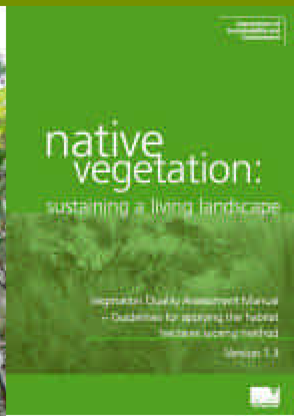
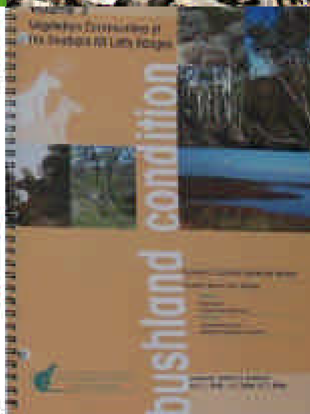
Department for Environment and Heritage

South Australian Native Vegetation Condition Indicator Pilot Project





Report

Government of South Australia

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Disclaimer

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Acronyms

BCM	Bushland Condition Monitoring
BS	Biological Survey of South Australia
DEH	Department for Environment and Heritage
DEM	Digital Elevation Model
DSE	Department of Sustainability and Environment
DWLBC	Department of Water, Land and Biodiversity Conservation
ESCAVI	Executive Steering Committee for Australian Vegetation Information
GIS	Geographic Information Systems
GPS	Global Positioning System
HH	Habitat Hectares
M&E	Monitoring and Evaluation
NCSSA	Nature Conservation Society of South Australia Inc.
NPWSA	National Park and Wildlife Reserves South Australia
NRM	Natural Resources Management
SA	South Australia
SABAT	South Australian Biodiversity Assessment Tool

Executive Summary

This report describes the activities undertaken for the South Australian Native Vegetation Condition Indicator Pilot project. This project is one of several being conducted in States and Territories around Australia for the Executive Steering Committee for Australian Vegetation Information (ESCAVI).

ESCAVI presents the Parkes *et al.* (2003) *Habitat Hectares* method as an example of an approach to the monitoring of native vegetation condition for the National Native Vegetation Condition indicator. The Nature Conservation Society of South Australia (NCSSA) developed a method for monitoring native vegetation condition for use in South Australia (SA) called the *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges* (Croft *et al.*, 2005). The Department for Environment and Heritage Biological Survey method (Heard and Channon, 1997) is used to collect native vegetation information in South Australia. This method was designed to provide an inventory of flora, rather than monitor change over time.

This report compares the *Habitat Hectares* method and the *Bushland Condition Monitoring* method. It also examines whether existing Biological Survey data can be used to provide data for *Bushland Condition Monitoring* condition analysis and mapping. The methods for developing benchmark groups are examined and the techniques used for undertaking site assessments are discussed to assess their variability. The results from the site assessments undertaken for this project are analysed and used to generate a vegetation condition surface. Implications for the application of ESCAVI's interim approach for a native vegetation indicator in South Australia are discussed and recommendations are suggested.

The analysis determined that the *Habitat Hectares* method and the *Bushland Condition Monitoring* method are relatively compatible. The specific measuring techniques vary but each method includes similar components of a vegetation community in the assessments. The *Bushland Condition Monitoring* method was developed to align with the Biological Survey method to assist in developing benchmark groups. As a result, many of the attributes common to both methods are measured similarly.

Field assessments were undertaken using the *Bushland Condition Monitoring* method and the *Habitat Hectares* method. A total of twenty-six sites were visited in the Para Wirra region of South Australia. Assessments using both methods were carried out at thirteen of these sites. Nine of the sites were located at existing Biological Survey sites to enable comparison of the results.

Benchmarks were developed for three vegetation benchmark groups within the study area. These benchmark groups were: *Eucalyptus camaldulensis var. camaldulensis, E. leucoxylon ssp.* Woodland with shrub understorey; *Eucalyptus fasciculosa, E. goniocalyx ssp. goniocalyx, Callitris*

gracilis Woodland with shrub understorey; and, *Eucalyptus goniocalyx spp. goniocalyx* Woodland with healthy understorey. Biological Survey data and expert knowledge were used to define the benchmark values. Data collected during the field trial was used to refine the benchmarks.

The vegetation condition scores recorded using the *Bushland Condition Monitoring* method and the *Habitat Hectares* method were compared. The vegetation condition scores were compared to the environmental characteristics of the study area. The small number of survey sites reduced the effectiveness of this analysis, inhibiting the ability to confidently determine any relationships between the environmental characteristics and the vegetation condition.

Different scores were recorded for the *Bushland Condition Monitoring* and the *Habitat Hectares* assessments at the thirteen coincident sites. *Bushland Condition Monitoring* scored both higher and lower than *Habitat Hectares* at the range of sites. The measuring techniques and method for categorising the results caused this score variation.

The Biological Survey data is compatible with the *Bushland Condition Monitoring* method, however only a limited number of Biological Survey attributes can be used within *Bushland Condition Monitoring* assessments. It is recommended that the Biological Survey data be further analysed to determine whether it can be used to represent the condition of vegetation at each site.

A surface of vegetation condition was produced for the study area. The inclusion of additional site data may improve the accuracy of the surface. The accuracy of this surface is unknown, however the use of extra digital layers within the model may also improve the accuracy and scale of the output surface.

Guidelines for a nationally consistent vegetation condition method could recommend the inclusion of attributes to measure a set of broad indicators. Specific methods and techniques for measuring these broad indicators can be developed by each state or territory. The relative weighting of each of the broad indicators should be nationally consistent. Other guidelines would also need to be developed such as the ability to weight each indicator and therefore generate a 'score' for each site assessed and the exclusion of landscape context components from the site condition assessment.

This report may assist in better understanding the relationship between the *Bushland Condition Monitoring* method employed in South Australia and the Victorian *Habitat Hectares* method. Understanding these relationships is important when developing a national data set of vegetation condition.

1. Introduction

This report describes the activities undertaken for the South Australian Native Vegetation Condition Indicator Pilot project. This project is one of several being conducted in States and Territories around Australia for the Executive Steering Committee for Australian Vegetation Information (ESCAVI).

The assessment of native vegetation condition is required under the National Natural Resource Management Monitoring and Evaluation (M&E) Framework (Natural Resource Management Ministerial Council, 2002). *Native Vegetation Communities' Integrity* is one 'matter for target' identified by the National Framework for Natural Resource Management Standards and Targets. Regional Natural Resources Management (NRM) plans will need to set targets in order to meet this national goal. This will contribute to the achievement of the following National outcome: *Biodiversity and the extent, diversity and condition of native ecosystems are maintained or rehabilitated.* Setting these targets will require guidance on the assessment of native vegetation condition, and the information required to underpin such assessment.

ESCAVI presents the Parkes *et al.* (2003) *Habitat Hectares* method as an example of an approach to the monitoring of native vegetation condition for the National Native Vegetation Condition indicator. The Victorian Department of Sustainability and Environment produced the *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method* (DSE, 2004a) as an extension to the Parkes *et al.* (2003) paper. This manual is referred to in this report as the *Habitat Hectares* approach.

The Nature Conservation Society of South Australia (NCSSA) developed a method for monitoring native vegetation condition for use in South Australia (SA) called the *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges* (Croft *et al.*, 2005). This method is being applied to a variety of projects in SA and is referred to throughout this report as the *Bushland Condition Monitoring* method. The Northern Yorke NRM group and the South Australian Murray Darling Basin NRM group have set vegetation condition targets within their NRM plans and intend to adopt this method for condition monitoring projects. The method is applied within the Upper South East Drainage/Levy Scheme to develop a Biodiversity Significance Index. This index is used to quantify biodiversity assets in order to offset the levy. The *Bushland Condition Monitoring* method is also being used as a part of the Eastern Mount Lofty Ranges Biodiversity Stewardship Initiative (*Bush Bids*) to allocate funds for the protection and enhancement of native vegetation.

The Department for Environment and Heritage Biological Survey method (Heard and Channon, 1997) is used to collect native vegetation information in South Australia. This method was designed to provide an inventory of flora, rather than monitor change over time. Almost 18,000 vegetation survey sites of varying ages exist across SA. The *Bushland Condition Monitoring* method was developed to be compatible with some aspects of the Department for Environment and Heritage Biological Survey to assist in developing benchmark values using existing Biological Survey data and to aid in future data storage requirements.

This report compares the *Habitat Hectares* method and the *Bushland Condition Monitoring* method. It also examines whether existing Biological Survey data can be used to provide data for *Bushland Condition Monitoring* condition analysis and mapping. The methods for developing benchmark groups are examined and the techinques used for undertaking site assessments are discussed to assess their variability. The results from the *Habitat Hectares* site assessments undertaken for this project are analysed and used to generate a vegetation condition surface. Implications for the application of ESCAVI's interim approach for a native vegetation indicator in South Australia are discussed and recommendations are suggested.

2. Objectives

The primary aim of this project is to test the application of ESCAVI's interim approach for a native vegetation indicator in the Mount Lofty Ranges region (Figure 2.1) of South Australia.

Figure 2.1 Location of the study area in the Mount Lofty Ranges

The specific objectives of this project are to:

1. Compare the *Bushland Condition Monitoring* method and the *Habitat Hectares* method and examine the suitability of the Biological Survey of South Australia data for providing information to *Bushland Condition Monitoring* condition assessments;
2. Undertake field assessments using the *Bushland Condition Monitoring* method and the *Habitat Hectares* method;
3. Develop three vegetation benchmark groups within the study area;
4. Analyse and compare the vegetation condition scores recorded using the two methods during the field assessments, and;
5. Produce a surface of vegetation condition across the study area.

The first objective involves a 'desktop' examination of the three methodologies. The aims are to:

a. Determine the compatibility of the site condition indicators within the *Bushland Condition Monitoring* and *Habitat Hectares* methods, and;
b. Determine whether the DEH Biological Survey data can be used to provide information for *Bushland Condition Monitoring* condition assessments.

ESCAVI provides guidance on the development of frameworks for vegetation information and presents the *Habitat Hectares* method as an example for assessing vegetation condition. The *Bushland Condition Monitoring* method has already been adopted by a number of groups within South Australia. For national reporting purposes, the first objective aims to examine whether the *Bushland Condition Monitoring* method is consistent with the *Habitat Hectares* method.

The second objective involves the collection of field data using the *Bushland Condition Monitoring* method and the *Habitat Hectares* method. Existing Biological Survey data and expert knowledge are used to develop three vegetation benchmark groups as a part of the third objective. This involves identifying vegetation types that are in a "mature and long-undisturbed state" (DSE, 2004a). The site characteristics of these benchmark groups are used for comparison purposes to assess the condition of remnant vegetation. The fourth objective examines the data collected as a part of the field trials. This involves comparing the results from the *Bushland Condition Monitoring* assessments and the *Habitat Hectares* assessments. Environmental characteristics are also examined in relation to the condition scores calculated using both methods. This is to determine whether there are any relationships between the condition scores and the land management, land use, fire history or benchmark group identified at the sites. The final objective is to generate a spatial surface of the native vegetation condition within the study area.

3. Methodology

This section explains the methods applied to each objective described in section 2. Figure 3.1 represents a flowchart of the methodology and provides a brief description of each step in the project.

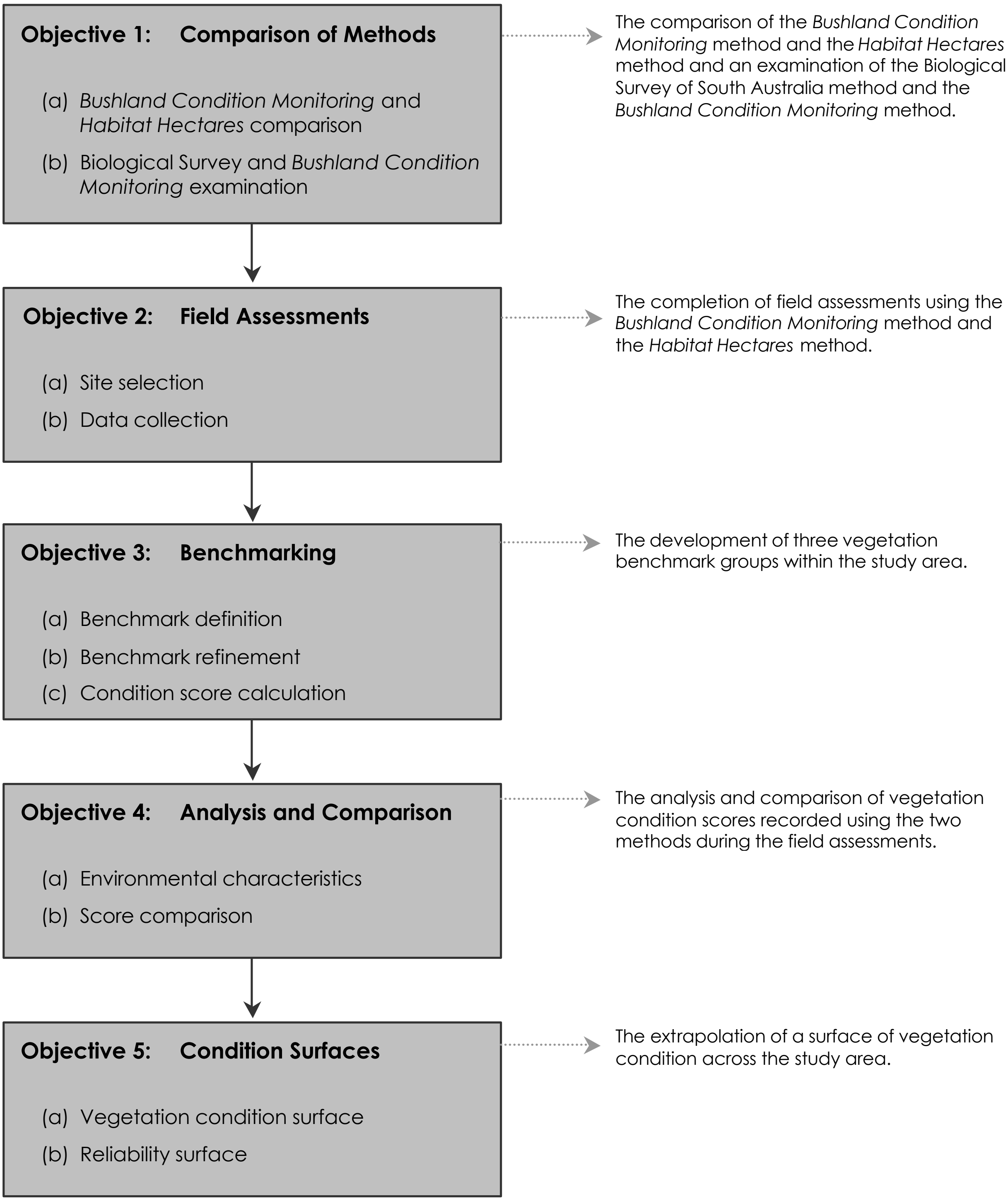

Figure 3.1 Methodology flowchart

3.1. Comparison of Methods

The method comparison involved two components. These were:

1. *Bushland Condition Monitoring* and *Habitat Hectares* comparison, and;
2. Biological Survey and *Bushland Condition Monitoring* examination.

These components are discussed in detail in the following sections.

3.1.1. *Bushland Condition Monitoring* and *Habitat Hectares*

The *Bushland Condition Monitoring* method was compared to the *Habitat Hectares* method. This involved a detailed assessment of each site condition component found within each method.

Table 3.1 and Table 3.2 list the site condition components of the *Habitat Hectares* and *Bushland Condition Monitoring* methods respectively.

Table 3.1 *Habitat Hectares* site condition components

Site condition components
Large Trees
Tree Canopy Cover
Understorey
Lack of Weeds
Recruitment
Organic Litter
Logs

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Table 3.2 *Bushland Condition Monitoring* site condition components

Site condition components
Plant Species Diversity
Weed Abundance and Threat
Structural Diversity A: Ground Cover
Structural Diversity B: Plant Life Forms
Regeneration
Tree and Shrub Health
Tree Habitat Features
Feral Animals
Total Grazing Pressure
Fauna Species Diversity

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

The initial analysis highlighted relationships between the site condition components of the two methods. In many cases these correlations were not simple or direct. One indicator in one method was not exclusive to one indicator in the other method. For example, the Structural Diversity B: Plant Life Forms site condition component of the *Bushland Condition Monitoring* method relates to aspects of the *Habitat Hectares* Understorey and Tree Canopy Cover indicators. The site condition components were grouped into four broader categories to more effectively compare the two methods. Table 3.3 lists the indicators from each method grouped within the four broad categories.

Table 3.3 Four broad indicator categories and the site condition components

Broad indicator categories	***Habitat Hectares* indicators**	***Bushland Condition Monitoring* indicators**
Diversity	Tree Canopy Cover Understorey Large Trees	Plant Species Diversity Structural Diversity B: Plant Life Forms Tree Habitat Features: Tree Habitat Tree and Shrub Health
Growth Stages	Recruitment	Regeneration
Litter	Organic Litter Logs	Structural Diversity A: Ground Cover Tree Habitat Features: Fallen Logs and Trees
Weeds	Lack of Weeds	Weed Abundance and Threat

There are several components of the *Bushland Condition Monitoring* method that are either excluded from the scoring process or that are duplicated within more than one indicator. These are summarised below.

- The *Bushland Condition Monitoring Manual* assesses Feral Animals, Total Grazing Pressure and Fauna Species Diversity. Feral animals and Fauna Species Diversity require several periods of monitoring to build up a comprehensive data set that will give a more accurate indication of bushland condition (S. Croft, pers. comm., 2005, NCSSA). They are not used to score the condition of a vegetation community.
- The Tree Habitat Features indicator contains a Tree Habitat score, a Tree Hollows score and a Fallen Logs and Trees score. The Tree Habitat score is the sum of the scores for tree hollows, tree size and canopy health. As tree hollows are measured within both the Tree Hollows score and the Tree Habitat score, the Tree Hollows score is excluded from the analysis to avoid duplicating the information.
- The *Bushland Condition Monitoring* Tree and Shrub Health indicator measures the dieback, lerp damage and mistletoe infestation of ten trees at a site. Lerp damage and mistletoe infestation were removed from the comparison and scoring processes for three reasons.
    1. Dieback is often a reflection of the adverse effects caused by unnaturally high and sustained lerp and mistletoe (S. Croft, pers. comm., 2005, NCSSA).

2. Lerp and mistletoe may be more of a temporary phenomenon than dieback and may not reflect the long-term tree health (however high levels may be early warning signs of tree decline) (S. Croft, pers. comm., 2005, NCSSA).
3. In South Australia, unnaturally high levels of lerp infestation are confined mainly to Red Gum, Blue Gum and Pink Gum, with other species being less susceptible (S. Croft, pers. comm., 2005, NCSSA).

Each *Habitat Hectares* site condition indicator was analysed in the context of the four broad indicators defined in Table 3.3 to determine the specific data collection elements. The comparable site condition indicators within the *Bushland Condition Monitoring* method were then analysed and compared to the *Habitat Hectares* indicators.

3.1.2. Biological Survey and *Bushland Condition Monitoring*

The DEH Biological Survey data was also examined. Almost 18,000 Biological Survey sites exist across South Australia. Data at these sites has been collected over the past thirty years with varying levels of detail. The ability to use parts of the Biological Survey site data as the basis for *Bushland Condition Monitoring* assessments has the potential to greatly increase the efficiency of condition assessments at these Biological Survey sites. Existing Biological Survey information was analysed to assess its ability to provide condition information to the *Bushland Condition Monitoring* assessments. This involved identifying the Biological Survey attributes that provide information for the *Bushland Condition Monitoring* site condition indicators.

The ability to integrate the *Bushland Condition Monitoring* information into existing DEH databases was also examined.

3.2. Field Assessments

The field assessments component of the project involved two stages. These were:

1. Site selection, and;
2. Data collection.

These components are discussed in detail in the following sections.

3.2.1. Site selection

Field assessment sites were selected using ortho-rectified photography in combination with the land management practises in the region. Sites were selected to represent a range of land management practises within each of the three vegetation benchmark groups. The land management types included in the field trial were:

- National park reserves
- Forestry SA reserves
- SA Water reserves
- Private property
- Vegetation heritage agreements
- Roadside reserves

The location and survey date of existing DEH Biological Survey sites was considered as a part of the selection process. The more recent Biological Survey sites were selected where possible as these contain more comprehensive information than the older survey sites. Nine Biological Survey sites were identified within the three vegetation benchmark groups and condition surveys were carried out at these locations. This allowed a comparison of the Biological Survey site data with the condition assessment data at coincident sites.

Private property owners, NPWSA authorities, Forestry SA staff and SA Water staff were contacted prior to commencement of the surveys. Permission to access each site was sought from the relevant party and arrangements were made to visit the sites. A total of twenty-six vegetation condition sites were assessed.

3.2.2. Data collection

Two groups collected the field data at a total of twenty-six sites. The NCSSA used both the *Bushland Condition Monitoring* method and the *Habitat Hectares* method to complete the assessments at thirteen sites. Staff from DEH used only the *Habitat Hectares* method to assess thirteen sites.

Each site was located using a GPS and hardcopy map. The vegetation community at the site was examined to ensure it matched the vegetation community mapped in the floristic dataset. In a few cases the vegetation mapping group did not represent the vegetation community on the ground. An alternative site was chosen in these cases.

A 30 x 30 metre quadrat was marked at each site. These sites were selected to represent the average condition of the vegetation community. Photographs of the vegetation at the site were taken and the number of the photograph was recorded on the datasheet.

The *Habitat Hectares* method scores many of the indicators through comparison to a benchmark value. However, due to an absence of this benchmarking data, DEH staff collected additional information at each site. The condition scores were calculated upon completion of the benchmarks. Table 3.4 lists each *Habitat Hectares* indicator and shows the information collected by DEH at each site.

Table 3.4 *Habitat Hectares* indicators and site information collected by DEH

Indicator	Site information collected
Large Trees & Tree Canopy Cover	*For each tree:*
	▪ Height (m)
	▪ Canopy type (%)
	▪ Canopy depth (m)
	▪ Canopy diameter (m)
	▪ Canopy gap (m)
	▪ % healthy cover
	▪ DBH of each 'large' tree
Understorey & Recruitment	*For each species:*
	▪ Life form
	▪ % cover
	▪ Woody (Yes/No)
	▪ Recruiting (Yes/No)
	▪ Weed (Yes/No)
Lack of Weeds	▪ Total cover (%)
Organic Litter	▪ Total cover (%)
	▪ Predominantly native or non-native
Logs	*For logs > 10cm diameter:*
	▪ Diameter (cm)
	▪ Length (cm)

*DBH = diameter at breast height

A series of attributes were recorded for the Large Trees and Tree Canopy Cover indicators (see Table 3.4). 'Large' trees were identified by the surveyor and were selected based on their size in relation to an expected large tree. Because the benchmark DBH of a 'large' tree was undefined, the surveyors measured all trees with a DBH of greater than approximately 20cm. The canopy type and canopy health were estimated for each large tree using the illustrations in the *Habitat Hectares* manual (DSE, 2004a) as a guide. The height, canopy depth, canopy diameter and canopy gap were measured using a two metre range pole. Figure 3.2 illustrates the characteristics of these measurements.

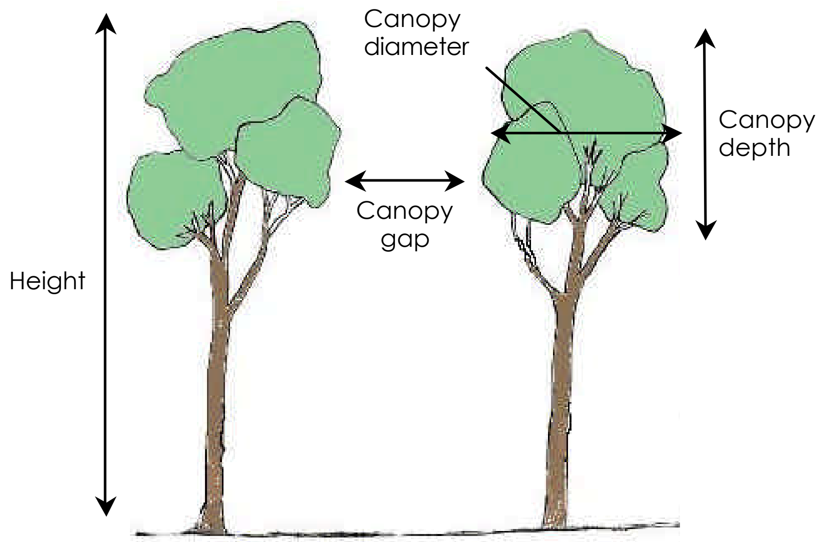

Figure 3.2 Canopy characteristics

The Understorey and Recruitment components were measured for each species at a site. A species list was compiled and the life form category was recorded against each species. The percentage cover of each species was also recorded on the data sheet. Each native woody species was identified and evidence of recruitment was recorded. Recruitment was only recorded for a species where it was deemed 'adequate'. DEH defined 'adequate' recruitment for the tree canopy as instances where at least two cohorts were present (DSE, 2004a). Weed species were also identified on the datasheet. Figure 3.3 is an example of the datasheet used to record the species information. The Understorey and Recruitment components were calculated using this information.

