. fasciculosa / E. leucoxylon* woodlands on gentler slopes	15.6	41%
Moderately cold, wet landscapes (rain 430-700mm, CV_{rain} 32-49, T°C 13-16°C)			
Proterozoic sedimentary limestone	*E. leucoxylon* woodland (poorly sampled)	20.4	100%
Proterozoic sedimentary mudstone	*E. camaldulensis* woodland in valleys, *E. leucoxylon / E. porosa* woodlands on slopes, *A. verticillata* on crests	3.4	78%
Proterozoic sedimentary sandstone	*E. leucoxylon* woodland (poorly sampled)	47.1	8%

Table 3. Vegetation Landscapes associated with the closed shrubland ecosystem response group. Vegetation landscapes with > 50% reduction in Area of Occupancy have been shaded grey.

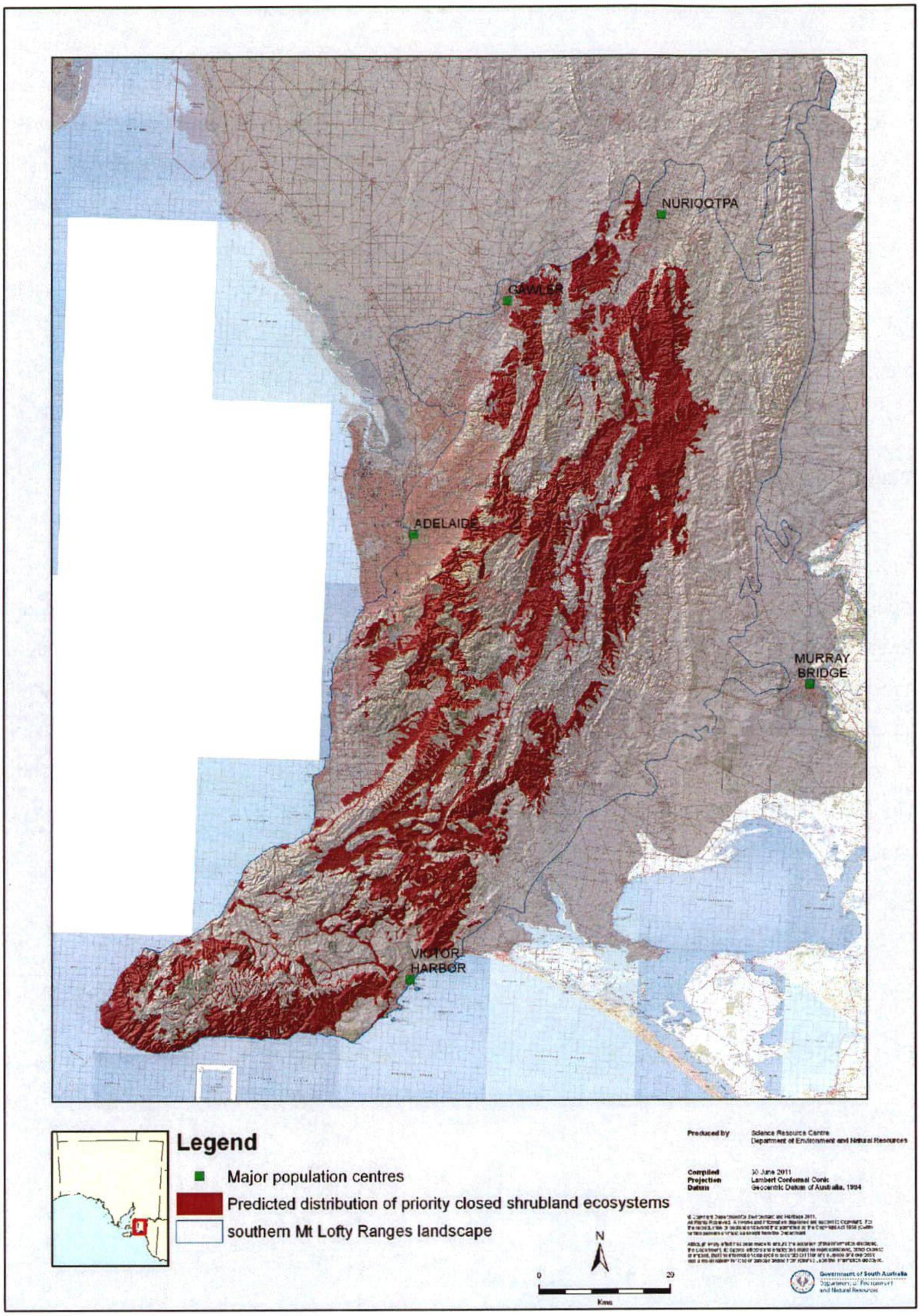


Figure 9. Predicted distribution of priority vegetation landscapes associated with closed shrublands ecosystem response group. The priority vegetation landscapes are the subset of vegetation landscapes presented in Figure 8 that have undergone a >50% reduction in area of occupancy of response group species.

Setting Targets for Priority Closed Shrubland Ecosystems

In the case of the lower rainfall grassy ecosystems priority above, an area target was set based on the known area requirements of area-sensitive species in the ecosystem response group, coupled with an estimate of minimum viable population for the species. However, the area requirements of the species in the closed shrubland species, as a whole, are very poorly understood. Based on a density estimate for Beautiful Firetail in Victorian coastal forests (0.1-0.19 birds.ha^{-1}; Palmer 2005), an estimated area requirement of 5 ha.individual-1 was used to calculate a preliminary target. Using a total minimum viable population of 5,000 individuals, this resulted in a landscape target of 25,000 ha of habitat required to support this response group.