Species List

	Species	Life Form	% cover	Woody?	Recruiting?	Weed?
1						
2						
3						
4						
5						

Figure 3.3 Datasheet used to record the Understorey and Recruitment components

The total percentage cover of weeds at a site was recorded for the Lack of Weeds indicator. The percentage cover of 'high threat' weeds was also noted. 'High threat' weeds are those that have a high impact on indigenous life forms regardless of their invasiveness (DSE, 2004a). A list of these high threat weeds (which also included their degree of invasiveness) was defined by the NCSSA for the Southern Mount Lofty Ranges prior to the survey (Croft *et al.*, 2005).

The percentage cover of organic litter was recorded at each site. It was also noted whether native or non-native litter dominated the site. Logs were identified as those with a diameter greater than 10cm. The diameter and length of each log was recorded.

3.3. Benchmarking

Three benchmark vegetation groups were defined within the study area using existing native vegetation mapping information and interpretive processes. The existing vegetation mapping groups were categorised into broader vegetation, or benchmark, groups. This involved identifying mapping groups with common dominant overstorey species and understorey structure and grouping them together. Three benchmark groups that covered the most significant proportion of the study area were selected for use within this study. These benchmark groups are listed in Table 3.5. Benchmark values were calculated according to both the *Bushland Condition Monitoring* method and the *Habitat Hectares* method. These will be used in a subsequent stage of the project to compare the condition scores calculated at identical sites using the *Bushland Condition Monitoring* and *Habitat Hectares* methods.

Table 3.5 Benchmark vegetation groups

Benchmark Number	Benchmark Description
5	*Eucalyptus camaldulensis* var. *camaldulensis, E. leucoxylon ssp.* Woodland with shrub understorey
6	*Eucalyptus fasciculosa, E. goniocalyx* ssp. *goniocalyx, Callitris gracilis* Woodland with shrub understorey
8	*Eucalyptus goniocalyx* spp. *goniocalyx* Woodland with heathy understorey

3.3.1. *Bushland Condition Monitoring* benchmarks

The NCSSA have previously developed *Bushland Condition Monitoring* benchmark groups for the vegetation types within the Southern Mount Lofty Ranges (Croft *et al.*, 2005). The vegetation types for which these benchmark groups exist are slightly broader than those listed in Table 3.5. As a result, the existing *Bushland Condition Monitoring* benchmark group "Eucalyptus Forests and Woodlands with a dense sclerophyll Shrub Understorey" was used for benchmark groups 6 and 8, while "Woodlands with an Open Shrub and Grassy Understorey" was used for benchmark group 5.

3.3.2. *Habitat Hectares* benchmarks

For the *Habitat Hectares* benchmark groups, it was necessary to determine the benchmark values for each of the site condition assessment components (Table 3.1). The Biological Survey site data was examined to obtain an initial understanding of the potential range of vegetation attributes within the benchmark communities. The attributes within the Biological Survey database that were relevant to the benchmarking process were:

- Number of native species
- Number and cover of weed species
- Number and cover of life forms
- Ground cover percent
- Bare ground percent

The survey sites present within the benchmark vegetation groups were identified and their attributes examined. The *Habitat Hectares* vegetation benchmark values were then developed using the knowledge of experts in the vegetation of the Southern Mount Lofty Ranges.

3.3.3. Condition score calculation

3.3.3.1. *Habitat Hectares*

The raw data collected during the field trials and the benchmark values were used to score each site according to the *Habitat Hectares* method. The field data was compared to the benchmark values for each indicator to determine the appropriate score. These scores were then summed to produce the total condition score out of a maximum seventy-five points.

3.3.3.2. *Bushland Condition Monitoring*

The NCSSA completed the *Bushland Condition Monitoring* site assessments using the method outlined in the *Bushland Condition Monitoring Manual* (Croft *et al.,* 2005). The results were then converted to scores based on the weightings developed for each indicator by the Department of Water, Land and Biodiversity Conservation (DWLBC) for the South Australian Biodiversity Assessment Tool (SABAT). This involved converting the values for each indicator into a percentage based on the maximum value obtainable for each indicator. The scores were then summed to determine the total condition score out of a maximum ninety-five points.

3.4. Analysis and Comparison

The analysis component of the project examined the results from the field assessments and consisted of three components:

1. Comparison of the condition scores at each site to the environmental characteristics;
2. Comparison of the condition scores from each method at the thirteen coincident sites, and;
3. Comparison of the *Bushland Condition Monitoring* condition scores to the existing Biological Survey data at the nine coincident sites.

The results from the field trials were converted into a comparable format prior to the analysis. The *Habitat Hectares* score is out of a possible total of seventy-five and the *Bushland Condition Monitoring* score is out of ninety-five. The weightings from both methods were therefore converted to a percentage of the total condition score to allow comparisons to be made between the results. Table 3.6 and Table 3.7 list the weightings and equivalent percentages calculated for each indicator of the *Bushland Condition Monitoring* and the *Habitat Hectares* methods. These weightings and percentages are used throughout the analysis.

Table 3.6 Weightings assigned to each *Bushland Condition Monitoring* indicator

***Bushland Condition Monitoring* indicators**	**Weighting**	**Percent (%)**
Plant Species Diversity	25	26
Structural Diversity A: Ground Cover	5	5
Structural Diversity B: Plant Life Forms	15	16
Weed Abundance and Threat	15	16
Regeneration	10	11
Tree and Shrub Health	10	11
Tree Habitat	10	11
Fallen Logs and Trees	5	5
Total	95	100

Table source: Adapted from DWLBC, South Australian Biodiversity Assessment Tool, 2005. Percent column calculated by S. Crossman, DEH, 2005.

Table 3.7 Weightings assigned to each *Habitat Hectares* indicator

***Habitat Hectares* indicators**	**Weighting**	**Percent (%)**
Understorey	25	33
Lack of Weeds	15	20
Recruitment	10	13
Large Trees	10	13
Tree Canopy Cover	5	7
Organic Litter	5	7
Logs	5	7
Total	75	100

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne. Percent column calculated by S. Crossman, DEH, 2005.

3.4.1. Environmental characteristics

The environmental characteristics were assessed relative to the vegetation condition scores at the survey sites to determine whether any relationships exist between the two. The results from this analysis were used to develop the surface of vegetation condition in section 3.5. The environmental characteristics assessed were:

- Surrounding land use
- Land management
- Vegetation benchmark group

The minimum, maximum and average site condition scores were calculated for each of the environmental characteristics. The number of sites present within each of the above categories was also recorded.

3.4.2. Score comparison

The condition of the vegetation at thirteen of the twenty-six sites was assessed using both the *Bushland Condition Monitoring* and the *Habitat Hectares* methods. The data collected at each site was expressed as a percentage of the possible total score for each indicator. The average total condition score measured using each method was calculated and a t-Test and p-value were generated to determine if there is a significant difference between the scores.

The difference between the total condition percentage scores at the thirteen coincident sites was also calculated. P-values and t-Tests were generated for the indicators from each method and used to compare analogous components of each condition assessment method.

The four broad indicator categories developed during the comparison process (outlined in section 3.1) were also used to analyse the field results. These were Diversity, Growth Stages, Litter and Weeds. The correlation between these broad indicator scores was examined for both the *Bushland Condition Monitoring* method and the *Habitat Hectares* method using t-Tests, p-value and correlation coefficients.

3.4.3. Biological Survey and *Bushland Condition Monitoring* comparison

Nine of the twenty-six condition assessment sites were located at existing Biological Survey sites (Figure 3.4). The attributes identified as equivalent to the *Bushland Condition Monitoring* method in section 3.1.2 were compared to the *Bushland Condition Monitoring* data collected at identical sites. The attributes compared were:

- Number of native species
- Number and cover of weed species
- Percent of bare ground

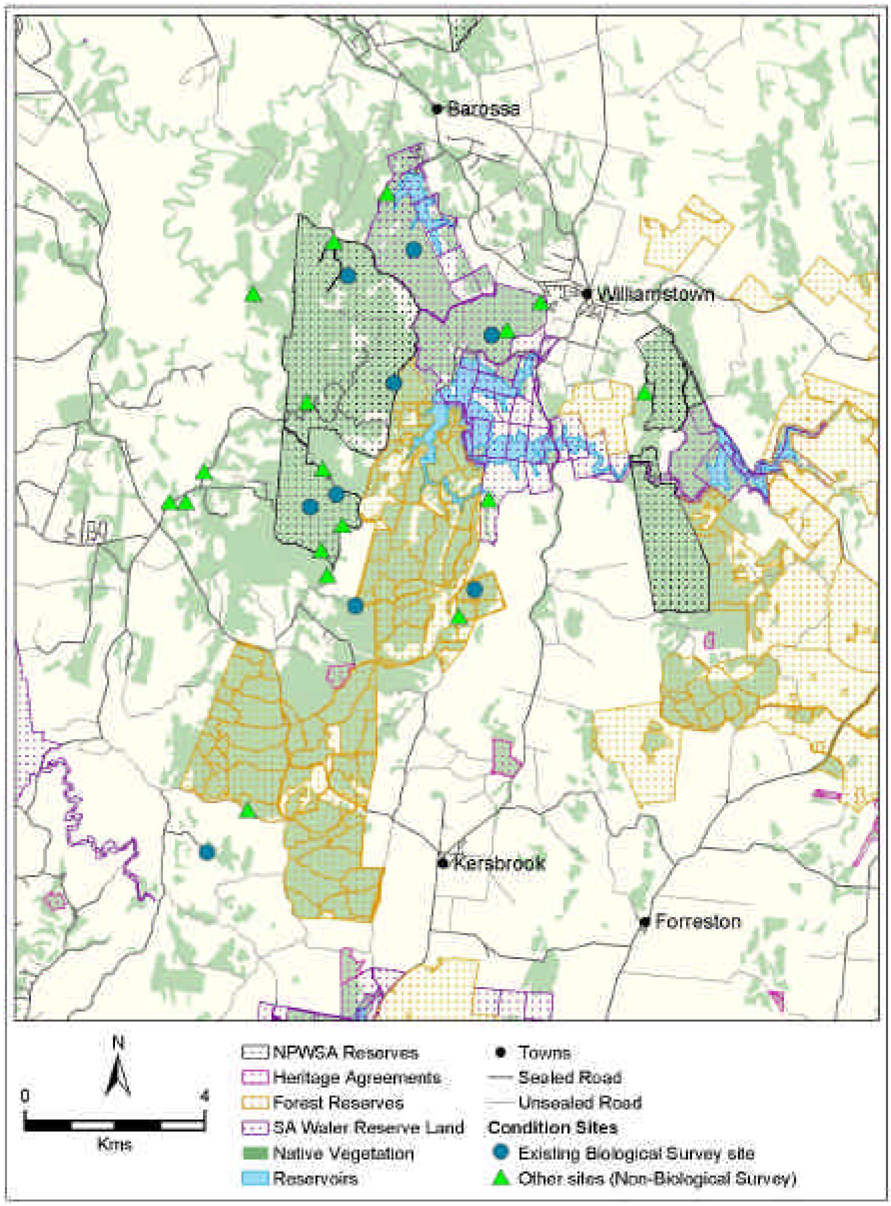

Figure 3.4 Location of Biological Survey sites

A series of queries were generated in Microsoft Access to extract the relevant data from the Biological Survey database for these nine sites. The number of native species was aggregated for each Biological Survey site.

The bare ground score from the *Bushland Condition Monitoring* sites was compared to the bare ground score from the Biological Survey sites for the ground cover indicator. The bare ground information was used instead of the *Bushland Condition Monitoring* total ground cover data and the Biological Survey plant litter information. This was due to the use of different interpretation and sampling methods to record leaf litter.

The five most abundant weed species recorded at each Biological Survey site were identified. At some sites there were several weed species with the same cover abundance. The species with the highest threat category were included in the analysis where this occurred to ensure only five species were analysed. These species and their cover abundance ratings were compared to those recorded in the *Bushland Condition Monitoring* assessments.

The Biological Surv ey assemblage information may possibly be used to provide life form information to the *Bushland Condition Monitoring* method. The assemblage data is recorded within different cover category ranges than the *Bushland Condition Monitoring* life form data. Further analysis is required to determine the use of the Biological Survey assemblage data within *Bushland Condition Monitoring* assessments and to align the cover categories from both methods.

3.5. Condition Surfaces

This component of the project involved developing a method to create a surface representing vegetation condition in the study area. The method was developed using the results from the field trial. The *Habitat Hectares* condition scores were used to develop the condition surface. This was due to the existence of data at twenty-six sites compared to only thirteen *Bushland Condition Monitoring* sites. However, the same method could be applied using the *Bushland Condition Monitoring* site data.

The methodology for this part of the project was to:

1. Generate a surface of overall condition classes, and;
2. Generate a surface of reliability.

Each of these components is discussed in detail in the following sections.

3.5.1. Vegetation condition surface

The surface of overall condition developed for this stage of the project was a 30 metre resolution grid representing vegetation condition in the study area. The size of these grid cells was selected to reflect the size of the field site quadrats. Three steps were completed to produce this surface:

1. Develop a site condition surface using the site condition scores;
2. Develop the landscape context surface, and;
3. Combine the site condition surface with the landscape context surface to develop overall condition classes.

These steps are described in the following sections.

3.5.1.1. Site condition

The site condition grid was generated using the *Habitat Hectares* site condition scores, a grid of native vegetation benchmark groups and a land use grid, as explained below.

3.5.1.1.1. Survey site grid

A survey site grid was produced using the *Habitat Hectares* site condition scores. The point-based site data was converted to a grid with each of the twenty-six grid cells representing a *Habitat Hectares* site condition score. The site condition scores were out of a total of seventy-five points. The remaining twenty-five points (producing a total of one hundred) are scored using the landscape context components described in section 3.5.1.2.

3.5.1.1.2. Vegetation grid

The native vegetation coverage was converted to a grid. This coverage contained an attribute called 'Benchmark_No' that stored the number of the benchmark vegetation community in the study area. Table 3.5 lists the three vegetation benchmark groups and their descriptions. This attribute was used to create the vegetation grid.

3.5.1.1.3. Land use grid

A coverage of land use was used as a basis for the land use grid. The land use information was obtained from the Department of Water, Land and Biodiversity Conservation (DWLBC). The *Land Use Mapping of South Australia: Mount Lofty Ranges* dataset was digitised from aerial photography and satellite imagery. Extensive fieldwork was undertaken to validate the mapping and it is deemed to be approximately 80% accurate (DWLBC, 1999). The land use mapping undertaken in 1999 does not completely cover the study area. The 1993 land use mapping was used to supplement the 1999 data set.

The DWLBC land use mapping is based on the Australian Land Use Mapping (ALUM) codes (BRS, 2002). The level of ALUM classification used within the DWLBC dataset is variable. The primary level description is used in some instances, while a tertiary level description is used in other cases. These descriptions were edited to ensure that all land use types were described at the primary level. Table 3.8 lists the six categories within the primary level of land use classification.

Table 3.8 Primary level of land use

ALUM Code	Description
1	Conservation and natural environments
2	Production from relatively natural environments
3	Production from dryland agriculture and plantations
4	Production from irrigated agriculture and plantations
5	Intensive uses
6	Water

Table source: Bureau of Rural Sciences 2002, Land Use Mapping at Catchment Scale. Principles, Procedures and Definitions. Edition 2. Commonwealth of Australia, Canberra.

The classification of some areas was altered slightly to more closely reflect the land use. The Forestry SA native forest reserves (data supplied by Forestry SA) were classified in the land use data set as 'Grazing natural vegetation' (within the primary level code 2 'Production from relatively natural environments'). Forestry SA state that their reserves are managed for biodiversity conservation (http://www.forestry.sa.gov.au/conserv.stm). These native forest reserve areas were therefore changed to primary level code 1 'Conservation and natural environments'.

An area of land classified by DWLBC as 'reservoir' within the 'Water' primary level was also changed. An examination of this particular area in relation to mapped water bodies and ortho rectified aerial photography revealed that it was not a part of the reservoir. The coding of this area was changed to 'Production from relatively natural environments' to align with the classification of other land owned by SA Water.

The ALUM codes (see Table 3.8) were multiplied by 100. This ensured the land use codes and the vegetation benchmark group codes could still be identified when the two grids were added together. The new ALUM codes were then used to generate the land use grid.

3.5.1.1.4. Vegetation and land use grid

The vegetation grid and the land use grid were then summed. The resulting grid contains unique combinations of vegetation benchmark group and land use type. It was assumed that the condition of vegetation is similar in areas of similar vegetation types and land uses. As a result, this grid was used in conjunction with the site condition grid to generate a surface of vegetation condition.

3.5.1.1.5. Extrapolation

The survey site grid was extrapolated across the study area to generate a surface of vegetation condition. The combined vegetation and land use grid was used to represent areas, or zones, of unique types. These zones were related to the cells in the survey site grid. The average value of the sites in each zone was assigned to equivalent areas within the study boundary. For example, if there are two condition sites within areas of the combined vegetation and land use grid identified as code 105 (i.e. vegetation benchmark group number 5 and land use code 100), the average of the scores at the two sites will be applied to all areas in the output grid that have a vegetation and land use code of 105. The scores at the original sites were reinstated in the final site condition surface. The surface was clipped to only those areas were native vegetation has been mapped.

3.5.1.2. Landscape context

The *Habitat Hectares* method includes a landscape context component in the condition assessment. This component examines the size of the vegetation patch, the proportion of vegetation in the neighbourhood area and the distance of the assessment area to core areas. These three components are discussed in detail in the following sections.

3.5.1.2.1. Patch size

The vegetation layer was used as a basis for the patch size grid. Each vegetation polygon was dissolved to remove any internal boundaries. The area of each vegetation polygon was then calculated and stored in a field in the attribute table. The *Habitat Hectares* method classifies the patch areas into six categories. These categories are listed in Figure 3.5. Patches in the vegetation layer were coded with values according to the patch area. The absence of disturbance information for each vegetation mapping polygon made it impossible to differentiate between 'significantly disturbed' and 'not significantly disturbed' areas. For the purposes of this project it was assumed that most of the vegetation in the study area is disturbed. As a result, the category marked with an asterisk in Figure 3.5 was excluded and all patches greater than 20 hectares were given a value of 8. The vegetation layer was then converted to a grid. The category values were used to generate the grid cell values.

Category & Description	Value
< 2 ha	1
between 2 and 5 ha	2
between 5 and 10 ha	4
between 10 and 20 ha	6
> 20 ha but 'significantly disturbed'*	8
* > 20 ha but 'not significantly disturbed'	10

* as defined in the Regional Forest Agreement Old Growth analyses
(note: effectively all remnants in the fragmented and relictual rural landscapes are classified as 'significantly disturbed')

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 3.5 Patch size categories

3.5.1.2.2. Neighbourhood

The neighbourhood grid represents the amount and configuration of vegetation within proximity to the assessment area. The amount of native vegetation is assessed within three neighbourhood radii of 100 metres, 1 kilometre and 5 kilometres.

A grid was produced that represents the presence and absence of vegetation. A value of one represented vegetation presence and zero represented absence. This grid was then used to determine the number of cells containing vegetation within each neighbourhood radii. The ArcInfo command FOCALSUM was implemented for each radii. This command produced a grid for each radius where the cell values indicate the number of vegetated grid cells within the specified distance from each cell.

The maximum number of vegetated cells within the three buffer areas was determined using the EUCDISTANCE command. Each neighbourhood radii grid was then divided by the maximum number of vegetated cells within each radius and converted to a percentage. The *Habitat Hectares* method assesses the vegetation rounded to the nearest 20%. A series of conditional statements were used to round the percentage grids to the nearest twenty percent.

The scores for each radius grid were determined by multiplying the percentage native vegetation values by a weighting. The *Habitat Hectares* method weightings are 0.03 for the 100 metre grid and the five kilometre grid values and a 0.04 weighting for the one kilometre grid values. These weighted grids are then added together to create a final neighbourhood grid with scores out of ten.

3.5.1.2.3. Distance to core areas

This part of the landscape context component involves calculating the distance from each cell to the nearest core area. DSE (2004) define a core area as an area of native vegetation greater than 50 hectares. The distance to a core area is considered contiguous where an assessment area is a part of a core area (DSE, 2004a).

The vegetation layer was used as a basis for the distance to core area grid. The layer was dissolved and areas greater than fifty hectares were identified and labelled as 'core areas'. This layer was then converted to a grid to represent core and non-core areas.

The distance from each grid cell to these core areas was then determined using the EUCDISTANCE command. The distances were then categorised and converted to a score as in the *Habitat Hectares* method (Figure 3.6) using a series of conditional statements. Only the 'not significantly disturbed' scores were used in this study. Differentiating between significant disturbance and insignificant disturbance is not possible when using only the available spatial layers.

Distance	Core Area not significantly disturbed*	Core Area significantly disturbed*
> 5 km	0	0
1 to 5 km	2	1
< 1 km	4	3
contiguous	5	4

* defined as per RFA 'Old Growth' analyses

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 3.6 Distance to core area scores

3.5.1.2.4. Landscape context grid

The patch size, neighbourhood and distance to core areas grids were combined to form the landscape context grid. The cells in this grid are scored out of a possible total of twenty-five points.

3.5.1.3. Condition surface

The final step involved in developing the surface of vegetation condition was to combine the site condition grid with the landscape context grid. The grids were added together to produce the vegetation condition grid containing scores out of one hundred. The condition values have been categorised into five condition classes. A value of 'unknown' was assigned to those cells where there was no site condition score.

3.5.2. Reliability surface

A reliability surface was produced to describe the accuracy of the vegetation condition surface. The area was classified into three categories; high, medium and low reliability. The cells were coded with high reliability where field sites exist. As described in the section 3.5.1.1.5, the site condition scores were averaged during the extrapolation process. The reliability of these extrapolated cells was then determined by assessing the magnitude of separation from the original field site values. For the purpose of this study, cells were assigned with a low reliability where the maximum and minimum site values varied by greater than or equal to fifteen points, as a natural break occurred at this point in the data range. A medium reliability was assigned to the cells where the range was between one and fifteen points. If more site data was available, a different measure of reliability, such as standard deviation, should be used indicate the confidence in the condition surface grid values.

4. Results

This section discusses the results from the five stages of the project. The method comparison process is summarised in the context of the four broad indicators and the results from the benchmarking process are discussed. The field assessment results are calculated and analysed and this section will conclude by discussing the results of the extrapolation process to define vegetation condition in the study area.

4.1. Comparison of Methods

4.1.1. *Bushland Condition Monitoring* and *Habitat Hectares*

The comparison process highlighted that the *Bushland Condition Monitoring* and *Habitat Hectares* vegetation condition assessment methods are relativ ely compatible. There are some fundamental differences in the design of the methods. These are discussed in the following sections.

4.1.1.1. Scoring

The *Bushland Condition Monitoring* method measures vegetation condition within a 30m x 30m quadrat. The method was designed for property owners to monitor temporal changes in vegetation condition. Consequently, assessments can be repeated over time on the same quadrat. The method is designed for use by people with a range of proficiencies, with the NCSSA offering training in the *Bushland Condition Monitoring* method prior to conducting surveys in the field.

Each site condition indicator is recorded as a raw value. These raw values are converted to a score and compared to a benchmark value for a particular vegetation type at the end of the assessment process (Croft *et al.*, 2005). Figure 4.1 is an example of some of the benchmark indicator scores for a particular vegetation community.

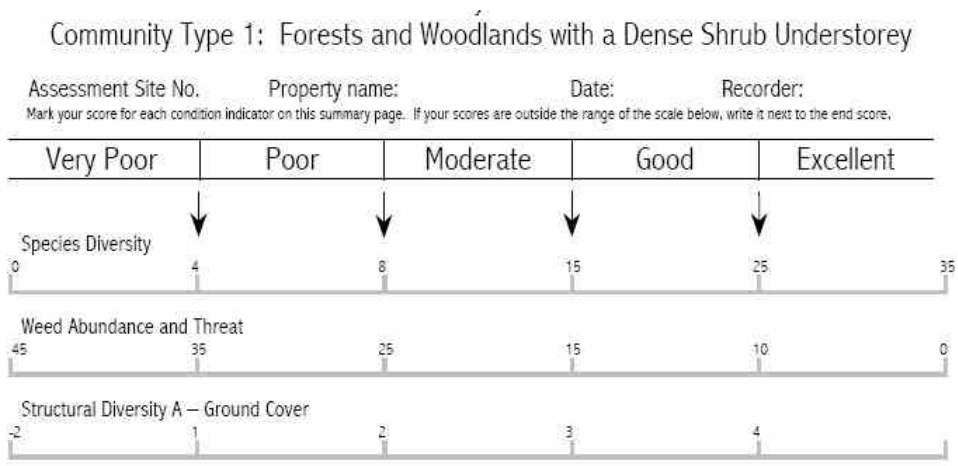

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.1 *Bushland Condition Monitoring* indicator scores for Community Type 1

Figure 4.1 represents Community Type 1: Forests and Woodlands with a Dense Shrub Understorey in the Southern Mount Lofty Ranges (Croft *et al.*, 2005). The values for each indicator are associated with the condition categories of Very Poor, Poor, Moderate, Good and Excellent. These values are often different for each benchmark group. In this example, a Species Diversity value of between zero and four relate to Very Poor. In a different benchmark group, Very Poor Species Diversity may be represented by values between zero and six, for example.

Croft *et al.* (2005) also record information not used to score vegetation condition in this project. This includes fauna species diversity, total grazing pressure and feral animals. These indicators are recorded to assist landholders to understand and monitor all aspects of vegetation condition change over time.

The *Habitat Hectares* method assesses vegetation condition within 'assessment areas'. The size and number of the assessment areas is variable and dependent on factors relating to the size of the patch being assessed, the variability of the vegetation condition within the patch and the context of the assessment (Parkes *et al.*, 2003). Similar to the *Bushland Condition Monitoring* method, *Habitat Hectares* is designed to be undertaken by natural resource managers with a range of expertise.

Rather than recording the raw values for each indicator as in Croft *et al.* (2005), *Habitat Hectares* scores are recorded relative to a benchmark value for a particular vegetation type. Many of the indicators in the *Habitat Hectares* methodology are assessed against more than one attribute. For example, the Large Trees site condition indicator (Figure 4.2) assesses the number of large trees in an assessment area in relation to the benchmark number of large trees. This percentage is then correlated with the canopy health to determine a condition score.

Category & Description	% Canopy Health*		
	> 70%	30-70%	< 30%
None present	0	0	0
> 0 to 20% of the benchmark number of large trees/ha	3	2	1
> 20% to 40% of the benchmark number of large trees/ha	4	3	2
> 40% to 70% of the benchmark number of large trees/ha	6	5	4
> 70% to 100% of the benchmark number of large trees/ha	8	7	6
≥ the benchmark number of large trees/ha	10	9	8

* Estimated proportion of an expected healthy canopy cover that is present (i.e. not missing due to tree death or decline, or mistletoe infestation.)

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.2 *Habitat Hectares* Larges Trees indicator

Another significant difference between the two methodologies is that *Habitat Hectares* weigh each indicator to generate a total habitat score when summed. This is in contrast to the *Bushland Condition Monitoring* method that ranks each indicator individually within a benchmark group to determine the site condition.

The quality and quantity of the vegetation in *Habitat Hectares* can be determined by multiplying the condition score generated through the *Habitat Hectares* method by the assessment area. For example, 10 hectares of vegetation could be counted as 10 'habitat hectares', but 10 hectares of vegetation with a site condition score of 50% would be scored as 5 'habitat hectares' (DSE, 2004a).

4.1.1.2. Indicators

The comparison process highlighted that the components of the *Bushland Condition Monitoring* and *Habitat Hectares* vegetation condition assessment methodologies are relatively compatible. Figure 4.3 lists the site condition components used to score vegetation condition in each methodology. The lines connecting the two boxes indicate equivalent components.

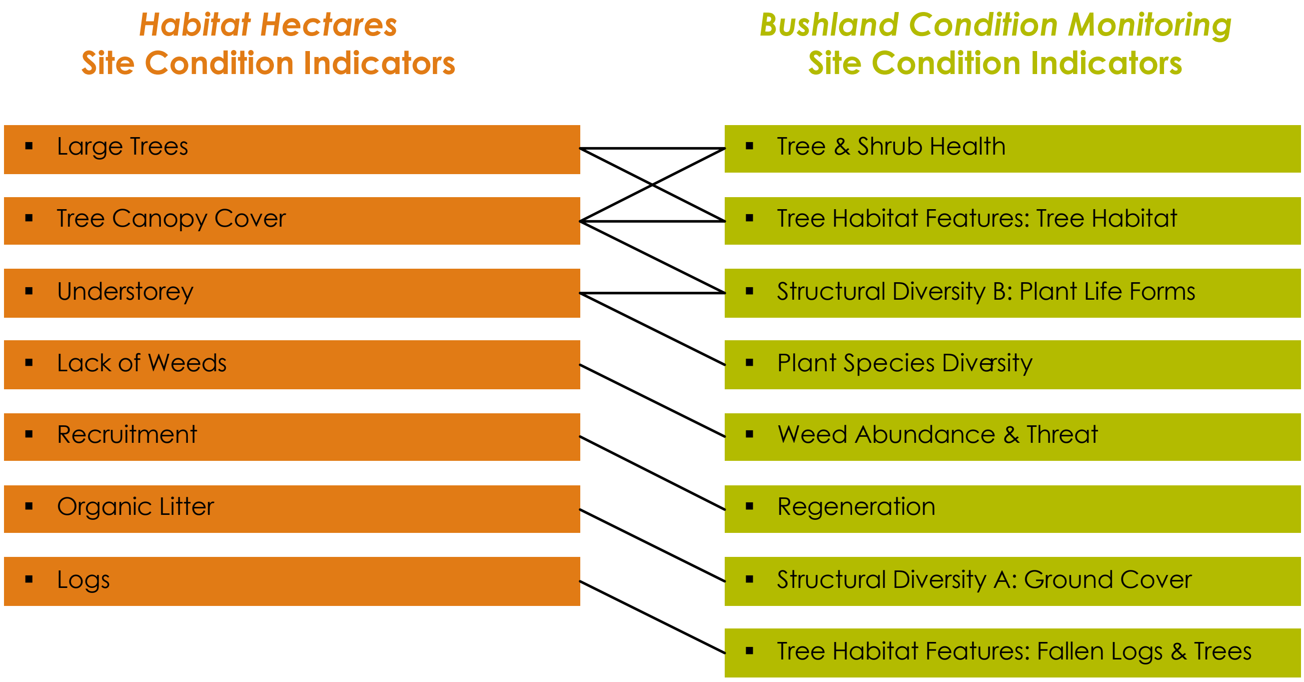

Figure 4.3 Relationship between *Habitat Hectares* and *Bushland Condition Monitoring* site condition indicators

As described in 3.1.1, the indicators from both methods have been grouped into four broad indicator categories to describe and compare the components of the *Habitat Hectares* and the *Bushland Condition Monitoring* methods (Table 3.3).

Table 4.1 illustrates the contribution of each indicator to the total condition scores of each method. This table shows that Diversity contributes the most to both the *Habitat Hectares* and the *Bushland Condition Monitoring* method score. Weeds is the second highest contributor in both methods followed by Growth Stages and Litter. The degrees of contribution help to explain the differences in the total condition scores for both methods.

Table 4.1 Broad indicator contribution to total condition score

Broad indicator categories	Contribution to *Habitat Hectares*	Contribution to *Bushland Condition Monitoring*
Diversity	53%	64%
Growth Stages	13%	11%
Litter	14%	10%
Weeds	20%	16%

Table 4.2 highlights the similarities and differences between the indicators used by the *Habitat Hectares* and *Bushland Condition Monitoring* methods. The following sections will explain each of these broad indicators in more detail.

Table 4.2 Comparison process summary

Broad Indicator	Similar to both	Unique to *Habitat Hectares*	Unique to *Bushland Condition Monitoring*
Diversity	▪ number of life forms present at a site ▪ estimated projective cover of canopy trees ▪ 'large' trees are determined by the diameter at breast height (DBH) and the canopy health	▪ scores Tree Canopy Cover in relation to canopy health ▪ incorporates species diversity and life form cover into modification component of Understorey indicator ▪ defines a large tree DBH specific to each vegetation type. ▪ incorporates dieback, lerp damage and mistletoe presence into canopy health component of the Large Trees indicator	▪ assesses and scores species diversity as a unique indicator ▪ includes the presence of tree hollows in the Tree Habitat Features score. ▪ defines a large tree by a set DBH for all vegetation types ▪ records dieback, lerp damage and mistletoe presence individually (but is excluded from the scoring process)
Growth Stages	▪ number, or proportion, of recruiting woody species.	▪ quantifies recruiting woody species according to species diversity ▪ considers the need for episodic recruitment events	
Litter	▪ number of logs present at a site ▪ percentage ground cover at a site	▪ defines logs as those with a diameter greater than 10cm ▪ categorises log presence by the length and diameter	▪ defines logs as those with a diameter greater than 30cm ▪ score logs based purely on the number present ▪ incorporates bare ground into the ground cover score
Weeds	▪ percentage cover of weeds at a site ▪ identification of high threat weeds	▪ measures the total cover of weeds	▪ records only the five most abundant weeds

4.1.1.2.1. Diversity indicator

Habitat Hectares: Tree Canopy Cover

Tree Canopy Cover is a measure of the estimated projective foliage cover of the tree canopy at a site in comparison to the benchmark. Canopy trees are defined as those that reach at least 80% of the benchmark mature tree height. The projective foliage cover score is qualified according to the health of the trees in the canopy layer to determine the Tree Canopy Cover score. Figure 4.4 represents the method used to score the Tree Canopy Cover attributes.

Category & Description	% Canopy Health *		
	> 70%	30-70%	< 30%
< 10% of benchmark cover	0	0	0
< 50% or > 150% of benchmark cover	3	2	1
≥ 50% or ≤ 50% of benchmark cover	5	4	3

* Estimated proportion of an expected healthy canopy cover that is present (i.e. not missing due to tree death or decline, or mistletoe infestation.)

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.4 *Habitat Hectares* Tree Canopy Cover indicator

<u>*Habitat Hectares*: Understorey</u>

The understorey component assesses the range of understorey life forms present in comparison to the benchmark. Table 4.3 lists the definition of 'present' for this indicator. The life forms considered to be 'present' are then assessed for their degree of modification for either diversity or cover. Modification is defined in Table 4.3.

Table 4.3 Definition of Present and Modified

Present	For life forms with benchmark cover of < 10%, considered 'present' if: • any specimens within life form are observed. For life forms with benchmark cover of ≥ 10%, considered 'present' if: • the life form occupies at least 10% of benchmark cover.
Modified apply only where life form is considered 'present'	For life forms with benchmark cover of <10%, then considered substantially 'modified' if: • the life form has < 50% of the benchmark species diversity; or • no reproductively-mature specimens are observed. For life forms with benchmark cover of ≥ 10%, then considered substantially 'modified' if the life form has either: • < 50% of benchmark cover; or • < 50% of benchmark species diversity; or • ≥ 50% of the benchmark cover due largely to immature canopy specimens but the cover of reproductively-mature specimens is < 10% of the benchmark cover.

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

The combination of understorey life forms present and their degree of modification determine the Understorey indicator score (Figure 4.5).

Category & Description		Value
All strata and life forms effectively absent		0
Up to 50% of life forms present		5
≥ 50% to 90% of life forms present	of those present, ≥ 50% substantially modified	10
	of those present, < 50% substantially modified	15
≥ 90% of life forms present	of those present, ≥ 50% substantially modified	15
	of those present, < 50% substantially modified	20
	of those present, none substantially modified	25

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.5 *Habitat Hectares* Understorey indicator

Habitat Hectares: Large Trees

The Large Trees indicator is a measure of the number of large trees per hectare in comparison to the benchmark. Large trees are defined by a minimum diameter at breast height (DBH) as indicated by the benchmark. The health of the trees (i.e. the proportion of the tree canopy not missing due to tree death, decline, insect attack or mistletoe infestation) is then assessed and used to rate the large trees (Figure 4.6).

Category & Description	% Canopy Health*		
	> 70%	30-70%	< 30%
None present	0	0	0
> 0 to 20% of the benchmark number of large trees/ha	3	2	1
> 20% to 40% of the benchmark number of large trees/ha	4	3	2
> 40% to 70% of the benchmark number of large trees/ha	6	5	4
> 70% to 100% of the benchmark number of large trees/ha	8	7	6
≥ the benchmark number of large trees/ha	10	9	8

* Estimated proportion of an expected healthy canopy cover that is present (i.e. not missing due to tree death or decline, or mistletoe infestation.)

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.6 *Habitat Hectares* Large Trees indicator

Bushland Condition Monitoring: Plant Species Diversity

The Plant Species Diversity score relates directly to the number of native plant species observed at the site. All native, weed and unknown species observed at each site are recorded. However only the aggregate number of native species forms the Species Diversity score.

Bushland Condition Monitoring: Structural Diversity B: Plant Life Forms

Each native life form category present at a site is recorded for this attribute. The estimated projective cover of each life form category present is also recorded but not used as a part of the condition score. The plant life form score is simply the number of native life forms observed at a site. Figure 4.7 shows how the Structural Diversity B: Plant Life Forms are scored.

Plant Life Forms Table

Life Form	Present	Estimate of % Canopy Cover	Canopy Cover Rating	Comments
Tall Trees > 15 m				
Medium Trees 5 – 15 m	✓	10	2	*Euc fasc, All vert, Cal gracilis*
Small Trees < 5 m	✓	8	2	*Euc fasc, All vert, Cal gracilis, Ac pyc*
Tall Mallee > 5 m				
Small Mallee < 5 m				
Tall Shrubs > 2 m	✓	5	2	*Dod visc, All muell, Ac pycn*
Medium Shrubs 0.5 m – 2 m	✓	30	3	*Dod visc, All muell, Ac pycn, Ac para, Ac cont, Hib crin, Cryp prop*
Small Shrubs < 0.5 m	✓	25	2	*Dod visc, Hib crin, Cryp propin, Spyr*
Herbs	✓	25	2	*Gonoc, Goodenia, Annuals*
Mat Plants/Groundcovers	✓	15	2	
Tall grasses > 0.5 m				
Low grasses < 0.5 m	✓	<1	1	*Austrostipa*
Tall Tussocks > 0.5 m				
Low Tussocks < 0.5 m	✓	1	1	*Lepid vis, Lomandra sp*
Vines, Twiners, Climbers	✓	<1	1	*Thys pat*
Mistletoe	✓	<1	1	*Am miqu*
Ferns	✓	3	1	*Chei aust*
Total no. of Plant Forms Observed		**Plant Life Forms Score** (total of cover ratings)	20	

Structural Diversity B - Your Plant Life Forms Score	20

Canopy Cover Rating Table

Criteria	Cover Rating
Not many, 1 – 10 individuals & total area < 5% **	1
Plentiful, but of small cover (< 5%)***	1
Any number of individuals covering 5 – 25% of the area	2
Any number of individuals covering 26 – 50% of the area	3
Any number of individuals covering 51 – 75% of the area	4
Covering more than 75% of the area	5

** where larger shrubs or trees are involved choose a category to reflect the cover rather than the number of individuals
*** NB: the cover rating for this category in Structural Diversity is 1 rather than 2 as in Weed Cover Rating.

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.7 *Bushland Condition Monitoring* Structural Diversity B: Plant Life Forms indicator

Bushland Condition Monitoring: Tree and Shrub Health

The proportion of dieback, lerp damage, mistletoe infestation and other signs of leaf damage disease are recorded at each site for the ten nearest adult trees from the dominant canopy layer (Figure 4.8). These may include standing dead trees (Croft *et al.*, 2005).

Tree Locations

	No. of Trunks & condition	Distance from stake (m)	Bearing from stake (degrees)	Tree Species (if known) & comments
Tree 1	3 (1 dead)	1.5m	250°	*Eucalyptus goniocalyx*
Tree 2	3 (1 dead)	4m	305°	*E. goniocalyx*
Tree 3	3 (1 dead)	7m	320°	*E. goniocalyx*
Tree 4	2	8m	320°	*E. fasciculosa*
Tree 5	7 (3 dead, 4 almost dead)	5m	0°	*E. fasciculosa*
Tree 6	3 - poor	7m	40°	*E. fasciculosa*
Tree 7	1 – good	5m	205°	*E. goniocalyx*
Tree 8	2 – good	5.5m	215°	*E. goniocalyx*
Tree 9	3 – good	7.5m	220°	*E. goniocalyx*
Tree 10	6 – 2 dead	8m	180°	*E. goniocalyx*

Tree Health Table (using trees on Adult Tree Map)

Tree Number	Dieback %	Dieback Rating	Lerp Damage %	Lerp Rating	No. Mistletoe Clumps	Mistle-toe Rating	Other Signs: Insect damage, fire scars, split limbs, epicormic growth
Tree 1	<5	4	0	4	0	1	
Tree 2	30	-2	0	4	0	1	
Tree 3	60	-4	0	4	0	1	
Tree 4	50	-2	0	4	0	1	
Tree 5	90	-6	0	4	0	1	
Tree 6	80	-6	0	4	1	1	
Tree 7	10	2	0	4	0	1	
Tree 8	8	4	0	4	0	1	
Tree 9	15	2	0	4	0	1	
Tree 10	15	2	0	4	0	1	
Totals		-6		40		10	
	Dieback Score (Total of ratings ÷ by 10)	-0.6	**Lerp Damage Score** (Total of ratings ÷ by 10)	4	**Mistletoe Score** (Total of ratings ÷ by 10)	1	

Your Tree Health Scores	Dieback Score -.6	Lerp Damage Score 4	Mistletoe Score 1

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.8 *Bushland Condition Monitoring* Tree and Shrub Health indicator

Dieback is measured as the proportion of the total possible tree canopy that is missing or dead due to ill health. Lerp damage and mistletoe infestation were excluded from the scoring process for the three reasons outline in section 3.1.

Bushland Condition Monitoring: Tree Habitat Features – Tree Habitat

The circumference, the canopy cover and the presence of hollows are recorded for each of the ten trees assessed in the Tree and Shrub Health indicator. Figure 4.9 demonstrates how these values are categorised and how the habitat value is calculated. The number of trees with a habitat value greater than four represents the Tree Habitat score.

Tree Habitat Table (using trees on Adult Tree Map)

Tree Number	Girth at Breast Height cm	% of canopy present	S Size category value	H Hollows present (Yes = 2, No =1)	CH Canopy Health category value	Habitat Value (S+H+CH)
Tree 1	60	>95	1	1	4	6
ree 2	60	70	1	1	3	5
Tree 3	62	40	1	1	2	4
Tree 4	24	50	1	1	3	5
Tree 5	23	10	1	1	1	3
Tree 6	50	20	1	1	1	3
Tree 7	62	90	1	1	4	6
Tree 8	68	92	1	1	4	6
Tree 9	43	85	1	1	4	6
Tree 10	60	85	1	1	4	6
	Tree Habitat Score (No. of Trees with Habitat Value > 5)					5

No. Trees Measured	10	Metres to most distant tree	8	No. of trees in Large Tree Category	0

No. of Large Trees	0	Your Tree Habitat Score	5

Canopy Health rating

% of Tree Canopy Present	Rating
> 75% canopy present (<25% dieback)	4
50 – 75% canopy present (25-50% dieback)	3
25 - 49% canopy present (51-75% dieback)	2
< 25% canopy present (75 - 99% dieback)	1
0% live canopy – tree appears dead	0

Tree Size Category based on GBH

Girth at Breast Height	Size Category
Large (gbh > 190cm)	3
Medium (gbh 125 – 190cm)	2
Small (gbh < 125cm)	1

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.9 *Bushland Condition Monitoring* Tree Habitat Features indicator

4.1.1.2.2. Growth Stages indicator

Habitat Hectares: Recruitment

Recruitment is initially determined by the presence of a recruitment cohort at a site. The proportion of native woody species adequately recruiting is quantified if at least one recruitment cohort is present. The total number of woody species at the site is then compared to the benchmark number of woody species to determine the relative diversity at the site, and consequently the recruitment score. If there is no recruitment occurring, and the vegetation at the site is dependent on episodic recruitment (as defined in the benchmark), the assessor must determine whether there is any evidence of this phenomenon at the site. Figure 4.10 is the matrix used to determine the recruitment score.

Category & Description			High diversity*◇	Low diversity*◇
No evidence of a recruitment 'cohort'+	within EVC not driven by episodic events		0	0
	within EVC driven by episodic events^	clear evidence of appropriate episodic event	0	0
		no clear evidence of appropriate episodic event	5	5
Evidence of at least one recruitment 'cohort' in at least one life-form	proportion of native woody species present that have adequate recruitment◇	< 30%	3	1
		30 - 70%	6	3
		≥ 70%	10	5

+ 'cohort' refers to a group of woody plants established in a single episode (can include suppressed canopy species individuals)
^ refer to EVC benchmark for clarification
* high diversity defined as > 50% of benchmark woody species diversity
◇ treat multiple eucalypt canopy species as one species

Table source: DSE 2004, Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.10 *Habitat Hectares* Recruitment indicator

Bushland Condition Monitoring: Regeneration

The presence of plant species in young life stages determines regeneration at a site. Each woody tree and shrub species present at a site is recorded. Evidence of regeneration is then assessed for each of these species. The total number of regenerating species determines the tree regeneration score, as illustrated in Figure 4.11.

Regeneration Table

Native Species Name or name-description	Regeneration Present
Tree Species – List all species	
E. fasciculosa	✓
Callitris gracilis	✓
Acacia pycnantha	✓
Tree Regeneration Score (Total no. of Tree Species Regenerating)	3
Shrub Species – scoring optional	
Dodonaea viscosa	✓
Hibbertia riparia	✓
Astroloma conostephioides	✓
Xanthorrhoea quadrangulata	✓
Shrub Regeneration Score (Total no. of Shrub Species Regenerating)	4

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.11 *Bushland Condition Monitoring* Regeneration indicator

4.1.1.2.3. Litter indicator

Habitat Hectares: Organic Litter

Organic Litter is determined by the percentage cover of organic litter at a site in comparison to the benchmark cover. This is then classified according to the site's dominance by native or non-native organic litter. Figure 4.12 is the matrix used to score the Organic Litter component.

Category Description	Dominated by native organic litter	Dominated by non-native organic litter
< 10% of benchmark cover	0	0
< 50% or > 150% of benchmark cover	3	2
≥ 50% or ≤ 150% of benchmark cover	5	4

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.12 *Habitat Hectares* Organic Litter indicator

Habitat Hectares: Logs

The logs component is assessed by first identifying those logs that are equal to or greater than 10cm in diameter. The length of these logs is then measured and compared to the benchmark log length per one tenth of a hectare. The logs are then assessed according to whether they are 'large' or not. A Large Log is defined as one that has a diameter of at least half the large tree benchmark DBH. Large logs are defined as 'present' if they are greater than or equal to 25% of the benchmark log length. Figure 4.13 shows how the presence or absence of large logs is used to categorise and score the Logs indicator.

Category Description	Large logs^ present*	Large logs^ effectively absent#
< 10% of benchmark length	0	0
< 50% of benchmark length	3	2
≥ 50% of benchmark length	5	4

^ **large logs** defined as those with diameter ≥ 0.5 of benchmark large tree dbh
* **present** defined as present if large log length is ≥ 25% of EVC benchmark log length
\# **effectively absent** defined as absent if large log length < 25% of EVC benchmark log length

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.13 *Habitat Hectares* Logs indicator

Bushland Condition Monitoring: Structural Diversity A: Ground Cover

The ground cover score is an aggregate of the percentage of the site covered by leaf litter, exposed rock, microphytic crust (moss, lichens, liverworts), native ground cover vegetation and weed ground cover vegetation. The proportion of bare ground is subtracted from this score. Figure 4.14 illustrates how these components are recorded and scored.

Ground Cover Table

Ground Cover Components	Estimate of % Cover	Total Cover Rating	Comments
Leaf Litter	25		
Exposed Rock	5		
Microphytic Crust – *Moss, Lichens, Liverworts*	5		
Native Ground Cover	65		
Weed Ground Cover	<1		
***Total Ground Cover**	101%	5	
Total Bare Ground	<1	-1	
Ground Cover Score *Add Total Ground Cover Rating to Total Bare Ground Rating*		4	

*NB: Total Cover may be > 100% as structural components may overlap and be hard to separate. Essential to score Bare Ground separately.

Structural Diversity A - Your Ground Cover Score	4

Conversion Table: Ground Cover/Bare Ground to Cover Rating

Criteria	Cover Rating Total Ground Cover	Cover Rating Bare Ground
Sparse cover <5%	1	-1
Cover 5 – 25% of the area	2	-2
Cover 26 – 50% of the area	3	-3
Cover 51 – 75% of the area	4	-4
Covering more than 75% of the area	5	-5

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.14 *Bushland Condition Monitoring* Structural Diversity A: Ground Cover indicator

Bushland Condition Monitoring: Tree Habitat Features - Fallen Logs and Trees

One point is scored for each fallen tree or log greater than 30cm in diameter at the assessment site (Figure 4.15).

Fallen Logs and Trees Score One point for each fallen tree or log >30 cm in diameter on the assessment site.	Your Fallen Logs & Trees Score	2

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.15 *Bushland Condition Monitoring* Fallen Logs and Trees indicator

4.1.1.2.4. Weeds indicator

Habitat Hectares: Lack of Weeds

The average percentage projective foliage cover of all weeds at a site is recorded for the Lack of Weeds indicator. A secondary assessment involves determining the proportion of total weed cover due to 'high threat' species. The NCSSA have determined an invasive category for most weeds in the Southern Mount Lofty Ranges with each weed assigned a number from one to five. 'Category one' weeds generally only invade disturbed bushland and are not considered a significant threat to biodiversity, while 'category five' weeds are highly invasive in either disturbed or intact remnant bushland and spread rapidly (Croft *et al.*, 2005). 'Category five' weeds also have the potential to eliminate almost all native understorey species (Croft *et al.*, 2005). The weeds with an invasive threat category of three, four or five were assigned the 'high threat' weed category for the *Habitat Hectares* method. Figure 4.16 represents the scoring matrix.