Prioritising Planning Units for Restoration

As with lower rainfall grassy ecosystems, land use planning units that contained priority vegetation landscapes for closed shrubland restoration were prioritised using Marxan With Zones. The output from this analysis is presented in Figure 10. This prioritisation was based on two parameters: the distance of a planning unit from an occupied planning unit, and the area of mapped remnant vegetation within the planning unit. Marxan then selects planning units based on the lowest ecological 'cost' in achieving the area target (in this case, 25,000 ha across the landscape). These high priority planning units can then be used to assess further on-ground investigations, particularly regarding socio-economic considerations (such as landowner willingness) and restoration opportunities (e.g. current land-use or current state).

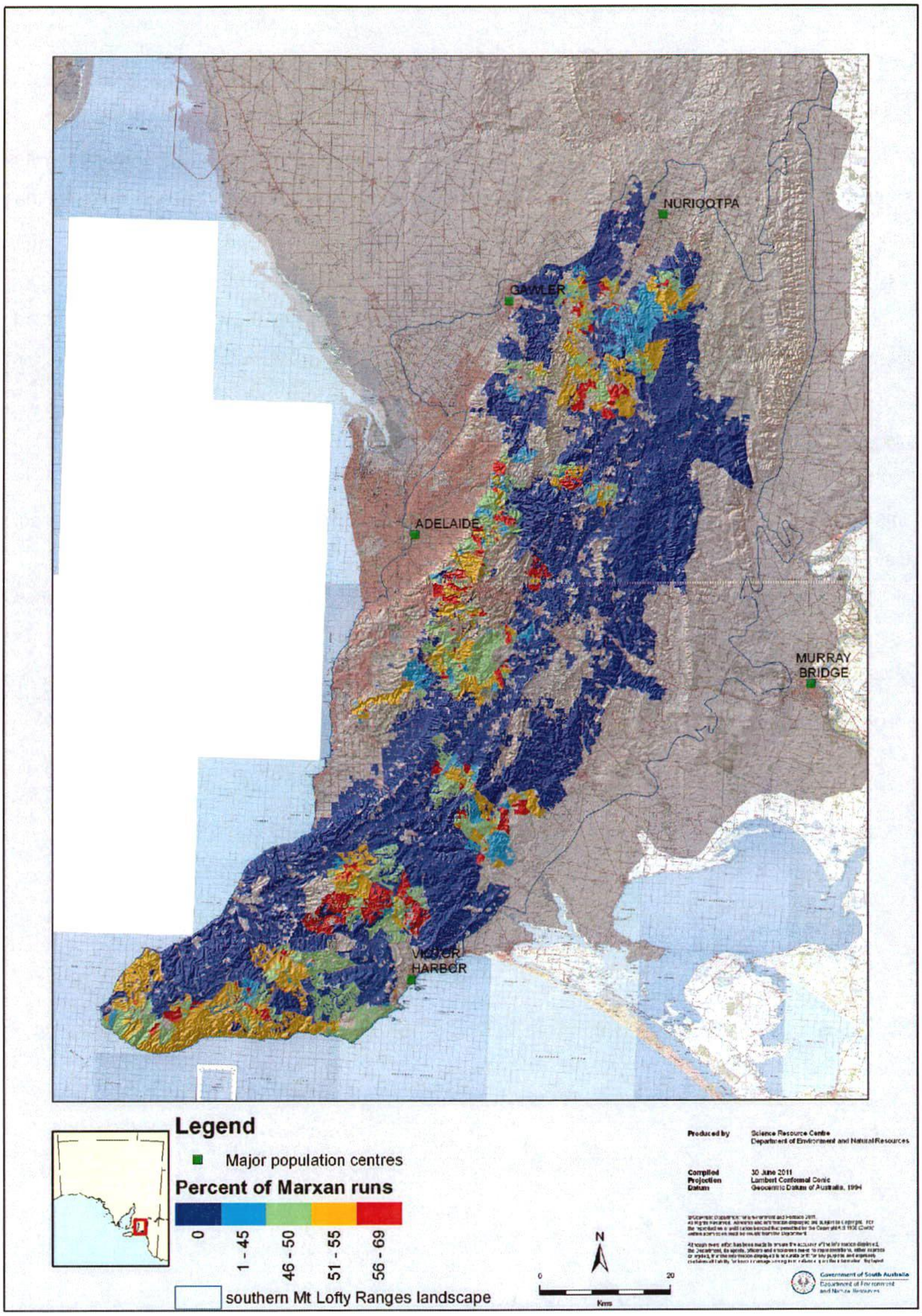


Figure 10. Prioritised planning units for the restoration of priority closed shrubland ecosystems in the southern Mt Lofty Ranges landscape. Colour scale reflects the percent of Marxan simulations in which the planning unit was included in the solution.

5. Conclusions and General Recommendations

This assessment has identified two coarse-filter systemic issues that require conservation attention within the southern Mt Lofty Ranges landscape. This general conclusion is based on the notion that each of these systems appear to be commonly associated with a group of bird species, the majority of which are regarded as threatened within this region. By identifying and acting on ecological requirements that are common across a range of species at risk in the landscape, we maximise our chances of meeting the conservation requirements of these species, as well as other species that have similar conservation requirements, for which we do not have adequate information to make such an assessment, but that are presumably threatened by the same systemic conservation.

In summary, this assessment has found that species at risk are most strongly associated with two broad groups of ecosystems:

1. Grassy ecosystems (and particularly grassy woodlands) on lower rainfall, gentle slope environments (typically *E. odorata*, *E. leucoxylon* and *A. verticillata* open woodlands)
2. Closed shrublands, and forests & woodlands with a closed shrubland understorey, associated with a range of higher rainfall environments.

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