Category & Description	Value 'high threat' weeds*		
	None	≤ 50%	> 50%
> 50% cover of weeds	4	2	0
25 - 50% cover of weeds	7	6	4
5 - 25% cover of weeds	11	9	7
< 5% cover of weeds**	15	13	11

* Proportion of weed cover due to 'high threat' weeds – see EVC benchmark for guide
** If total weed cover is negligible (< 1%) and high threat weed species are present then the habitat zone scores '13'

Table source: DSE 2004, *Vegetation Quality Assessment Manual – Guidelines for applying the habitat hectares scoring method*. Version 1.3. Victorian Department of Sustainability and Environment, Melbourne.

Figure 4.16 *Habitat Hectares* Lack of Weeds indicator

Bushland Condition Monitoring: Weed Abundance and Threat

The five most abundant weeds at a site are recorded for this indicator. These five weeds are selected according to the dominant projective cover, the largest number of individuals and the largest biomass/volume. The projective foliage cover is recorded for each of these five weeds (Figure 4.17). This value is converted to a cover rating and an invasive threat category is assigned. These two scores are multiplied to generate an abundance and threat score.

Weed Abundance & Threat Table

Weed Name	Unknown if weed or native	% Area covered &/or no. of plants if less than 10	Cover Rating from conversion table below	Invasive Threat Category from Attachment 2	Abundance & Threat Score Cover Rating x Threat Category
Phalaris sp.		10%	3	3	9
Avena sp. Oats		40%	4	2	8
Tagasaste		5%	3	2	6
Oxalis pes-caprae		10%	3	3	9
Olea europaea		5%	3	4	12
	Total Cover	70%	Abundance & Threat Score (Total of Abundance & Threat)		44

NB: Because some weed species within each structural layer may "overlap", the total cover estimated may be >100%.

Your Weed Abundance & Threat Score	44

Weed Cover/Abundance to Cover Rating

Criteria	Cover Rating
Not many, 1 – 10 individuals & total area < 5% **	1
Plentiful, but of small cover (<5%)	2
Any number of individuals covering 5 – 25% of the area	3
Any number of individuals covering 26 – 50% of the area	4
Any number of individuals covering 51 – 75% of the area	5
Covering more than 75% of the area	6

** where larger shrubs or trees are involved choose a category to reflect the cover rather than the number of individuals

Table source: Croft, S.J., Pedler J.A., and Milne, T.I. 2005, *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*, The Nature Conservation Society of South Australia Inc, Adelaide, South Australia.

Figure 4.17 *Bushland Condition Monitoring* Weed Abundance and Threat indicator

4.1.2. Biological Survey and *Bushland Condition Monitoring*

Existing Biological Survey information was analysed to assess its use within vegetation condition assessments using the *Bushland Condition Monitoring* approach. The ability to integrate the *Bushland Condition Monitoring* information into existing DEH databases was also examined.

Table 4.4 shows the relevant Biological Survey attributes and their relationship to the *Bushland Condition Monitoring* indicators.

Table 4.4 Biological survey attributes and *Bushland Condition Monitoring* indicators

***Bushland Condition Monitoring* indicator**	**Biological Survey attribute**
Plant Species Diversity	Number of native species
Weed Abundance and Threat	Number & cover of weed species
Structural Diversity A: Ground cover	Ground cover percent
	Bare ground percent
Structural Diversity B: Plant Life Forms	Number & cover of life forms

The Biological Survey method has developed over time and not all of these attributes were collected at every Biological Survey site. Native and weed species cover, life form cover and ground cover percent were not recorded during some surveys. This limits the use of this data for establishing benchmarks and for completing *Bushland Condition Monitoring* assessments. There is, however, commonality between the two data sets that allows the integration of data for a limited set of indicators.

The Biological Survey data is stored in an Oracle database. Each survey site has a unique site and survey number with the spatial coordinates stored against each record in the table. A series of linked tables store the Biological Survey information. There is flexibility within this database to allow the *Bushland Condition Monitoring* survey data to be integrated with relative ease. The data common to both methods could be easily integrated into the existing database and additional tables could be produced to store other condition attributes and condition scores.

Section 4.4.3 compares the data collected for the *Bushland Condition Monitoring* attributes with the existing Biological Survey site data mentioned in Table 4.4.

4.2. Field Assessments

The field trial component of the project involved two stages. These were:

- Site selection
- Data collection

4.2.1. Site Selection

Sites were selected to represent a range of vegetation groups, land management types and land uses. The location of Biological Survey sites and presence of past fires was also considered. Table 4.5 lists the sites selected within the study area.

Table 4.5 Survey sites

Site Number	Vegetation group	Land Management	Land Use	Fire History	Biological Survey Site?	Method Completed
1	5	NPWSA Reserve	Natural feature protection	1975	Yes	BCM & HH
5C	5	NPWSA Reserve	Natural feature protection	1975	No	HH
5G	5	Private	Grazing modified pastures		No	HH
5A	5	Private	Grazing modified pastures		No	HH
5B	5	Road Reserve	Grazing modified pastures		No	HH
4	5	Road Reserve	Rural residential		No	BCM & HH
2	5	SA Water	Grazing natural vegetation		No	BCM & HH
7	6	Forestry SA	Grazing natural vegetation		Yes	BCM & HH
8	6	NPWSA Reserve	Natural feature protection		Yes	BCM & HH
6B	6	NPWSA Reserve	Natural feature protection		No	HH
10	6	Private	Grazing modified pastures		No	BCM & HH
12	6	SA Water	Grazing natural vegetation		Yes	BCM & HH
9	6	SA Water	Grazing natural vegetation		Yes	BCM & HH
6D	6	SA Water	Grazing natural vegetation		No	HH
6E	6	SA Water	Grazing natural vegetation		No	HH
16	8	Forestry SA	Grazing natural vegetation	1975	Yes	BCM & HH
6A	8	Forestry SA	Grazing natural vegetation		No	HH
8A	8	Forestry SA	Grazing natural vegetation		No	HH
13	8	NPWSA Reserve	Natural feature protection	1975	Yes	BCM & HH
15	8	NPWSA Reserve	Natural feature protection		Yes	BCM & HH
8C	8	NPWSA Reserve	Natural feature protection	1975	No	HH
8E	8	NPWSA Reserve	Natural feature protection		No	HH
14	8	Private	Grazing natural vegetation		Yes	BCM & HH
8D	8	Private	Grazing natural vegetation	1975	No	HH
8F	8	SA Water	Grazing natural vegetation		No	HH
19	8	Trinity College	Grazing natural vegetation	1975	No	BCM & HH

BCM = *Bushland Condition Monitoring*, HH = *Habitat Hectares*

The map in Figure 4.18 shows the location of these sites. A *Habitat Hectares* assessment and a *Bushland Condition Monitoring* assessment were carried out by the NCSSA at thirteen of these sites. These are represented by the green and the blue triangles (Figure 4.18). Nine of these sites were located at existing Biological Survey sites (the blue triangles). DEH staff surveyed the remaining thirteen sites using only the *Habitat Hectares* methodology (the red triangles).

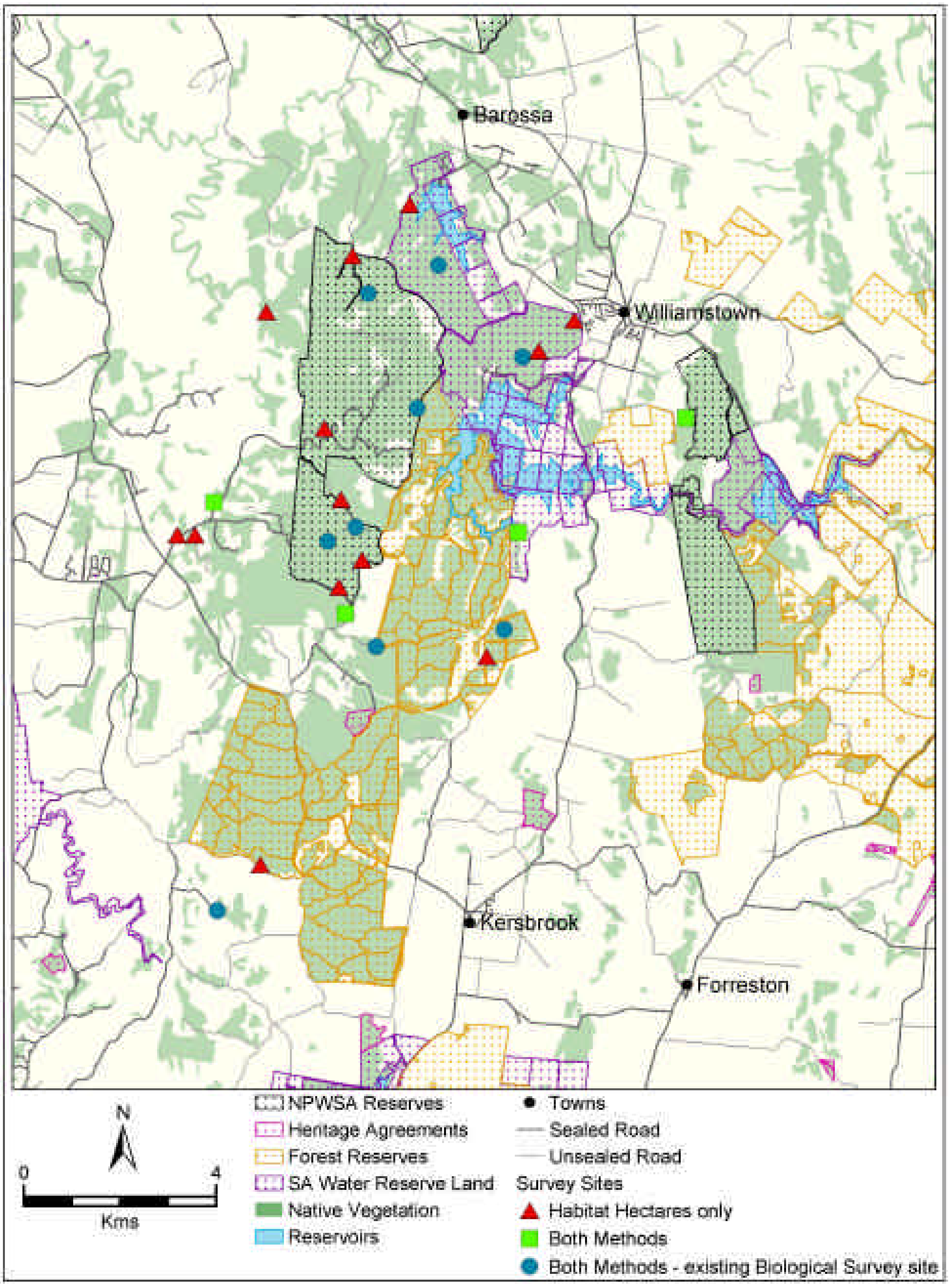

Figure 4.18 Location of survey sites

4.2.2. Data Collection

Staff from both DEH and NCSSA undertook the data collection. The NCSSA completed *Bushland Condition Monitoring* and *Habitat Hectares* assessments at each site, while DEH completed only the *Habitat Hectares* assessments.

The time taken to complete a *Bushland Condition Monitoring* assessment was approximately one and a half hours for each site. The *Habitat Hectares* assessments were slightly quicker, taking approximately one hour for each site.

The data collected at each site was compiled and converted into scores using the benchmarks developed in section 4.3. The scores for both the *Habitat Hectares* and *Bushland Condition Monitoring* assessments are presented in section 4.4.

4.3. Benchmarking

The benchmarks were initially formulated using data from the Biological Survey database. Discussions with vegetation experts helped to refine the benchmark groups within the study area. The final *Habitat Hectares* benchmark descriptions are listed in Figure 4.19, Figure 4.20 and Figure 4.21.

5 *Eucalyptus camaldulensis* var. *camaldulensis*, *Eucalyptus leucoxylon* ssp. Woodland with shrub underorey

Description: *Eucalyptus camaldulensis var. camaldulensis*, *Eucalyptus leucoxylon ssp*. Woodland with shrub understorey

Large Trees:

Species	DBH (cm)	#/ha	Height (m)
E. camaldulensis var. camaldulensis	100	10	15
E. leuxcoylon ssp.	90	15	15

Tree Canopy Cover:

% cover	Character Species	Common Name
20%	*E. camaldulensis var. camaldulensis*	River Red Gum
20%	*E. leuxcoylon ssp*	Blue Gum

Understorey:

Life form	% cover	LF code
Medium Shrub	20	MS
Tall Grasses	25	TTG
Low Grasses	5	LTG
Mat Plant	5	MP
Herb	10	H
Fern	5	F
Mistletoe	10	MI
Vines, Twiners, Climbers	5	V

Species:

LF Code	Species typical of at least part of benchmark group	Common Name
T	Acacia pycnantha	Golden Wattle
SS	Astroloma humifusum	Cranberry Heath
SS	Hibbertia exutiacies	Prickly Guinea-flower
SS	Olearia ramulosa	Twiggy Daisy-bush
MTG	Themeda triandra	Kangaroo Grass

Recruitment:

4 species = high diversity

Organic Litter:

30 % cover

Logs:

5.5 m/0.1 ha

Weediness:

LF Code	Typical weed species	Common Name	Impact
V	Asparagus asparagoides	Bridal Creeper	high
MS	Chrysanthemoides monilifera	Boneseed	high
H	Hypericum perforatum	St John's Wort	high
LTG	Pentaschistis pallida	Pussy Tail	high
MT	Pinus radiata	Radiata Pine	high
MS	Ulex europaeus	Gorse	high

Figure 4.19 Final *Habitat Hectares* benchmark group 5 description

6 *Eucalyptus fasciculosa, Eucalyptus goniocalyx* ssp. *goniocalyx, Callitris gracilis* Woodland with shrub understorey

Description: *Eucalyptus fasciculosa, Eucalyptus goniocalyx ssp. goniocalyx, Callitris gracilis* Woodland with shrub understorey

Large Trees:

Species	DBH (cm)	#/ha	Height (m)
Eucalyptus fasciculosa	60	30	10
Eucalyptus goniocalyx ssp. goniocalyx	60	30	10
Callitris gracilis	50	40	10

Tree Canopy Cover:

% cover	Character Species	Common Name
25 %	*Eucalyptus fasciculosa*	Pink Gum
25 %	*Eucalyptus goniocalyx ssp. goniocalyx*	Long-leaved Box
25 %	*Callitris gracilis*	Southern Cypress Pine

Understorey:

Life form	% cover	LF code
Mallee	25	M
Medium Shrub	10	MS
Tall Grasses	5	TTG
Herb	5	H
Fern	5	F
Mistletoe	5	MI

Species:

LF Code	Species typical of at least part of benchmark group	Common Name
ST	Acacia pycnantha	Golden Wattle
TS	Allocasuarina muelleriana ssp. muelleriana	Common Oak-bush
MI	Amyema miquelii	Box Mistletoe
LS	Astroloma conostephioides	Flame Heath
MT	Callitris gracilis	Southern Cypress Pine
MS	Calytrix tetragona	Common Fringe-myrtle
H	Gonocarpus elatus	Hill Raspwort
LS	Hibbertia exutiacies	Prickly Guinea-flower
LS	Hibbertia riparia	Bristly Guinea-flower
LS	Hibbertia sericea	Silky Guinea-flower

Recruitment:
7 species = high diversity

Organic Litter:
35 % cover

Logs:
3.3 m/0.1 ha

Weediness:

LF Code	Typical weed species	Common Name	Impact
MS	Chrysanthemoides monilifera	Boneseed	high
MT	Pinus radiata	Radiata Pine	high

Figure 4.20 Final *Habitat Hectares* benchmark group 6 description

8 *Eucalyptus goniocalyx* ssp. *goniocalyx* Woodland with heathy understorey

Description: *Eucalyptus goniocalyx ssp. goniocalyx* Woodland with heathy understorey

Large Trees:

Species	DBH (cm)	#/ha	Height (m)
Eucalyptus goniocalyx ssp. goniocalyx	60	30	9

Tree Canopy Cover:

% cover	Character Species	Common Name
25 %	*Eucalyptus goniocalyx ssp. goniocalyx*	Long-leaved Box

Understorey:

Life form	% cover	LF code
Mallee	20	M
Medium Shrub	20	MS
Tall Grasses	35	TTG
Low Grasses	25	LTG
Mat Plant	5	MP
Herb	15	H
Fern	5	F
Mistletoe	5	MI
Vines, Twiners, Climbers	5	V

Species:

LF Code	Species typical of at least part of benchmark group	Common Name
MS	Acacia myrtifolia var. myrtifolia	Myrtle Wattle
ST	Acacia pycnantha	Golden Wattle
LS	Astroloma conostephioides	Flame Heath
MS	Calytrix tetragona	Common Fringe-myrtle
H	Gonocarpus tetragynus	Small-leaf Raspwort
MS	Hakea rostrata	Beaked Hakea
LS	Hibbertia exutiacies	Prickly Guinea-flower
LS	Hibbertia sericea var. sericea(NC)	Silky Guinea-flower
LTG	Lepidosperma semiteres	Wire Rapier-sedge
MS	Leptospermum myrsinoides	Heath Tea-tree
LS	Pultenaea largiflorens	Twiggy Bush-pea
MS	Xanthorrhoea semiplana ssp. semiplana	Yacca

Recruitment:
7 species = high diversity

Organic Litter:
35 % cover

Logs:
3.3 m/0.1 ha

Weediness:

LF Code	Typical weed species	Common Name	Impact
V	Asparagus asparagoides	Bridal Creeper	high
MS	Chrysanthemoides monilifera	Boneseed	high
H	Disa bracteata		high
TTG	Holcus lanatus	Yorkshire Fog	high
LTG	Pentaschistis pallida	Pussy Tail	high
MT	Pinus radiata	Radiata Pine	high
MS	Ulex europaeus	Gorse	high

Figure 4.21 Final *Habitat Hectares* benchmark group 8 description

Weeds with an invasive threat category of four or five according to the *Bushland Condition Monitoring* method were selected to represent 'high threat' weeds in the *Habitat Hectares* method. Some of these weeds are listed in Figure 4.19, Figure 4.20 and Figure 4.21 but the complete list of 'high threat' weeds is in Appendix 1.

4.4. Analysis and Comparison

The data collected in the field assessments were converted to condition scores for both the *Habitat Hectares* and *Bushland Condition Monitoring* methods (Table 4.6 and Table 4.7). Each indicator is listed in a column and the potential total score is listed in brackets.

Table 4.6 *Bushland Condition Monitoring* data collection results

Site Number	Species Diversity (25)	Weed Abundance and Threat (15)	Structural Diversity A: Ground Cover (5)	Structural Diversity B: Plant Life Forms (15)	Regener-ation (10)	Tree Health (10)	Fallen Trees & Logs (5)	Tree Habitat Features (10)	Total Condition Score (95)
1	25	14	5	15	8	3	4	4	77
2	4	5	5	9	2	8	5	8	46
4	4	0	5	5	2	6	0	4	26
7	21	15	5	8	8	6	5	5	72
8	25	13	5	15	9	6	1	8	82
9	25	6	5	12	10	9	0	7	74
10	13	6	5	6	3	5	2	2	42
12	22	14	5	8	9	8	5	8	80
13	23	15	5	7	8	8	0	8	73
14	21	11	5	7	5	9	2	9	69
15	18	15	5	13	8	5	1	5	70
16	15	14	5	12	6	4	3	4	63
19	16	6	5	4	4	7	5	7	54

Table 4.7 *Habitat Hectares* data collection results

Site Number	Large Trees (10)	Tree Canopy Cover (5)	Lack of Weeds (15)	Underst-orey (25)	Recruit-ment (10)	Organic Litter (5)	Logs (5)	Total Condition Score (75)
5A	0	4	2	5	0	5	2	18
5B	0	4	2	5	6	5	3	25
5C	9	2	11	5	3	5	2	37
5G	0	5	4	5	6	5	0	25
6A	0	3	15	5	10	3	4	40
6B	0	3	11	5	10	0	4	33
6D	0	3	15	5	10	5	5	43
6E	0	2	9	5	10	3	4	33
8A	0	5	15	15	10	3	4	52
8C	0	5	15	5	10	5	4	44
8D	0	5	15	5	6	5	5	41

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Site Number	Large Trees (10)	Tree Canopy Cover (5)	Lack of Weeds (15)	Underst-orey (25)	Recruit-ment (10)	Organic Litter (5)	Logs (5)	Total Condition Score (75)
8E	0	4	13	5	10	5	5	42
8F	0	5	9	5	6	3	4	32
1	2	2	13	15	5	5	3	45
2	0	3	2	5	3	5	4	22
4	0	3	0	5	3	3	0	14
7	0	4	11	25	6	5	3	54
8	0	5	13	25	10	5	4	62
9	0	4	13	25	10	5	4	61
10	0	4	9	10	1	3	5	32
12	4	5	11	10	6	5	5	46
13	0	4	15	25	10	5	0	59
14	0	5	15	10	3	5	4	42
15	0	4	15	15	5	5	4	48
16	0	4	15	25	6	5	5	60
19	0	5	11	10	1	5	5	37

These results were analysed to determine any patterns or trends. The first part of this section will explain the analysis of the condition scores from all twenty-six sites relative to a series of environmental factors. The thirteen sites where both the *Bushland Condition Monitoring* method and the *Habitat Hectares* method were undertaken were analysed relative to each other and will be discussed in section 4.4.2.

4.4.1. Environmental characteristics

The results from the field trial were analysed relative to a series of environmental factors. These include:

- Land use
- Land management
- Vegetation benchmark group

The small number of sites included in this study restricts the ability to draw conclusions about the relationship between the site condition scores and the environmental characteristics. However, trends in the data can be examined without determining definite relationships between the environmental characteristics and the vegetation condition scores.

4.4.1.1. Land use

Table 4.8 represents the minimum, maximum and average condition scores for each land use type in the study area for both condition assessment methods. The number of sites assessed is also listed in the table.

Table 4.8 Land Use characteristics

Land Use	NCSSA				Habitat Hectares			
	No. of sites	Min	Max	Mean	No. of sites	Min	Max	Mean
Conservation and natural environments	6	66	86	77	12	44	83	64
Production from relatively natural environments	5	48	83	70	9	29	81	55
Production from dryland agriculture and plantations	1	44	44	44	4	24	43	31
Intensive uses	1	27	27	27	1	19	19	19

The information in this table suggests that vegetation in more natural environments (i.e. Conservation and natural environments, and Production from relatively natural environments) has a higher vegetation condition score than more modified environments. While there is only a small set of sample data, this is evident for both the *Habitat Hectares* and the *Bushland Condition Monitoring* condition assessment results, highlighting consistent patterns of condition for both methods.

4.4.1.2. Land management

An analysis of the land management practises in the study area relative to the condition scores is represented in Table 4.9. The land management types were identified from a set of spatial layers. These included National Parks and Wildlife Reserves, Forestry SA reserves, SA Water reserves and road reserves. Private properties were identified using a spatial layer of property boundaries and ownership information.

Table 4.9 Land Management characteristics

Land Management	NCSSA				Habitat Hectares			
	No. of Sites	Min	Max	Mean	No. of Sites	Min	Max	Mean
Forestry SA	2	66	77	72	4	53	80	69
NPWSA Reserve	4	74	86	80	8	44	83	62
SA Water	3	48	83	70	6	29	81	53
Road Reserve	2	22	27	25	3	19	33	25
Private	3	44	73	58	6	24	56	43

The small set of site data limits the ability to draw conclusions about the relationship between land management and vegetation condition. In many cases there is a large difference between the minimum and maximum condition scores recorded within each land management type. The land managed by SA Water exhibits the greatest variance with a range of 52% between the minimum and maximum *Habitat Hectares* values. The NPWSA reserves were visited the most number of times with a total of eight *Habitat Hectares* sites. The variation of 39% between the maximum and minimum values indicates that factors other than the land manager influences vegetation condition. For example, the existence of management plans and the location of the sites in relation to roads, walking tracks, the edge of the park and powerlines all influence the condition of a site. A greater number of sites are needed before conclusions can be made about the relationship between land management and vegetation condition.

4.4.1.3. Vegetation benchmark groups

Table 4.10 represents the minimum, maximum and average condition scores recorded for each vegetation benchmark group. These results indicate that the surveyed sites within benchmark group number 6 (*Eucalyptus fasciculosa, E. goniocalyx ssp. goniocalyx, Callitris gracilis* Woodland with shrub understorey) have the highest average condition score for both methods. The average condition score of the sites within benchmark group number 8 (*Eucalyptus goniocalyx spp. goniocalyx* Woodland with healthy understorey) is within 5% of group 6. Benchmark group 5 (*Eucalyptus camaldulensis var. camaldulensis, E. leucoxylon ssp*. Woodland with shrub understorey) records the lowest condition score in both methods. This may be due to the type of vegetation community this group represents. Kraehenbuehl (1996) stated that the settlers removed various types of woodlands for agricultural and horticultural purposes, and noted that Red gums and Blue gums along creek lines were cleared extensively. Red gum and Blue gum woodlands were also grazed heavily after settlement. This may explain the poor condition of this vegetation community within the study area. There is large variation between the minim um and maximum condition score for each benchmark group, making it impossible to conclude that the benchmark group relates directly to vegetation condition.

Table 4.10 Vegetation Benchmark Group characteristics

Benchmark Group	NCSSA				Habitat Hectares			
	No. of sites	Min	Max	Mean	No. of sites	Min	Max	Mean
5	3	27	82	53	7	19	60	35
6	5	44	86	74	8	43	83	61
8	5	57	78	69	11	43	80	60

4.4.2. Score comparison

The data collected at the sites where both the *Bushland Condition Monitoring* and the *Habitat Hectares* methods were undertaken were expressed as a percentage of the potential total score for each indicator at each site (Table 4.11 and Table 4.12) and represented graphically in Figure 4.22 and Figure 4.23.

Table 4.11 Bushland Condition Monitoring data collection results expressed as a percentage of potential total

Site Number	Species Diversity	Weed Abundance and Threat	Structural Diversity A: Ground Cover	Structural Diversity B: Plant Life Forms	Regener-ation	Tree Health	Fallen Trees & Logs	Tree Habitat Features	Total Condition Score
1	100	93	100	100	80	30	80	40	81
2	16	33	100	60	20	80	100	80	48
4	16	0	100	33	20	60	0	40	27
7	84	100	100	53	80	60	100	50	76
8	100	87	100	100	90	60	20	80	86
9	100	40	100	80	100	90	0	70	78
10	52	40	100	40	30	50	40	20	44
12	88	93	100	53	90	80	100	80	84
13	92	100	100	47	80	80	0	80	77
14	84	73	100	47	50	90	40	90	73
15	72	100	100	87	80	50	20	50	74
16	60	93	100	80	60	40	60	40	66
19	64	40	100	27	40	70	100	70	57
Average	71	69	100	62	63	65	51	61	67
Standard Deviation	29	34	0	25	28	19	41	22	18

Table 4.12 *Habitat Hectares* data collection results expressed as a percentage of potential total

Site Number	Large Trees	Tree Canopy Cover	Lack of Weeds	Underst-orey	Recruit-ment	Organic Litter	Logs	Total Condition Score
1	20	40	87	60	50	100	60	60
2	0	60	13	20	30	100	80	29
4	0	60	0	20	30	60	0	19
7	0	80	73	100	60	100	60	72
8	0	100	87	100	100	100	80	83
9	0	80	87	100	100	100	80	81
10	0	80	60	40	10	60	100	43
12	40	100	73	40	60	100	100	61
13	0	80	100	100	100	100	0	79
14	0	100	100	40	30	100	80	56
15	0	80	100	60	50	100	80	64
16	0	80	100	100	60	100	100	80
19	0	100	73	40	10	100	100	49
Average	5	80	73	63	53	94	71	60
Standard Deviation	12	18	32	33	32	15	34	20

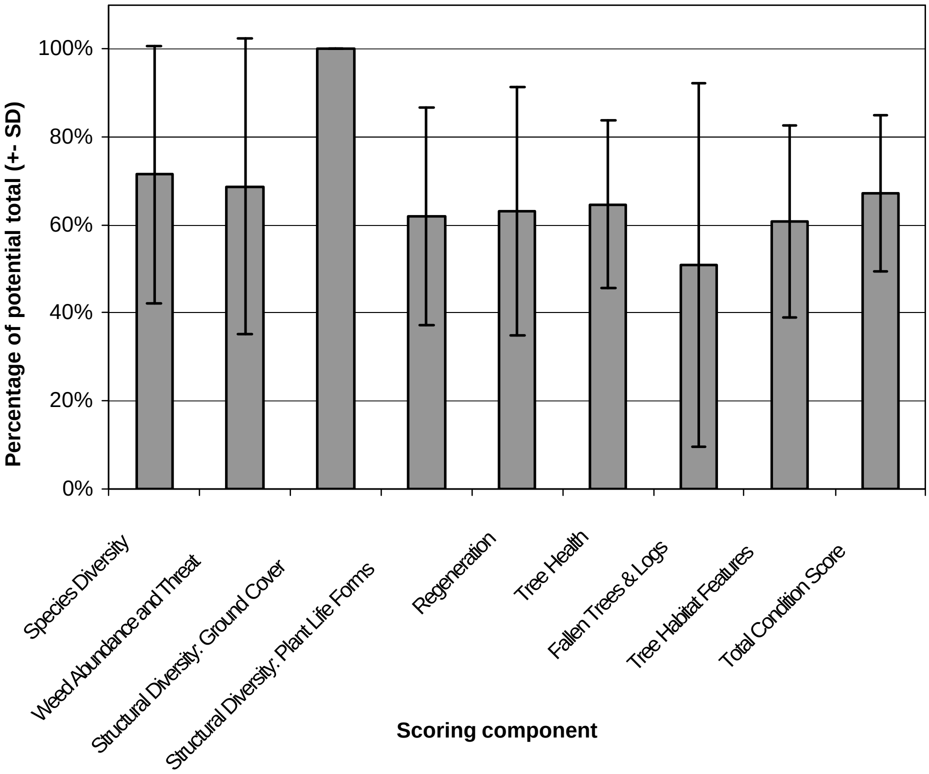

Figure 4.22 ***Bushland Condition Monitoring*** **site data expressed as a percentage of potential total and standard deviation**

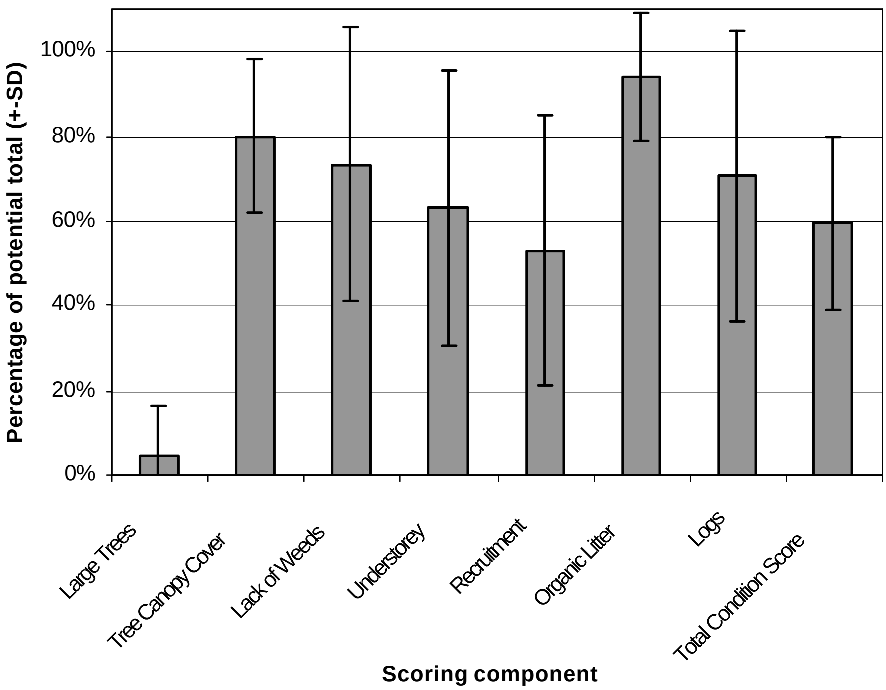

Figure 4.23 ***Habitat Hectares*** **site data expressed as a percentage of potential total and standard deviation**

The *Bushland Condition Monitoring* method and *Habitat Hectares* approach produced similar average scores for total condition across all thirteen sites (Table 4.11 and Table 4.12). The *Bushland Condition Monitoring* sites averaged 67% compared with 60% for *Habitat Hectares*. This difference was not statistically significant, as indicated by the small t-Test value in Table 4.13. These overall condition scores were also highly correlated, based on the correlation coefficient (r).

Table 4.13 Statistical comparison of total condition scores for both assessment methods

	***Bushland Condition Monitoring* method**	***Habitat Hectares* method**	**t-Test and P-value**	**Correlation coefficient (r), Degrees of Freedom (df) and P-value**
Total Condition Score	67 %	60 %	t=0.31, P>0.7	r = 0.85, df=11, P<0.001

Whilst this correlation was significant, there was some variability between site scores as evidenced by five of thirteen sites with condition scores that varied by more than 10% (Table 4.14). To help understand these differences, individual scoring components from the *Bushland Condition Monitoring* method were analysed against the most analogous components of the *Habitat Hectares* approach (Table 4.15).

Table 4.14 Difference in total condition scores between *Bushland Condition Monitoring* and *Habitat Hectares* at each site

Site Number	BCM Total Condition Score (%)	HH Total Condition Score (%)	Difference
16	66%	80%	-14%
9	78%	81%	-3%
13	77%	79%	-2%
10	44%	43%	2%
8	86%	83%	4%
7	76%	72%	4%
19	57%	49%	8%
4	27%	19%	9%
15	74%	64%	10%
14	73%	56%	17%
2	48%	29%	19%
1	81%	60%	21%
12	84%	61%	23%

Table 4.15 Comparison of analogous components of condition assessment methods

Bushland Condition Monitoring Scoring Components	Average percentage of possible total for all 13 sites	Habitat Hectares Scoring Components	Average percentage of possible total for all 13 sites	t-Test and P-value
Species Diversity Structural Diversity B: Plant Life Forms	71 62	Understorey	63	t=-0.13, P>0.8
Weed Abundance and Threat	69	Lack of Weeds	73	t=-0.74, P>0.4
Structural Diversity A: Ground Cover	100	Organic Litter	94	t=0.28, P>0.7
Regeneration	63	Recruitment	53	t=0.43, P>0.6
Tree Health	65	Tree Canopy Cover	80	t=-2.8, P=0.01
Fallen Logs & Trees	51	Logs	71	t=-1.7, P>0.1
Tree Habitat Features	61	Large Trees	5	t=7.4, P<0.001
Total Condition Score	67	Total Condition Score	60	t=0.31, P>0.7

All *Bushland Condition Monitoring* scoring components averaged from 51% to 100% of their possible total across the thirteen sites (Table 4.15). *Habitat Hectares* scoring components were more variable across the sites, ranging from 5% of the possible total for Large Trees to 94% for Organic Litter (Table 4.15).

Some trends appear obvious from these data despite only a limited sample of thirteen sites. Table 4.15 shows *Bushland Condition Monitoring* scoring components compared to the *Habitat Hectares* components to which they are most analogous. Statistically significant differences occur between Tree Health and Tree Canopy Cover and between Tree Habitat Features and Large Trees where there is a large discrepancy of 56%.

These discrepancies could be due to:

- Differences in the scoring methodology, and;
- Differences due to variation between benchmarking used within the two methods.

In all cases the cause for the discrepancy appears to be the former. A comparison of the methods performed in section 4.1.1.2. shows that the Fallen Logs and Trees scoring component for the *Bushland Condition Monitoring* method requires logs to be greater than 30cm diameter, whereas for *Habitat Hectares* it is greater than 10cm diameter. This is likely to be one of the key sources of variation between these two scoring components.

The Tree Canopy Cover and Tree Health components are scored differently. Reflection upon the method by which scores are allocated suggests that the *Habitat Hectares* Tree Canopy Cover component is likely to score consistently higher values, particularly in areas where canopy is mostly still present (which occurred in this study). For example, where tree canopy cover is between 50% and 150% of the benchmark cover, and tree health is moderate (30-70%), a site scores four out of five points, or 80% of maximum (Figure 4.4). This actually occurred at six of the thirteen sites measured (Table 4.12). This contrasts with the *Bushland Condition Monitoring* method where these same sites averaged 62% for the Tree Health indicator (Table 4.11).

Most sites had no Large Trees for the *Habitat Hectares* method, or if present, were only a low percentage of the benchmark number. This accounts for the very low average score of 5% across all sites for this indicator (Table 4.12, Figure 4.23). The Tree Habitat Features as scored using the *Bushland Condition Monitoring* method (Figure 4.9) is a combination of tree size, tree health and the presence of hollows. Whilst few large trees were recorded at each site, many were scored as habitat trees due to a combination of moderate size, good health and the presence of hollows. This explains the discrepancy between the two scoring methods. The latter score focuses upon a holistic assessment of the value of a tree as habitat based upon a number of components rather than the habitat value that could be provided by a large tree alone.

In section 4.1.1.2., scoring components of both the *Bushland Condition Monitoring* method and the *Habitat Hectares* method were grouped into broader categories to allow for more meaningful comparison. Table 4.16 shows the average percentage of the possible total for the four broad indicators for each method. When pooled into these four groupings, no significant differences were observed between the two methods. There was also positiv e correlation between the scoring of the two methods for these broad indicator components (Table 4.16). This supports the results of the comparison of the overall scores undertaken previously in this section.

Table 4.16 Comparison of broad indicator components of condition assessment methods

Broad indicator categories	*Habitat Hectares*		*Bushland Condition Monitoring*		t-Test and P-value	Correlation coefficient (r) and P-value
	Average percentage of possible total for all 13 sites	Standard deviation for all 13 sites	Average percentage of possible total for all 13 sites	Standard deviation for all 13 sites		
Diversity	51 %	20 %	66 %	18 %	t=-1.4, P=0.17	r=0.70, P<0.005
Growth Stages	53 %	32 %	63 %	28 %	t=0.43, P>0.6	r=0.81, P<0.001
Litter	82 %	28 %	75 %	38 %	t=-1.5, P=0.15	r=0.54, P<0.05
Weeds	73 %	32 %	69 %	34 %	t=0.43, P>0.6	r=0.78, P<0.001

4.4.3. Biological Survey and *Bushland Condition Monitoring* comparison

Existing Biological Survey data was compared to the data collected using the *Bushland Condition Monitoring* method at nine coincident sites. The Biological Survey sites were visited at various times between 1978 and 2000. Table 4.17 shows the date each Biological Survey site was visited.

Table 4.17 Biological Survey site visit dates in relation to the *Bushland Condition Monitoring* sites

BCM Site Number	Survey Site Number	Year of Survey
1	17840	2000
9	17825	2000
13	17811	2000
16	17579	2000
14	9032	1988
7	5220	1986
12	5306	1986
8	5273	1986
15	9524	1978

For each of these sites, the data common to both methods and relevant to a *Bushland Condition Monitoring* indicator was identified and examined (Table 4.18).

Table 4.18 *Bushland Condition Monitoring* indicator and relevant Biological Survey data

Bushland Condition Monitoring indicator	Relevant Biological Survey data
Plant Species Diversity	Number of native species
Weed Abundance and Threat	Number and cover of weed species
Structural Diversity A: Ground Cover	Bare ground percent

The Biological Survey method has evolved over time. Only some of the above attributes were collected in every survey. Four of the nine revisited Biological Survey sites contain the complete set of attributes examined. Those four sites were visited in 2000. The remaining five sites lack weed species cover, life form number and cover and bare ground records. As a result, the date of the original Biological Survey will influence the usability of the Biological Survey data within *Bushland Condition Monitoring* assessments.

The following sections examine each of the attributes listed above. Their value within the existing Biological Survey site data is compared to that collected using the *Bushland Condition Monitoring* method.

4.4.3.1. Plant Species Diversity

The number of native species recorded at a site is used to score Plant Species Diversity using the *Bushland Condition Monitoring* method. The native species score recorded using the *Bushland*

Condition Monitoring method was compared to the data previously collected using the Biological Survey method at the same location. Table 4.19 lists the *Bushland Condition Monitoring* site number and the native species score. The equivalent Biological Survey site number is listed and the native species score is displayed. A location number is assigned to each location surveyed by each method. The difference between the two sets of data is displayed in the right hand column of Table 4.19.

Table 4.19 *Bushland Condition Monitoring* and Biological Survey Native Species measurements

Location Number	Method	Site Number	Year of Survey	Native Species score	Difference (BCM – BS)
01	BCM	1	2005	25	-7
	BS	17840	2000	32	
02	BCM	7	2005	38	4
	BS	5220	1986	34	
03	BCM	8	2005	43	12
	BS	5273	1986	31	
04	BCM	9	2005	53	8
	BS	17825	2000	45	
05	BCM	12	2005	41	11
	BS	5306	1986	30	
06	BCM	13	2005	41	-24
	BS	17811	2000	65	
07	BCM	14	2005	38	-8
	BS	9032	1988	46	
08	BCM	15	2005	36	26
	BS	9524	1978	10	
09	BCM	16	2005	30	10
	BS	17579	2000	20	

BCM = *Bushland Condition Monitoring*, BS = Biological Survey

The 'Difference' column indicates that the native species score at two of the nine locations varies by more than 23 species for the two surveys (Location numbers 06 and 08), however there is a degree of variation between the methods at all sites. These Biological Survey sites were assessed between five and twenty-seven years ago. This alone may account for the variation in species diversity recorded at the sites.

4.4.3.2. Weed Abundance and Threat

The *Bushland Condition Monitoring* method records the five most abundant weed species and cover at each site. The Biological Survey method records weed species and cover in the list of species present at each site. The Biological Survey cover data was used to select the five most abundant weed species recorded in the Biological Survey species list. The Weed Abundance and Threat score was calculated using this data and was compared to the *Bushland Condition Monitoring* results (Table 4.20). Cover abundance was not recorded for the Biological Survey sites at location numbers 02, 03, 05, 07 and 08 therefore a Weed Abundance & Threat score was not calculated.

Table 4.20 *Bushland Condition Monitoring* and Biological Survey Weed Abundance and Threat scores

Location Number	Method	Site Number	Weed Abundance & Threat score	Difference (BCM – BS)
01	BCM	1	14	-1
	BS	17840	15	
02	BCM	7	3	-
	BS	5220	-	
03	BCM	8	9	-
	BS	5273	-	
04	BCM	9	11	-6
	BS	17825	17	
05	BCM	12	10	-
	BS	5306	-	
06	BCM	13	1	-6
	BS	17811	7	
07	BCM	14	10	-
	BS	9032	-	
08	BCM	15	0	-
	BS	9524	-	
09	BCM	16	6	2
	BS	17579	4	

BCM = *Bushland Condition Monitoring*, BS = Biological Survey

The higher the Weed Abundance and Threat score, the greater the threat to native species diversity (Croft *et al.*, 2005). These results indicate a small amount of variation between the Weed Abundance and Threat scores generated using the *Bushland Condition Monitoring* data and the Biological Survey data. The variation is by one or two points at two of the four locations where a Weed Abundance and Threat score was calculated. The score dropped by 6 points at location numbers 04 and 06.

The position of the sites at location number 06 was examined in an attempt to further understand the changes in the weed score. These sites are located in the Para Wirra Recreation Park in land described as "Conservation and natural environments" in the DWLBC land use dataset. This implies that the land is managed for conservation purposes. An increase in the Weed Abundance and Threat score at this site indicates an increase in the abundance and threat of weeds. This is in opposition to the management objectives of the park. The small number of sites used in this analysis however, makes it difficult to draw any conclusions about the relationship between these two data sets.

4.4.3.3. Structural Diversity A: Ground Cover

The ground cover score is calculated as the difference between the total ground cover rating and the total bare ground rating. The definition of total ground cover in the Biological Survey is slightly different to that in the *Bushland Condition Monitoring* method. As a result, the percentage of bare ground recorded at each Biological Survey site was used to determine the total ground cover percent and hence, the ground cover score. The *Bushland Condition Monitoring* Ground Cover score was compared to the Biological Survey Ground Cover score (Table 4.21). Ground cover was only recorded at the four most recently surveyed Biological Survey sites.

Table 4.21 *Bushland Condition Monitoring* and Biological Survey Ground Cover scores

Location Number	Method	Site Number	Ground Cover score	Difference (BCM – BS)
01	BCM	1	4	0
	BS	17840	4	
02	BCM	7	4	-
	BS	5220	-	
03	BCM	8	4	-
	BS	5273	-	
04	BCM	9	4	0
	BS	17825	4	
05	BCM	12	4	-
	BS	5306	-	
06	BCM	13	4	0
	BS	17811	4	
07	BCM	14	4	-
	BS	9032	-	
08	BCM	15	4	-
	BS	9524	-	
09	BCM	16	4	0
	BS	17579	4	

BCM = *Bushland Condition Monitoring*, BS = Biological Survey

These results indicate there is no difference in the ground cover score calculated using the Biological Survey data and the *Bushland Condition Monitoring* data. An examination of the raw data reveals small variations of less than two percent, possibly due to variation between different observers. The ground cover score is generated using cover rating categories and therefore eliminates these small differences. The small number of survey sites used limits this analysis and therefore conclusions cannot be drawn from these results.

4.5. Condition Surfaces

This section will discuss the results from the development of the vegetation condition and the reliability surfaces.

4.5.1. Vegetation condition surface

The vegetation condition surface was developed within the study area. This involved developing grids of site condition, vegetation and land use. These grids were then used to define the vegetation condition in the study area. The following section discusses the results from this component of the project.

4.5.1.1. Site condition

4.5.1.1.1. Survey site grid

The survey site grid was generated from a layer of the field assessment locations. This grid contains individual grid cells coded with the *Habitat Hectares* site condition score while the remaining cells are coded as 'NODATA'. This grid is not shown within the report, as the survey site cells are too small to view within a map presented at a scale appropriate for this report.

4.5.1.1.2. Vegetation grid

The vegetation grid was generated from a layer of vegetation benchmark groups used for this study. Figure 4.24 represents the grid of vegetation benchmark groups in the study area. The grey colour indicates the areas where other vegetation communities exist or where vegetation has not been mapped.

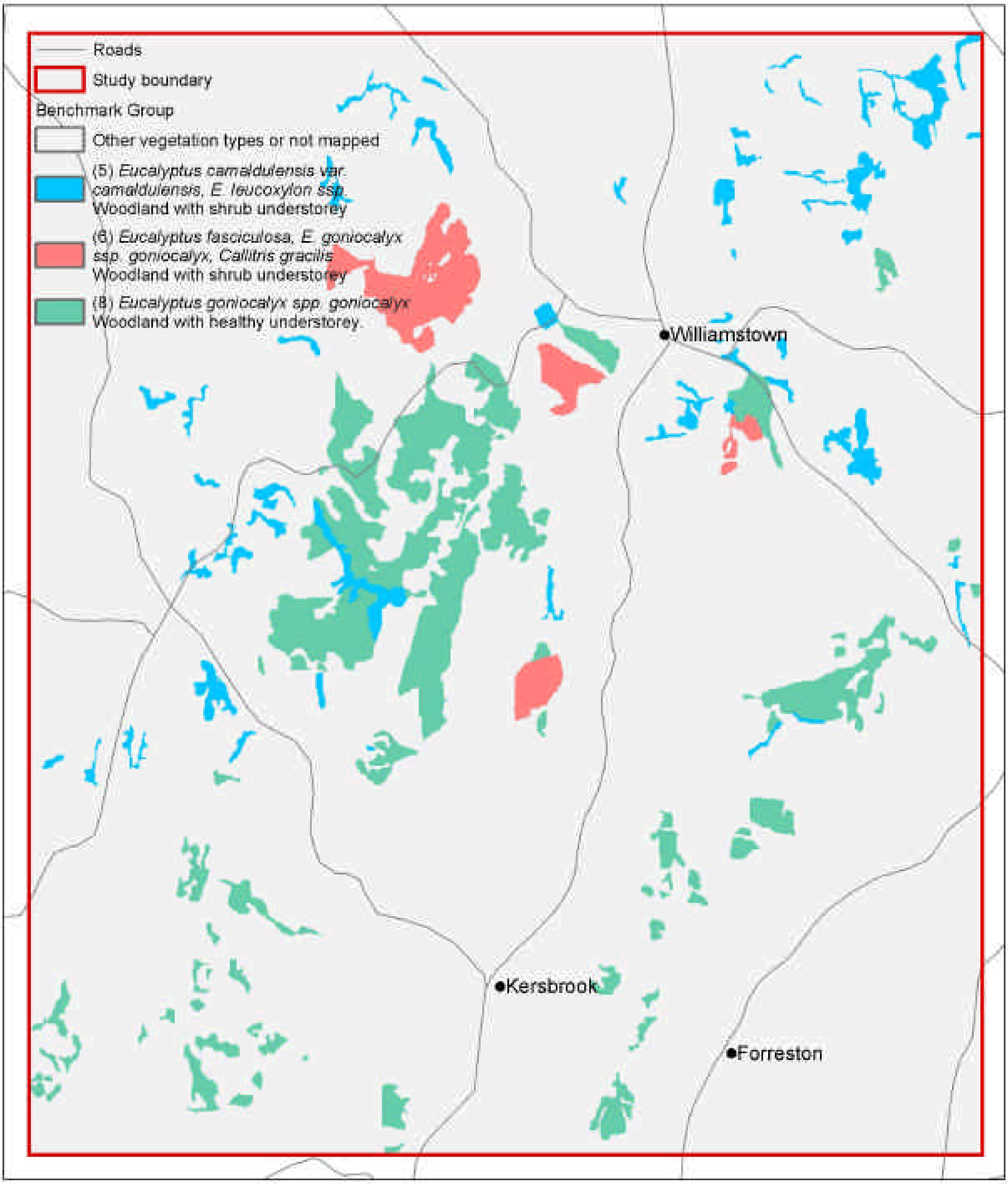

Figure 4.24 Grid of vegetation benchmark groups

4.5.1.1.3. Land use grid

The DWLBC land use layer was used as a basis for the land use grid (Figure 4.25). Each colour in this grid represents a category within the primary level of land use classification. These categories were multiplied by 100 in the land use layer for processing purposes and converted to a grid.

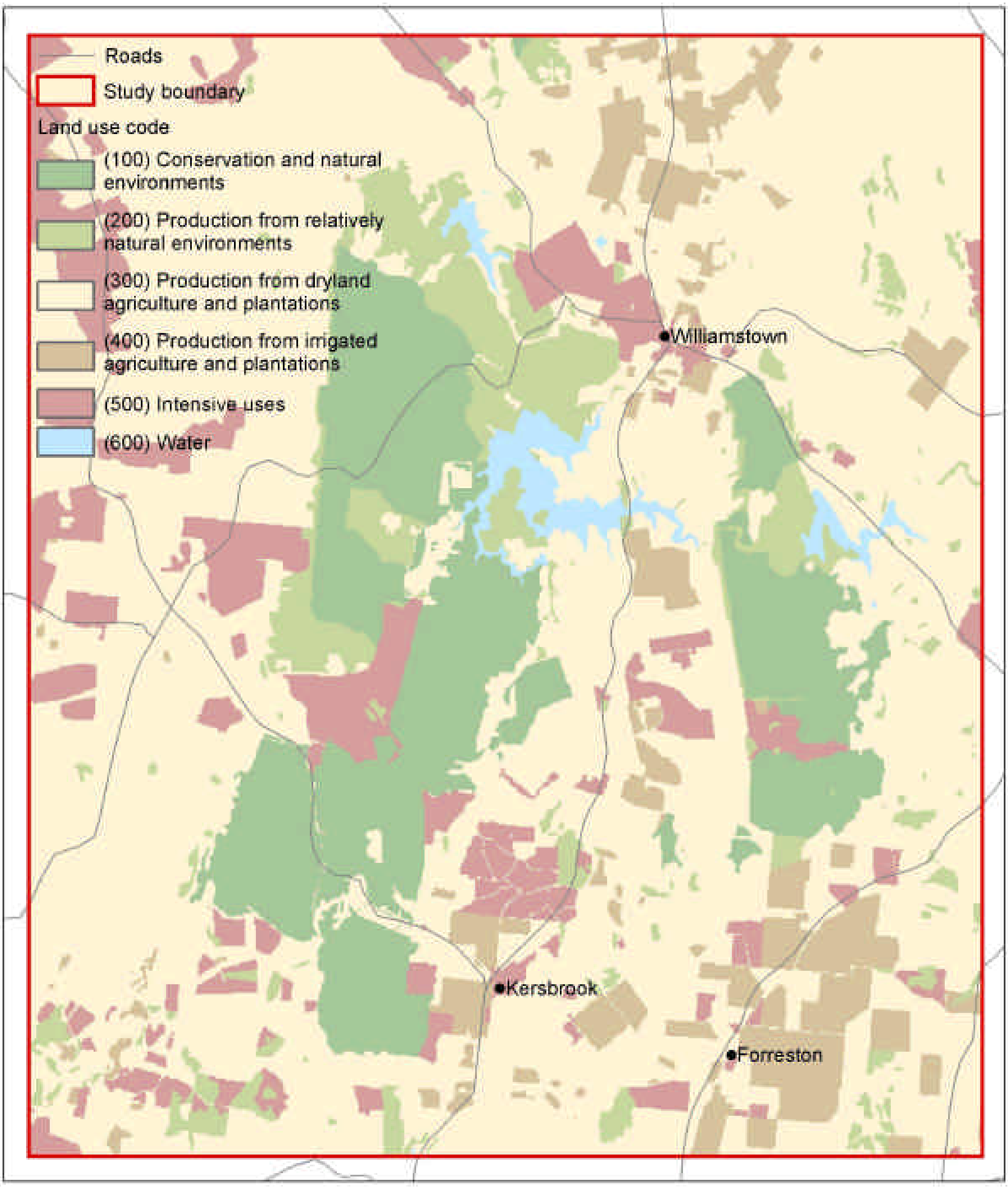

Figure 4.25 Land use grid

4.5.1.1.4. Vegetation and land use grid

The vegetation grid and the land use grid were added together. The resulting grid formed unique combinations of vegetation benchmark group and land use type. Figure 4.26 illustrates the combined vegetation and land use grid.

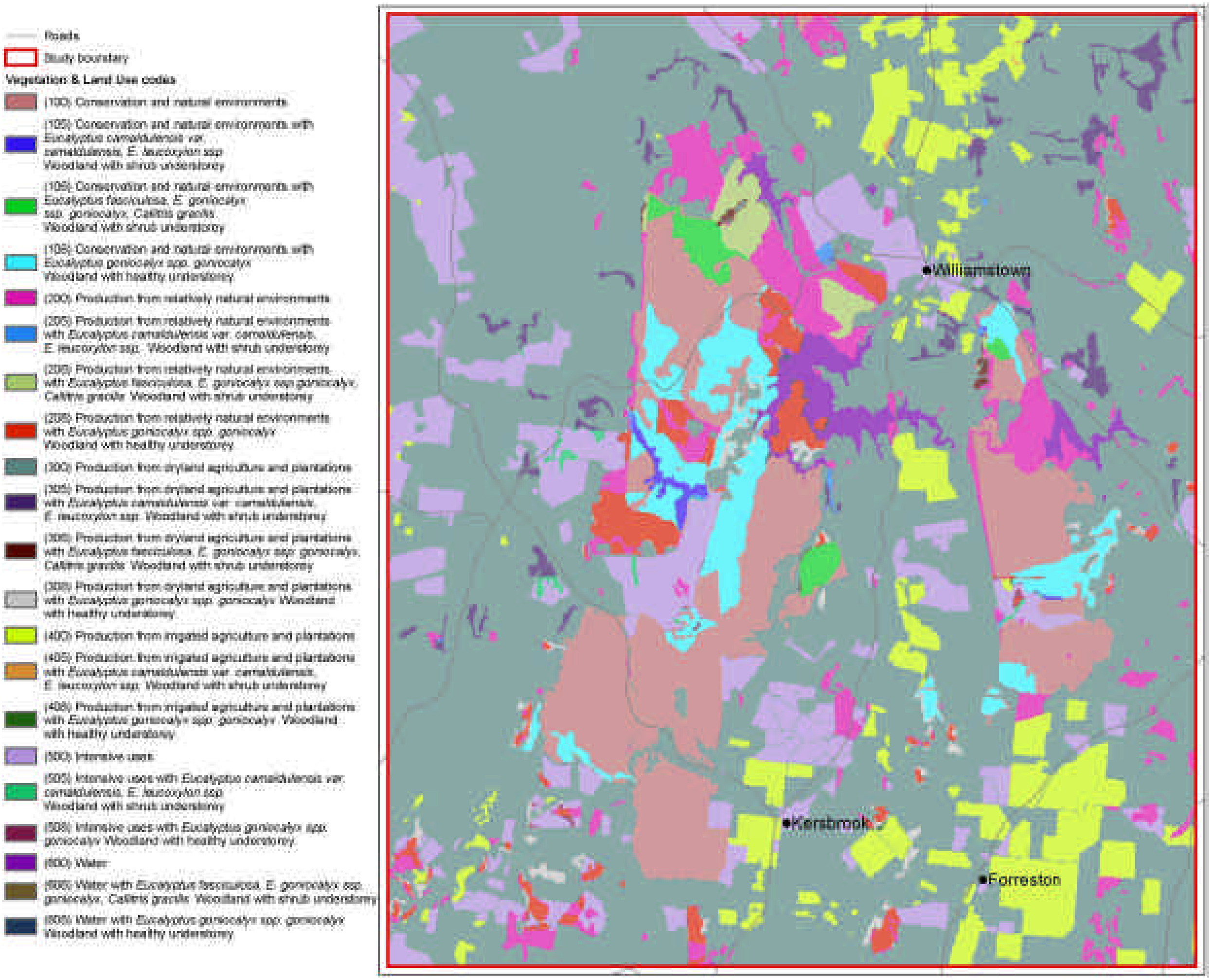

Figure 4.26 Vegetation and land use grids combined

4.5.1.1.5. Extrapolation

Figure 4.27 represents the site condition surface. This grid was generated from the survey site grid and the combined vegetation and land use grid (Figure 4.26). Table 4.22 represents the average condition score of the sites within each vegetation and land use value. These values were extrapolated to produce the site condition surface. The surface represents the vegetation condition scored out of a possible total of 75 points. The blue to red colour ramp represents the condition scores. The red areas represent those patches of vegetation with higher condition while the blue areas have lower vegetation condition scores. The areas in grey are areas where the condition is unknown. This is due to the absence of a survey site within the combined vegetation and land use type in these areas.

Table 4.22 Average site condition scores within each vegetation and land use category

Vegetation / Land Use Code	Benchmark Group Description	Land Use Description	Average Condition Score (out of 75)	Average Condition Score (%)
105	*Eucalyptus camaldulensis* var. *camaldulensis*, *Eucalyptus leucoxylon* ssp. Woodland with shrub understorey	Conservation and natural environments	45	60 %
108	*Eucalyptus goniocalyx* ssp. *goniocalyx* Woodland with heathy understorey	Conservation and natural environments	56	75 %
106	*Eucalyptus fasciculosa, Eucalyptus goniocalyx* ssp. *goniocalyx, Callitris gracilis* Woodland with shrub understorey	Conservation and natural environments	58	77 %
206	*Eucalyptus fasciculosa, Eucalyptus goniocalyx* ssp. *goniocalyx, Callitris gracilis* Woodland with shrub understorey	Production from relatively natural environments	54	72 %
208	*Eucalyptus goniocalyx* ssp. *goniocalyx* Woodland with heathy understorey	Production from relatively natural environments	40	53 %
205	*Eucalyptus camaldulensis* var. *camaldulensis*, *Eucalyptus leucoxylon* ssp. Woodland with shrub understorey	Production from relatively natural environments	22	29 %
306	*Eucalyptus fasciculosa, Eucalyptus goniocalyx* ssp. *goniocalyx, Callitris gracilis* Woodland with shrub understorey	Production from dryland agriculture and plantations	32	43 %
505	*Eucalyptus camaldulensis* var. *camaldulensis*, *Eucalyptus leucoxylon* ssp. Woodland with shrub understorey	Intensive uses	14	19 %

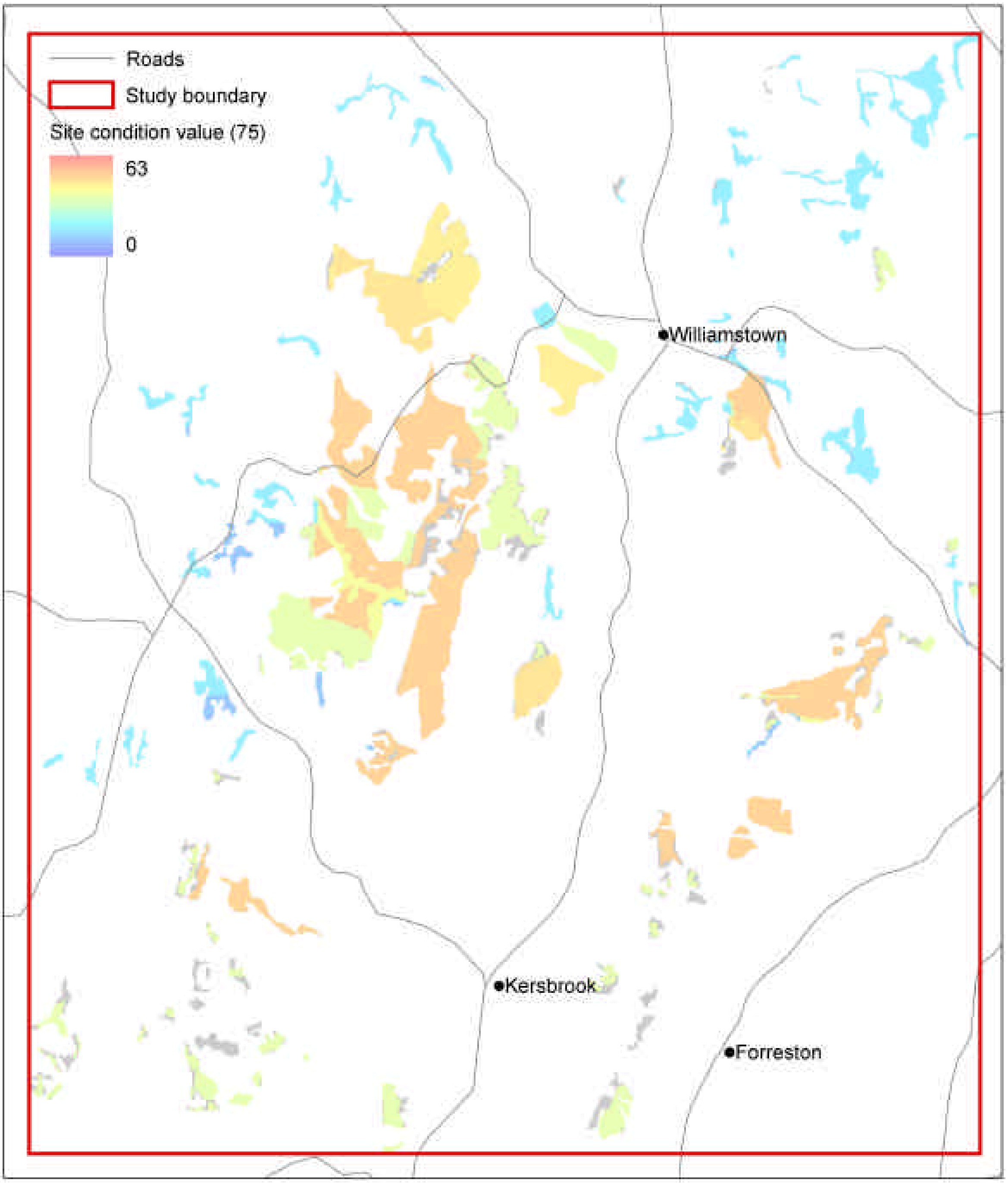

Figure 4.27 Site condition surface

The site condition grid forms one component of the final condition surface. The landscape context grid forms the other component and is discussed in the following section.

4.5.1.2. Landscape context

The landscape context component of the *Habitat Hectares* method incorporates three variables. These are patch size, neighbourhood and distance to core area. These three variables will be discussed in the following sections.

4.5.1.2.1. Patch size

Figure 4.28 represents the patch size grid. The numbers in brackets represent the patch size values for each category. The grid shows that the green areas represent the largest category of vegetation patch size while the pink areas are the smallest patches.

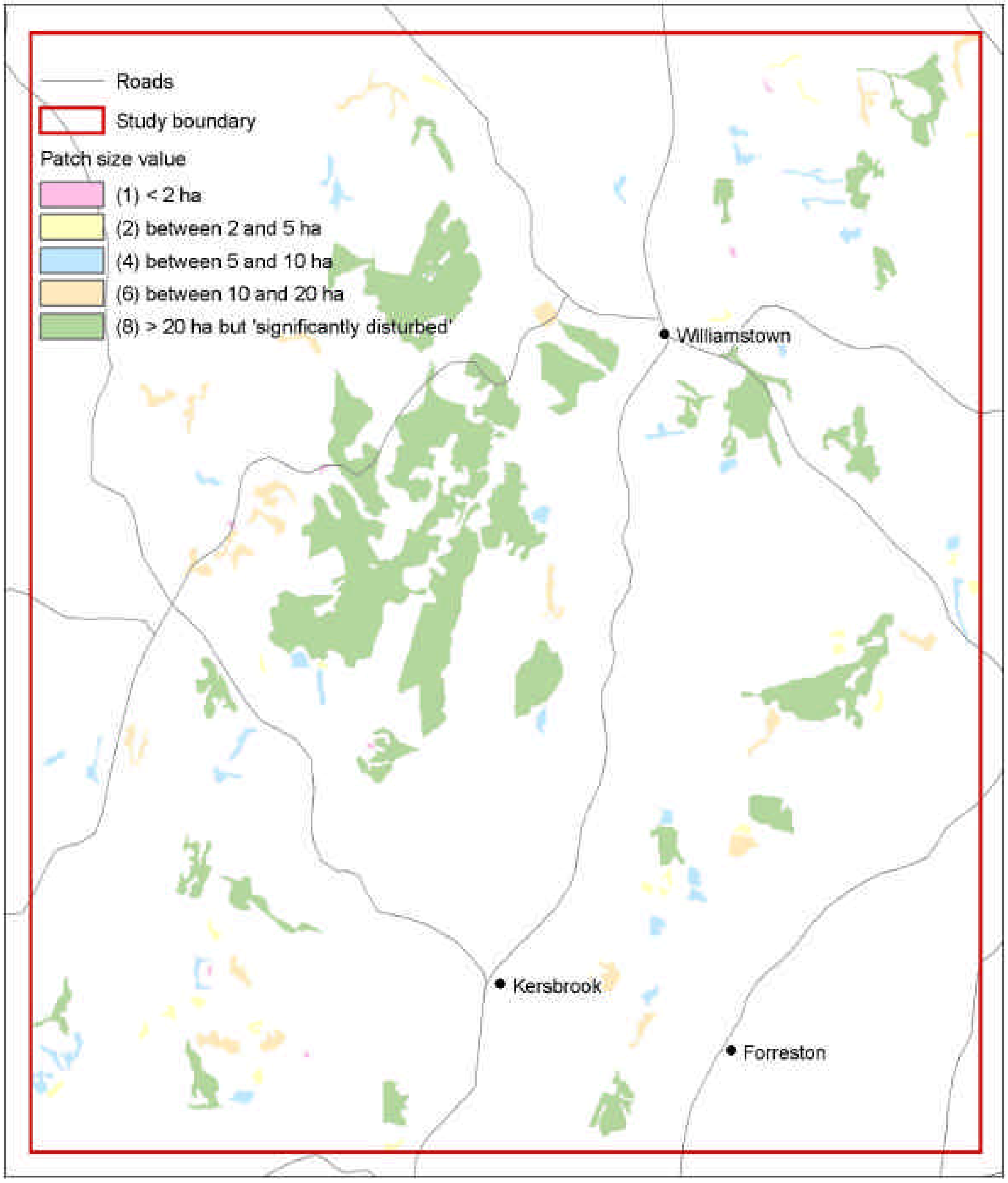

Figure 4.28 Patch size grid

4.5.1.2.2. Neighbourhood

The neighbourhood was developed to represent the amount of vegetation within specified proximities of each patch of vegetation. The grids in Figure 4.29, Figure 4.30 and Figure 4.31 illustrate the number of vegetated cells within 100m, 1km and 5km of each cell respectively. The blue colour represents a small number of vegetated cells while the red indicates a large number of vegetated cells within the specified buffers.

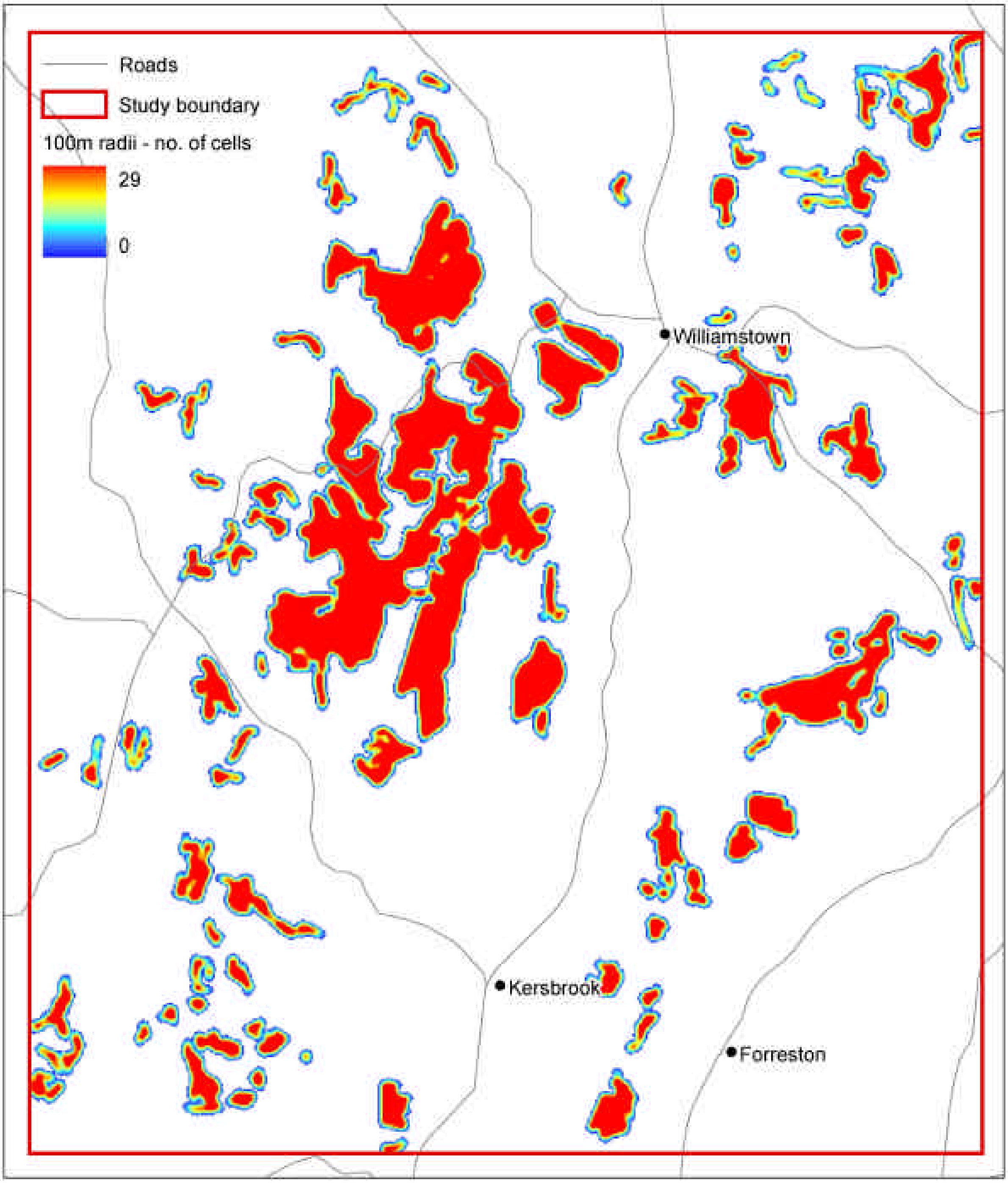

Figure 4.29 Neighbourhood radii grid of 100 metres

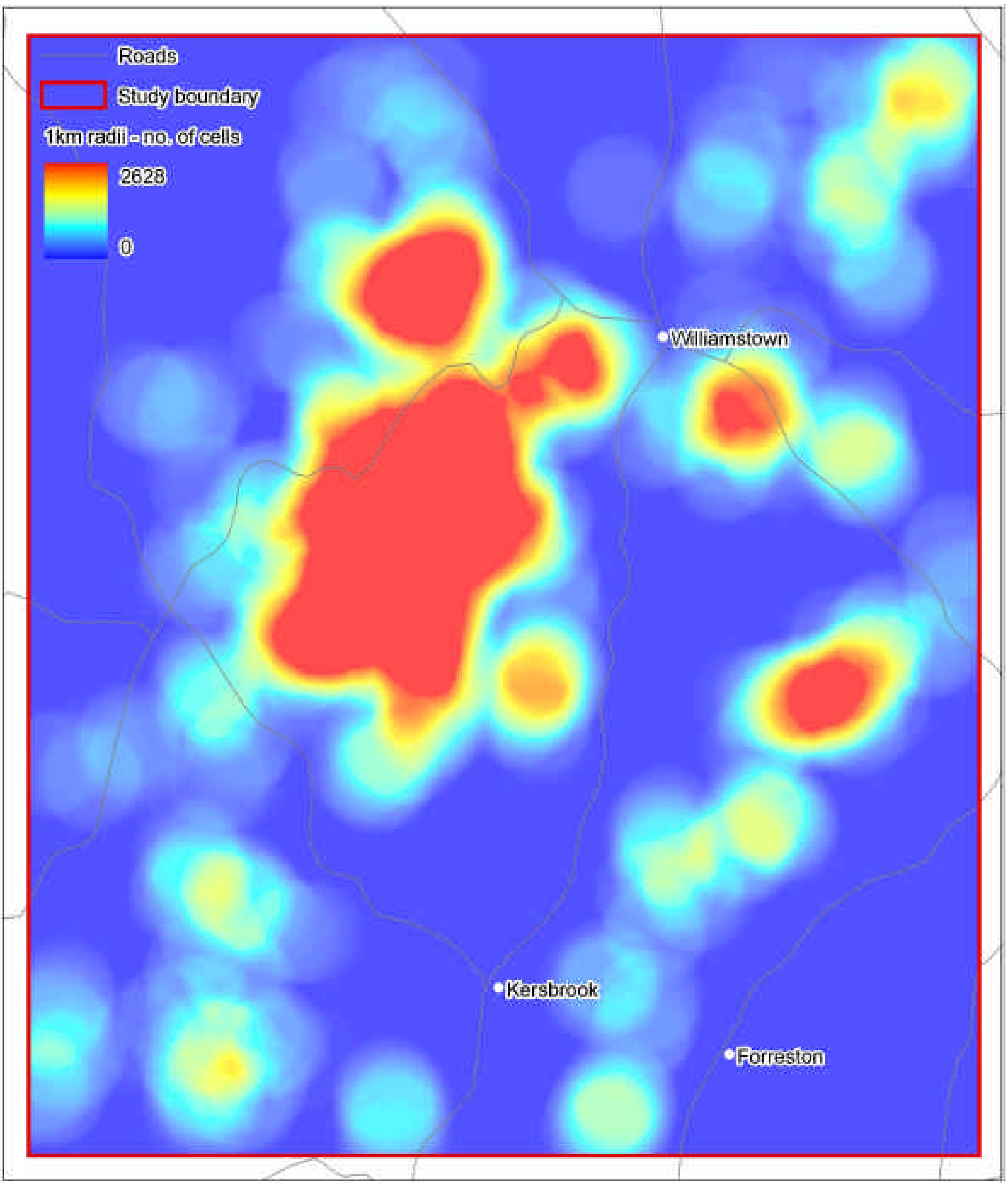

Figure 4.30 Neighbourhood radii grid of 1 kilometre

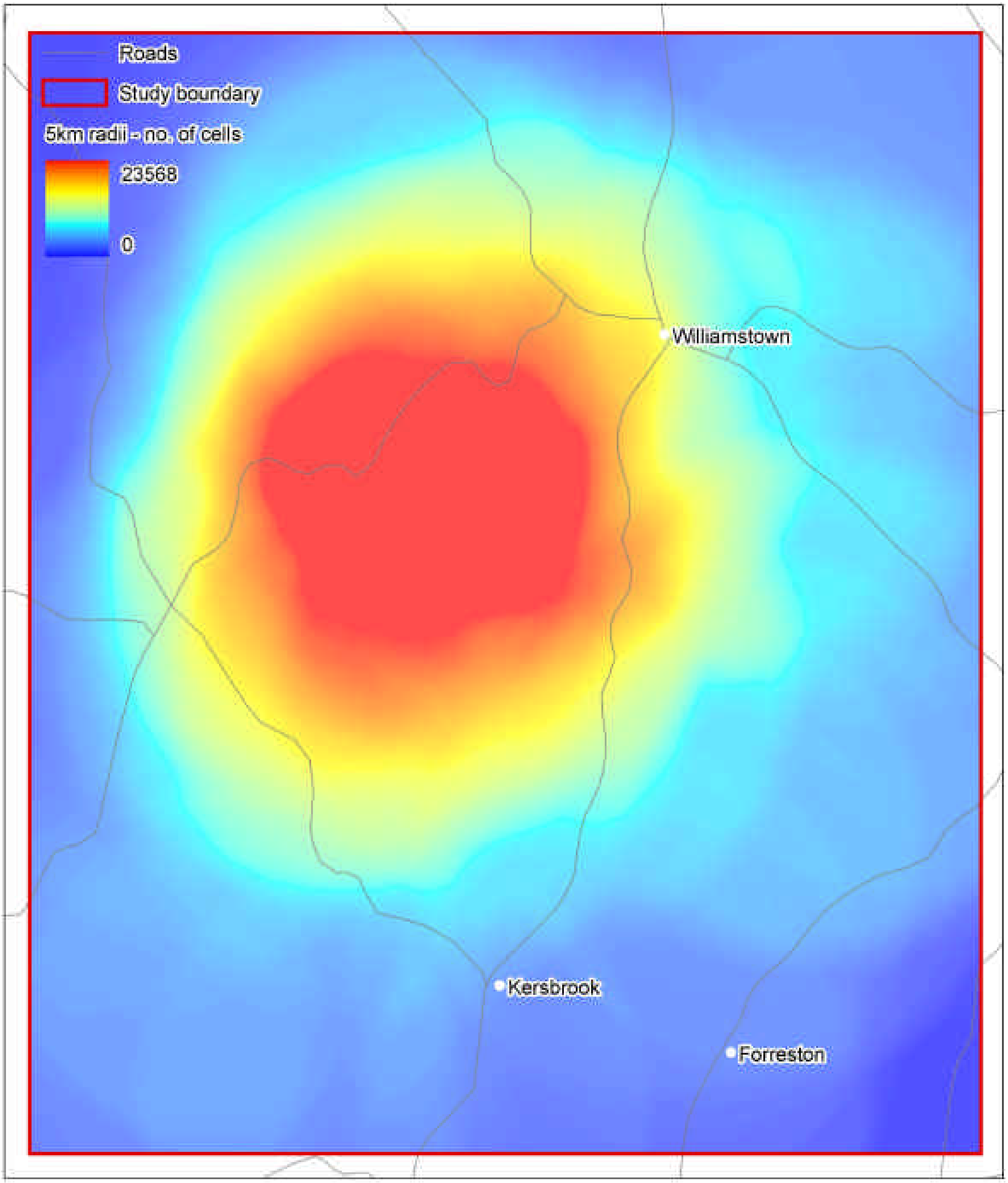

Figure 4.31 Neighbourhood radii grid of 5 kilometres

Figure 4.32 shows the final neighbourhood grid where the 100m, 1km and 5km grids were combined. This grid reflects the method outlined in DSE (2004a), scoring the neighbourhood component out of a total of ten points.

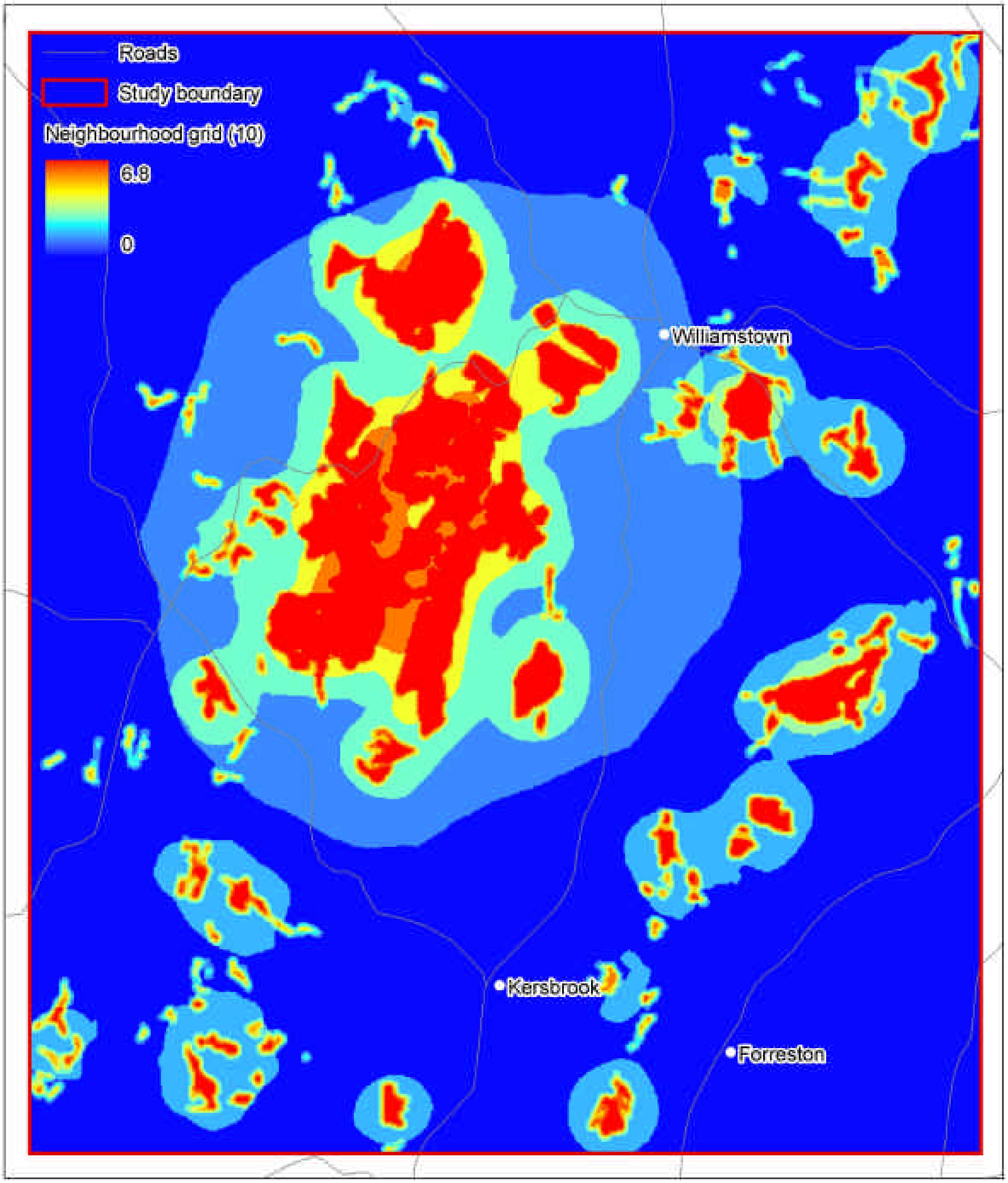

Figure 4.32 Neighbourhood grid

4.5.1.2.3. Distance to core areas

The distance to core areas grid indicates the distance category from a vegetation patch to a core area. A core area is a patch of vegetation greater than fifty hectares in size (DSE, 2004a). Figure 4.33 illustrates the core and non-core vegetation in the study area. The green areas represent the core areas and the grey represents the non-core areas.

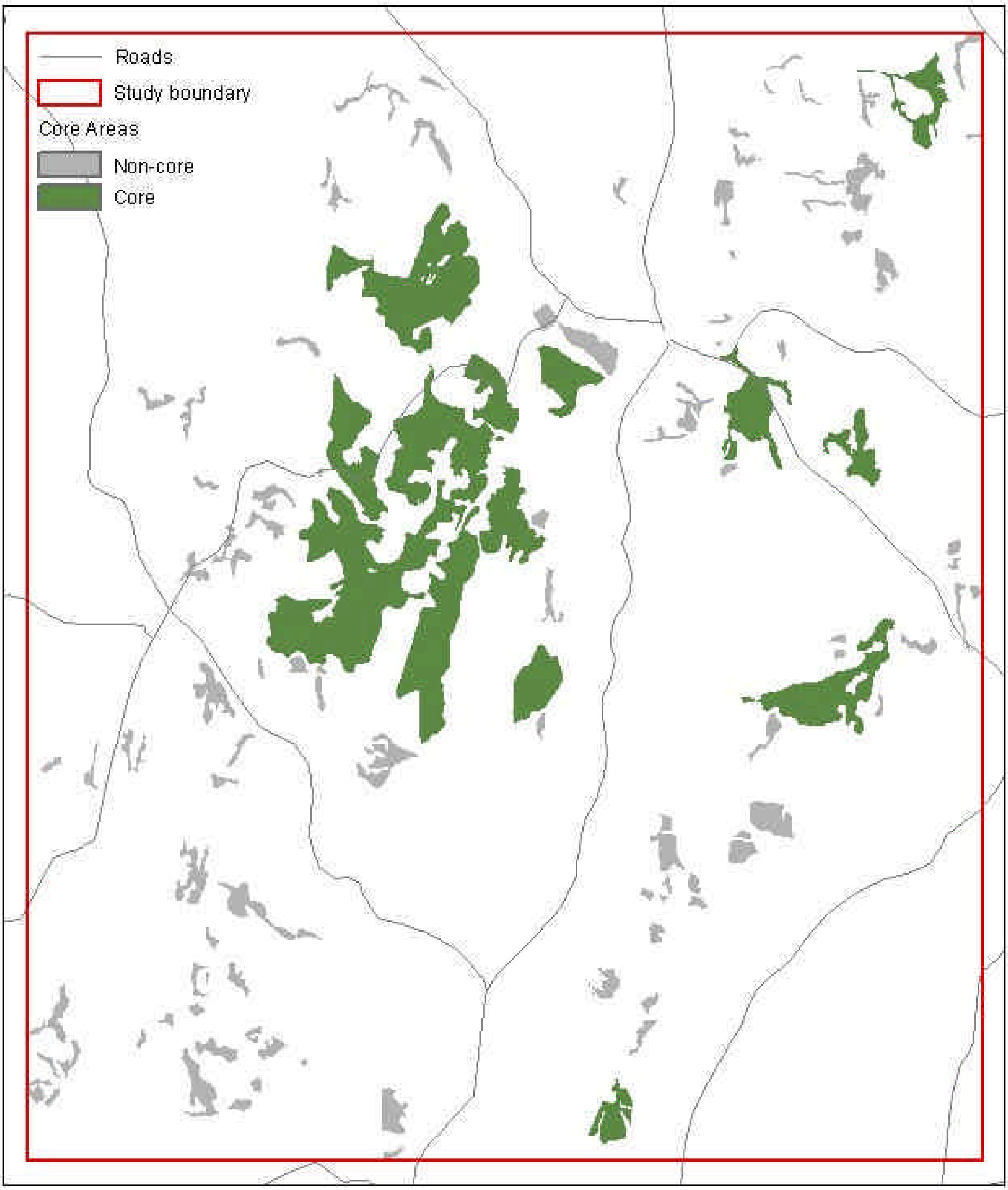

Figure 4.33 Core and non-core areas

The distance from each grid cell of native vegetation to these core areas is illustrated in Figure 4.34. The distances are categorised according to the method outlined by DSE (DSE, 2004a) (Figure 3.6). The dark green areas represent those cells that are adjoining a core area. The paler green indicates a distance of less than one kilometre from the cell to the nearest core area. The blue and the orange cells represent those cells that are between one and five kilometres, and greater than five kilometres from a core area respectively.

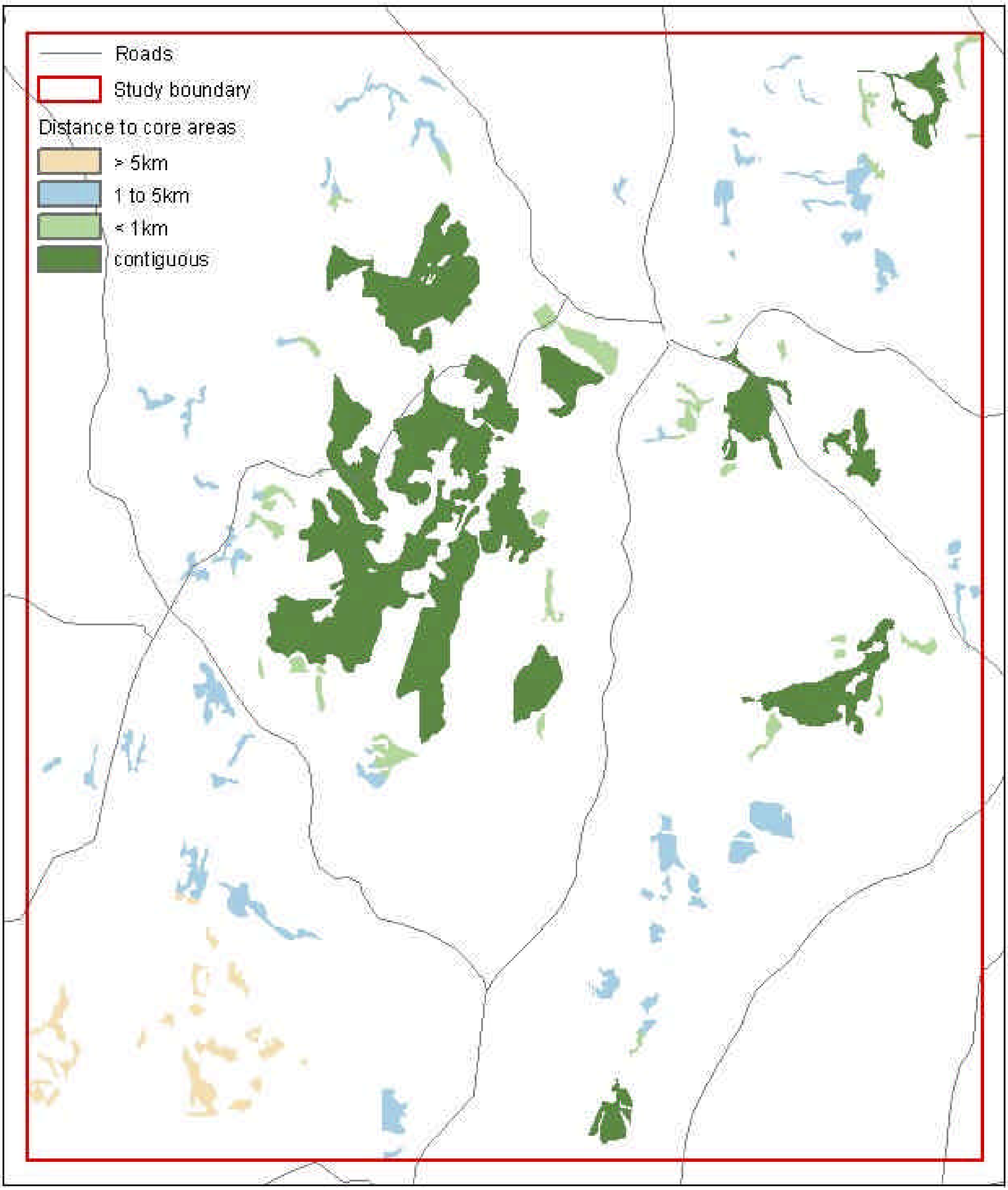

Figure 4.34 Distance to core area grid

4.5.1.2.4. Landscape context grid

The patch size, neighbourhood and distance to core areas grids were combined to form the landscape context grid (Figure 4.35). The cells in this grid are scored out of a possible total of twenty-five points. The dark brown areas have a higher landscape context value than the pale brown areas. These darker areas will contribute a larger amount to the total condition score when added to the site condition surface.

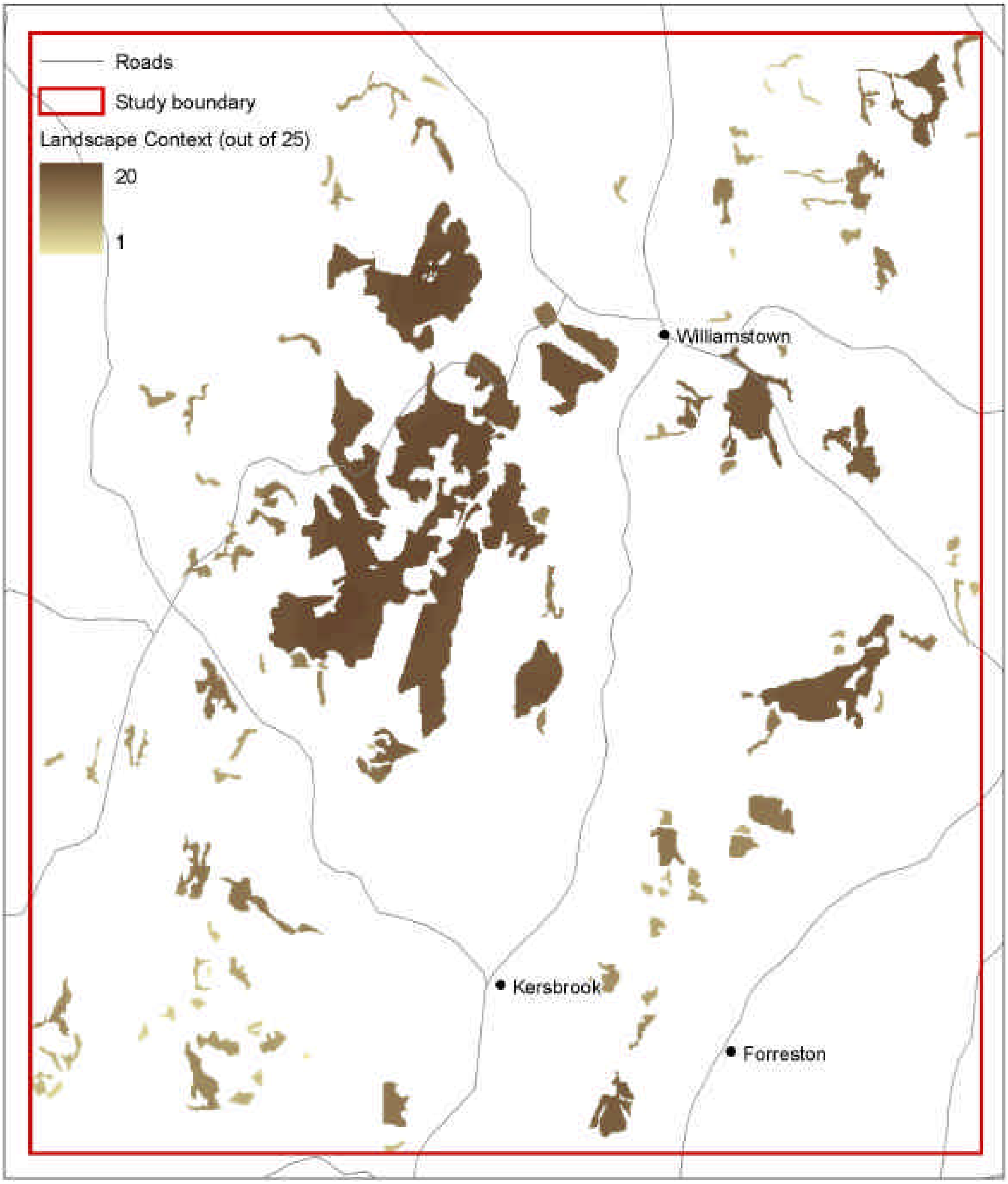

Figure 4.35 Landscape context grid

4.5.1.3. Condition surface

The final step involved in developing the surface of vegetation condition was to combine the site condition grid (Figure 4.27) with the landscape context grid (Figure 4.35). The grids were added together to produce the vegetation condition grid out of a possible total of 100 points (Figure 4.36). A value of 'unknown' was assigned to those cells where there was no site condition score (represented in grey). The condition values have been categorised into five condition classes. The areas with the highest vegetation condition are those represented in dark blue, while areas with the lowest vegetation condition are represented in yellow.

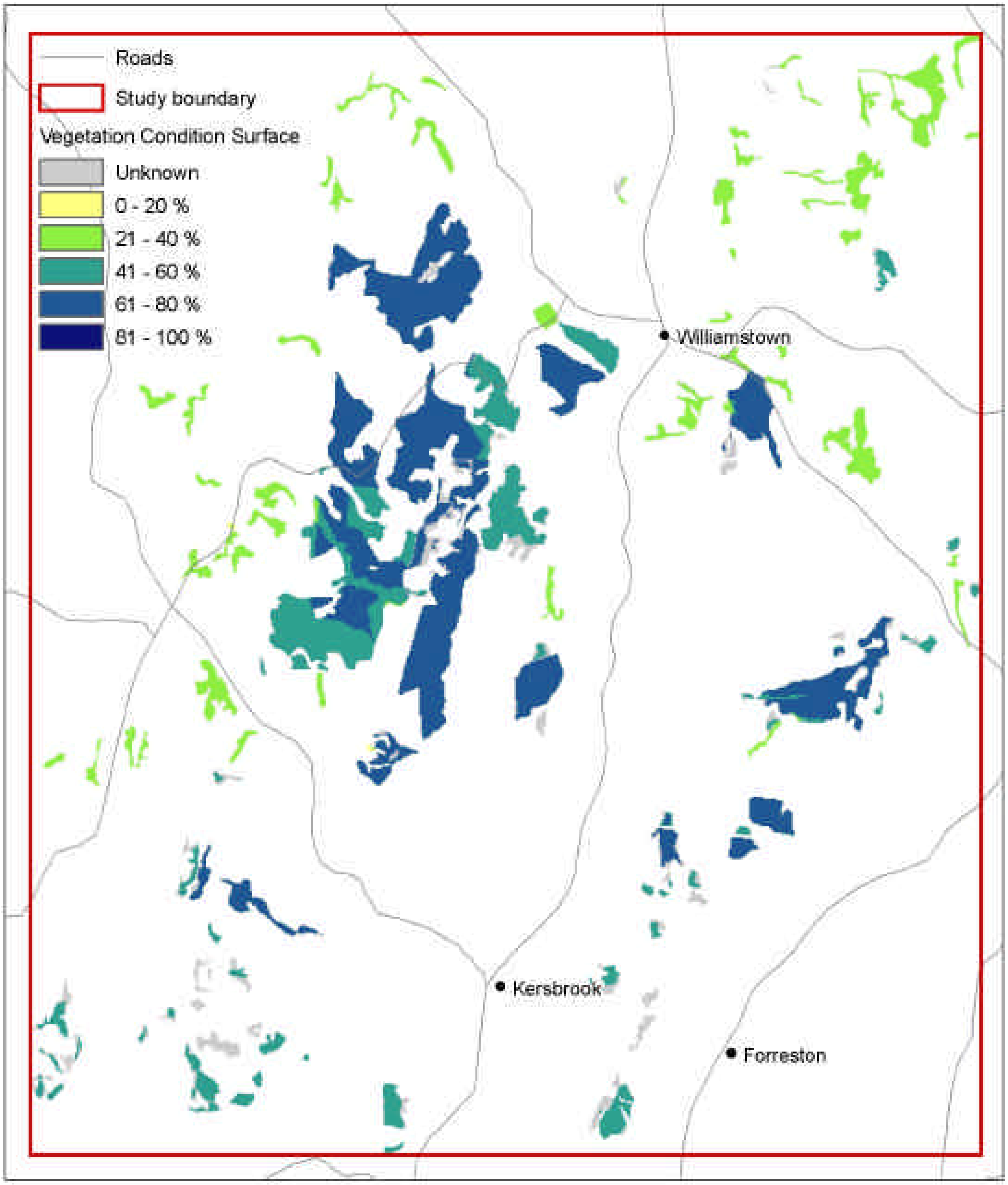

Figure 4.36 Condition surface

4.5.2. Reliability surface

A reliability surface was produced to describe the accuracy of the vegetation condition surface (Figure 4.37). The area was classified into three categories; high, medium and low reliability. The cells were coded with high reliability where field sites exist. As described in the section 3.5.1.1, the site condition scores were averaged during the extrapolation process. The reliability of these extrapolated cells was then determined by assessing the magnitude of the range between the original field site values. Cells were assigned with a low reliability, represented in red, where the maximum and minimum site values varied by greater than or equal to fifteen points. A medium reliability was assigned to the cells where the range was between one and fifteen points. These cells are represented in orange in Figure 4.37. The grey cells represent those cells where the condition value was unknown.

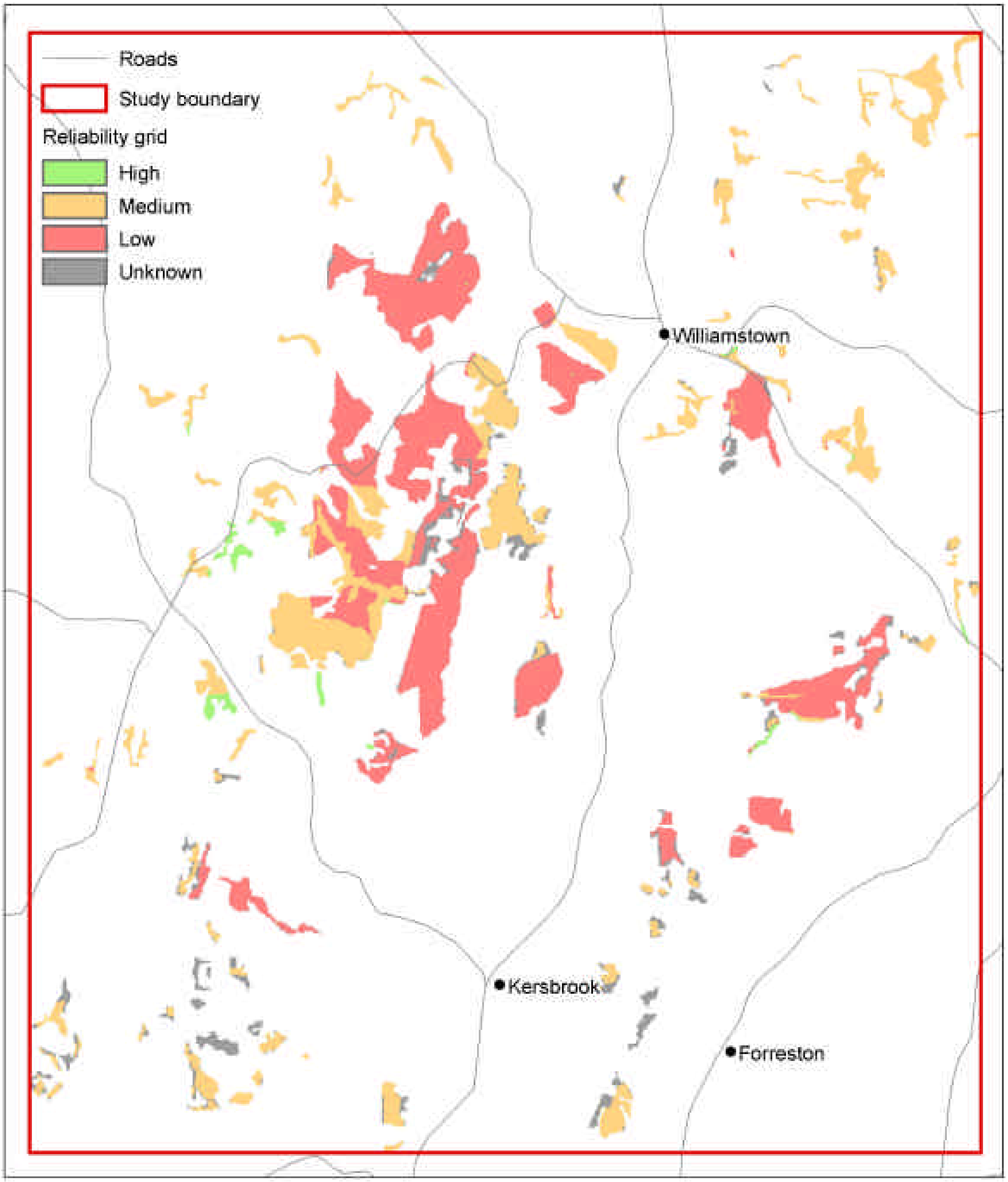

Figure 4.37 Reliability grid

5. Discussion & Recommendations

This section discusses the results from each objective outlined in this report. Implications of the application of ESCAVI's interim approach for a nativ e vegetation indicator in South Australia are discussed and recommendations for future applications are suggested.

5.1. Comparison of Methods

This section discusses the comparison between the *Bushland Condition Monitoring* method, the *Habitat Hectares* method and the Biological Survey method.

5.1.1. Bushland Condition Monitoring versus Habitat Hectares

The comparison between the *Bushland Condition Monitoring* method and the *Habitat Hectares* method highlighted some fundamental differences in the design of each method. These differences are discussed in section 5.1.1.1 and recommendations for method refinement are suggested. The techniques used to measure each indicator were analysed in detail and are discussed in section 5.1.1.2.

5.1.1.1. Method design

The *Bushland Condition Monitoring* method is designed for landowners and bushland managers to monitor temporal changes in native vegetation on their property (Croft *et al.*, 2005). The surveys are performed in 30m x 30m quadrats, therefore allowing repeatable and comparable surveys over time. In contrast, the *Habitat Hectares* method is design as a rapid assessment of vegetation quality and allows a repeatable comparison of condition between vegetation types. The ability to compare the quality of different stands of vegetation is highly valuable in natural resource management. This enables environmental planners and managers to prioritise the allocation of resources for conservation purposes (Parkes *et al.*, 2003). On the other hand, the ability of the *Bushland Condition Monitoring* method to monitor vegetation condition over time is also important. This assists environmental managers and landowners to understand the effect of various management techniques or reasons for natural temporal change. The NCSSA allowed the adaptation of the *Bushland Condition Monitoring* method for this project, and various other projects, to weight each indicator and produce a total condition score for each survey site. This allows comparison of vegetation condition between vegetation types and condition survey sites, as in the *Habitat Hectares* approach. A permanent alteration to the *Bushland Condition Monitoring* method to produce a total condition score for each site would prove beneficial to natural resource managers prioritising on-ground projects.

Habitat Hectares measures vegetation condition in 'assessment areas'. The vegetation type and the assumed vegetation quality define the size and location of these assessment areas.

Changes in vegetation condition over time could result in an altered definition of the assessment area. This may hinder the monitoring of temporal change in vegetation quality as the boundaries of the assessment units may have changed making comparison difficult. On the other hand, defining an assessment area based on the vegetation type and the assumed vegetation quality is beneficial when attempting to map vegetation condition. Theoretically, if a condition assessment is performed within each area of unique vegetation type and quality the results from the assessments form the vegetation condition map. The use of a 30m x 30m quadrat in the *Bushland Condition Monitoring* method requires the site data to be extrapolated across the project area in order to produce a map of vegetation condition. The method of extrapolation introduces factors of error as condition values are assumed in many areas based on the quality of vegetation types in similar environmental conditions. Both flexible 'assessment areas' and set quadrat sizes have merit depending on the desired outcome. Monitoring of temporal change in a particular area of vegetation is better performed using a set quadrat size. 'Assessment areas' are suitable for monitoring temporal changes in vegetation condition across large areas for prioritising environmental projects. The flexibility to implement either set quadrats or variable 'assessment areas' in both the *Bushland Condition Monitoring* and the *Habitat Hectares* methods would allow the techniques to be applied more widely.

The use of categories to score many of the indicators within *Habitat Hectares* minimises the potential for error. The variability between observers is minimised where survey data is categorised rather than scored as a raw value (Parkes *et al.,* 2003). This is particularly beneficial where observers with different skill levels are completing the site assessments.

The *Habitat Hectares* method uses a matrix-style format to assess many of the indicators. This involves the assessment of more than one environmental factor to score an indicator. For example, the Large Trees indicator assesses the number of large trees against the health of the tree canopy. This method of assessing indicators increases the complexity of the assessment. It also reduces the temporal comparability of the assessment site because in many cases an indicator score can be achieved in more than one way. For example, a site containing '> 20% to 40% of the benchmark number of large trees/ha' and '> 70%' tree health scores a Large Trees value of four. A Large Trees score of four is also achieved at a site where there is '> 40% to 70% of the benchmark number of large trees/ha' and '< 30%' tree health. An increase in the number of large trees per hectare and a dramatic reduction in tree health will not be detected in the above scenario. The *Bushland Condition Monitoring* method is simpler as it mostly records raw values and aggregates them at the end of the process. Multiple factors do not require assessment in the field, as in the *Habitat Hectares* approach.

5.1.1.2. Indicators

The points below suggest alterations to particular components of the *Bushland Condition Monitoring* indicators.

- Exclude Tree Hollows score from the Tree Habitat Features indicator to avoid duplication where a total condition score is calculated.
- Alter the Fallen Trees and Logs criteria of 30cm to a 10cm diameter to align with *Habitat Hectares* and Biological Survey methods.
- Remove lerp damage and mistletoe infestation from condition assessments where a total condition score is calculated.

5.1.2. Biological Survey versus *Bushland Condition Monitoring*

The Biological Survey is designed as an inventory of vegetation composition. The *Bushland Condition Monitoring* method is designed to monitor temporal changes in vegetation. Data is collected in a 30m x 30m quadrat in both methods. Section 4.1.2 describes the similar data collected in both the Biological Survey and the *Bushland Condition Monitoring* method. This section also indicates that the Biological Survey does not collect all the data required for *Bushland Condition Monitoring* assessments. It is recommended to undertake further research to determine how certain components of the Biological Survey data relate to the overall condition of vegetation at a site. This information will determine the usefulness of existing Biological Survey site data for indicating vegetation condition.

5.2. Field Assessments

The *Habitat Hectares* method measures all of the indicators, excluding Lack of Weeds, in relation to benchmark values. The assessment of a vegetation type requires the definition of benchmarks for that community, however it is difficult to establish benchmark groups and values without significant site data. The absence of *Habitat Hectares* benchmark group values increased the time taken to complete each field assessment. Additional information was collected to enable the benchmarks to be defined upon completion of the survey. Subsequent surveys in these benchmark community types would be quicker now that the benchmarks have been established.

5.3. Benchmarking

The *Habitat Hectares* benchmarking process was difficult to undertake without adequate field data. Expert opinion was used to develop the benchmark values. The process of defining the benchmarks was therefore very subjective and will therefore evolve over time as new data becomes available.

Bushland Condition Monitoring benchmark values for the Southern Mount Lofty Ranges were used within this project for the *Bushland Condition Monitoring* assessments. These benchmark values come from groupings at the community and sub community level in the *Bushland Condition Monitoring* manual, and correspond to vegetation alliances as described by Specht (1972). These alliances are ecosystems that share the same structural characteristics, related dominant species in the uppermost stratum, and the same or related species in the understorey. Whilst this is a broader level grouping than NVIS level 5, it is considered appropriate for assessing vegetation condition using the *Bushland Condition Monitoring* approach due to the following reasons:

- Numerous fine scale vegetation benchmark groups are unnecessary when the data collected by assessment techniques such as *Bushland Condition Monitoring* and *Habitat Hectares* are categorical and relatively coarse;
- The condition indicators used by the *Bushland Condition Monitoring* method describe features that are shared within an alliance, but differ between alliances, and so further subdivision is unnecessary, and;
- Alliances are a level of classification that community groups and extension officers will have the capacity to recognise (T. Milne, pers. comm., 2006, NCSSA).

To ensure compatibility between data systems within South Australia, all Biological Survey of Southern Mount Lofty Ranges floristic mapping groups are grouped within *Bushland Condition Monitoring* vegetation communities in Volume 3 of the *Bushland Condition Monitoring Manual: Southern Mount Lofty Ranges*. These floristic mapping groups correspond to NVIS level 5 or level 6. Thus the benchmarking undertaken by the authors of the *Bushland Condition Monitoring* Manual can be used for vegetation classified at NVIS level 5 or better. There are some vegetation mapping groups that have been identified within more than on benchmark group. These groups will need to be examined in more detail to identify the most appropriate benchmark group for each of these floristic mapping groups.

The use of benchmark groups to score the indicators ensures consistency when measuring temporal vegetation condition. The incorporation and use of benchmark groups within condition assessments should be encouraged at the national level to ensure consistency in measurement techniques. The level of the benchmark group may not cause significant variation and could be different for each State or Territory.

5.4. Analysis and Comparison

The Analysis and Comparison section of the project highlighted many differences in the condition assessment results. These results are discussed in the following sections.

5.4.1. Environmental characteristics

The analysis demonstrated that land in areas used or managed for conservation purposes measured higher vegetation condition than land used for agricultural or intensive purposes and land managed privately. This pattern was true for both the *Bushland Condition Monitoring* and the *Habitat Hectares* assessments. While the small sample set of data used for this analysis undermines the integrity of this relationship, it does indicate that attributes of a vegetation community are measured similarly in both methods.

5.4.2. Score comparison

The comparison between the scores recorded by the *Bushland Condition Monitoring* method and the *Habitat Hectares* method at thirteen coincident sites revealed several differences. There appears to be a high degree of correlation between each method for both the overall scores and the scores for the four broad indicators. The insignificant difference between the overall average condition scores indicates that the methods are relatively compatible. There were some differences between the individual analogous condition components due to the differences in the scoring methods, however this appears to have little effect on the overall site score.

5.4.3. Biological Survey and *Bushland Condition Monitoring* comparison

The *Bushland Condition Monitoring* results were compared to the Biological Survey data at nine coincident sites. Several factors influenced the compatibility between the *Bushland Condition Monitoring* data and the Biological Survey data, however further research is required due to the small sample of data.

The year of the Biological Survey influences the compatibility between the *Bushland Condition Monitoring* data and the Biological Survey data. The age of the site data used varied between five and more than fifteen years old. It is possible that this time difference accounts for all the variation between the Biological Survey data and the *Bushland Condition Monitoring* data collected at the equivalent site. However, it is difficult to determine differences relating to real change, data collection techniques, observer differences or time since data collection.

The comparison process highlighted that certain components of the Biological Survey database can be used within *Bushland Condition Monitoring* assessments. Further research into the Biological Survey components is required to determine their correlation to vegetation condition.

It is possible that some of this data could be used to create a condition score. The Biological Survey database could be expanded to store all *Bushland Condition Monitoring* data, including the condition scores.

5.5. Condition Surfaces

The small number of *Habitat Hectares* sites used to produce the vegetation condition surface reduced the accuracy of the output data set. However, the process identified a potential method for developing a surface of vegetation condition. To refine the scale of the output surface other data sets, such as soils, climate, digital elevation model (DEM) and tree density, could be introduced (DSE, 2004b). These additional data sets were not used in this project due to the small size of the study area. Climate variables are relatively constant across this small area and therefore would not greatly influence the results.

The reliability surface could also be refined if more input data sets were used. The accuracy of the input data sets could be used to supply accuracy information to the reliability surface. Where more site data is available, the standard deviation should be used instead of the range, as the range will tend to increase with the size of the data set.

5.6. General

Guidelines for a nationally consistent vegetation condition method could recommend the inclusion of attributes to measure a set of broad indicators. Specific methods and techniques for measuring these broad indicators can be developed by each state or territory. The relative weighting of each of the broad indicators should be nationally consistent. Other guidelines would also need to be developed such as the ability to weigh each indicator and therefore generate a 'score' for each site assessed and the exclusion of landscape context components from the site condition assessment.

It is recommended that other States and Territories undertake similar comparable studies where condition assessment methods different to *Habitat Hectares* exist. This will help to understand and qualify the differences between the specific methods used in each jurisdiction. This will be beneficial at the national level as differences in vegetation condition scores between regions will be understood. This is similar to the current process used to interpret vegetation mapping types between States and Territories. Different mapping and classification techniques are used by each jurisdiction. A national map of vegetation types is still produced and the different capture techniques are acknowledged.

A state-wide database should be developed and maintained to ensure consistent data storage and to aid data retrieval.

6. Summary of Recommendations

- Build capacity for the *Bushland Condition Monitoring* method to quickly and easily calculate a total condition score from weighted indicator scores.
- The flexibility to implement either set quadrats or variable 'assessment areas' in both the *Bushland Condition Monitoring* and the *Habitat Hectares* methods.
- Exclude the Tree Hollows score from the *Bushland Condition Monitoring* Tree Habitat Features indicator.
- Alter the *Bushland Condition Monitoring* method to record fallen trees and logs with a diameter greater than 10cm rather than 30cm.
- Remove lerp damage and mistletoe infestation from condition assessments where a total condition score is calculated.
- Undertake further investigations to determine the use of Biological Survey data to represent vegetation condition.
- Introduce other data sets, such as soils, climate, digital elevation model (DEM) and tree density, into the development of the vegetation condition surface.
- Requirements for a nationally consistent vegetation condition method should include the use of a set of broad indicators, should state their relative weighting, should recommend the use of benchmarks and should measure the landscape context component separately to the site condition score.
- Other States and Territories should undertake similar comparable studies to help to understand and qualify the differences between the specific methods used in each jurisdiction.
- Develop and maintain a state-wide database to ensure consistent data storage and to aid retrieval of vegetation condition information.

7. Conclusion

The specific aims of this project were to:

1. Compare the *Bushland Condition Monitoring* method and the *Habitat Hectares* method and examine the suitability of the Biological Survey of South Australia data for providing information to *Bushland Condition Monitoring* condition assessments;
2. Undertake field assessments using the *Bushland Condition Monitoring* method and the *Habitat Hectares* method;
3. Develop three vegetation benchmark groups within the study area;
4. Analyse and compare the vegetation condition scores recorded using the two methods during the field assessments, and;
5. Produce a surface of vegetation condition across the study area.

The first objective found a broad level of compatibility between the *Bushland Condition Monitoring* method and the *Habitat Hectares* method. While the attributes collected are similar, there are fundamental differences in the measuring techniques used by the *Bushland Condition Monitoring* method and the *Habitat Hectares* method. The *Bushland Condition Monitoring* method was developed to align with the Biological Survey method to assist in developing benchmark groups. As a result, many of the attributes common to both methods are measured similarly.

Field assessments were undertaken using the *Bushland Condition Monitoring* method and the *Habitat Hectares* method. A total of twenty-six sites were visited in the Para Wirra region of South Australia. Assessments using both methods were carried out at thirteen of these sites. Nine of the sites were located at existing Biological Survey sites to enable comparison of the results.

The third objective was achieved by developing benchmarks for three vegetation benchmark groups within the study area. These benchmark groups were: *Eucalyptus camaldulensis var. camaldulensis, E. leucoxylon ssp*. Woodland with shrub understorey; *Eucalyptus fasciculosa, E. goniocalyx ssp. goniocalyx, Callitris gracilis* Woodland with shrub understorey; and, *Eucalyptus goniocalyx spp. goniocalyx* Woodland with healthy understorey. Biological Survey data and expert knowledge were used to define the benchmark values.

The vegetation condition scores recorded using the *Bushland Condition Monitoring* method and the *Habitat Hectares* method were compared. The vegetation condition scores were compared to the environmental characteristics of the study area. The small number of survey sites reduced the effectiveness of this analysis, inhibiting the ability to confidently determine any relationships between the environmental characteristics and the vegetation condition.

Different scores were recorded for the *Bushland Condition Monitoring* and the *Habitat Hectares* assessments at the thirteen coincident sites, but overall these differences were not considered statistically significant. *Bushland Condition Monitoring* scored both higher and lower than *Habitat Hectares* at the range of sites. The measuring techniques and method for categorising the results caused this score variation.

The Biological Survey data is compatible with the *Bushland Condition Monitoring* method. Only a limited number of Biological Survey attributes can be used within *Bushland Condition Monitoring* assessments. It is recommended that the Biological Survey data is further analysed to determine whether it can be used to represent the condition of vegetation at each site.

A surface of vegetation condition was produced for the study area to achieve the final objective. The inclusion of additional site data may improve the accuracy of the surface. The accuracy of this surface is unknown, however the use of extra digital layers within the model may also improve the accuracy and scale of the output surface.

This report may assist in better understanding the relationship between the *Bushland Condition Monitoring* method employed in South Australia and the Victorian *Habitat Hectares* method. Understanding these relationships is important when developing a national data set of vegetation condition.

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Appendix 1 – High threat weeds

Scientific name	**Common Name**
Acacia longifolia var. longifolia	Sydney Wattle
Allium triquetrum	Three-cornered Garlic
Ammophila arenaria	Marram Grass
Arundo donax	Bamboo or Spanish Reed
Asparagus asparagoides	Bridal Creeper
Asparagus declinatum	Bridal Veil
Chamaecytisus palmensis	Tagasaste/Tree Lucerne
Chasmanthe floribunda var. floribunda	African Corn-flag
Chrysanthemoides monilifera	Boneseed
Crataegus spp.	Hawthorn
Cytisus scoparius	English Broom
Delairea odorata (was Senecio mikanioides)	Cape Ivy
Disa bracteata	Monadenia or African Weed Orchid
Ehrharta calycina	Perennial Veldt Grass
Ehrharta erecta	Pyp Grass
Erica species	Erica
Euphorbia paralias	Sea Spurge
Euphorbia terracina	False Caper
Euryops abrotanifolius	Euryops
Foeniculum vulgare	Fennel
Fraxinus rotundifolia	Desert Ash
Freesia spp.	Freesias
Genista monspessulana	Montpellier Broom
Gladiolus spp.	Gladiolus species
Hedera helix	English Ivy
Holcus lanatus	Yorkshire Fog
Homeria flaccida	One-leaved Cape Tulip
Homeria miniata	Two-leaf Cape Tulip
Hypericum perforatum	St Johns Wort
Ipomoea indica	Purple Morning-glory
Ixia spp.	Ixias
Juncus acutus	Sharp Rush or Spiny Rush
Lavandula stoechas	Topped Lavender
Lycium ferocissimum	African Boxthorn
Marrubium vulgare	Horehound
Melianthus comosus	Tufted Honey-flower
Moraea setifolia	Thread Iris
Nasella neesiana and N. leucotricha	Chilean Needle Grass and Texas Needle Grass
Olea europaea	Olive
Oxalis pes-caprae	Soursob
Paspalum distichum	Water Couch
Pennisetum macrourum	African Feather Grass
Pennisetum setaceum	Fountain Grass

Scientific name	**Common Name**
Pennisetum villosum	Feather-top
Pentaschistis pallida	Pussytail Grass
Phalaris spp.	Phalaris or Canary Grass
Pinus radiata	Radiata Pine
Piptatherum miliaceum	Rice Millet
Pittosporum undulatum	Sweet Pittosporum
Plantago coronopus	Bucks-horn Plaintain
Polygala myrtifolia	Milkwort
Rhamnus alaternus	Buckthorn or Blowfly Bush
Rosa canina, Rosa rubiginosa	Dog Rose
Rubus spp.	Blackberry
Salix species	Willows
Scabiosa atropurpurea	Scabiosa
Sollya heterophylla	Blue-bell Creeper
Sparaxis tricolor and S. bulbifera	Harlequin Flower
Tropaeolum majus	Nasturtium
Ulex europaeus	Gorse
Vinca major	Periwinkle
Watsonia meriana cv. Bulbillifera	Bulbil Watsonia
Zantedeschia aethiopica	Arum Lily

Table source: 'High Threat' weeds selected by S.Crossman, DEH, 2005 from a table developed by NCSSA.