TARGETED FLORA SURVEY AND MAPPING

NSW WESTERN REGIONAL ASSESSMENTS

SEPTEMBER 2002

Brigalow Belt South

Stage 2

Resource and Conservation
Assessment Council

TARGETED FLORA SURVEY AND MAPPING

NSW WESTERN REGIONAL ASSESSMENTS

BRIGALOW BELT SOUTH BIOREGION (STAGE 2)

NSW National Parks & Wildlife Service

A project undertaken for the
Resource and Conservation Assessment Council
NSW Western Regional Assessments
project number WRA / 16

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Common Acronyms used in this report

API - Aerial Photographic Interpretation
BBS - Brigalow Belt South Bioregion
Greater BBS - The Brigalow Belt South Bioregion plus a 15 km buffer around the bioregion
DEM - Digital Elevation Model
DLWC - NSW Department of Land and Water Conservation
EPBC - Environmental and Biodiversity Conservation Act 1999
GAM - Generalised Additive Model
GDM - Generalised Dissimilarity Model
GIS - Geographic Information System(s)
GLM - Generalised Linear Model
JANIS - Joint ANZECC / MCFFA National Forest Policy Statement
JVMP - RACD Joint Vegetation Mapping Project
NPWS - NSW National Parks and Wildlife Service
NVMP - Native Vegetation Mapping Program
RACAC - Resource and Conservation Assessment Council
RACD - The Resource and Conservation Division within the NSW Department of Urban Affairs and Planning
RFA - Regional Forest Agreement
ROTAP - Rare or Threatened Australian Plants List (Briggs and Leigh 1996)
SF - NSW State Forests
TFP - RACD Targeted Flora Survey and Mapping Project
TSC - Threatened Species Conservation Act 1995
TSR - Travelling Stock Reserve
WRA - Western Regional Assessments
YETI - The Yet Another Vegetation Survey Database (Bedward and Ellis 2001)

PROJECT SUMMARY

This report describes a project undertaken for the Resource and Conservation Assessment Council as part of the regional assessments of western New South Wales. The Resource and Conservation Assessment Council advises the State Government on broad-based land use planning and allocation issues. An essential process for the western regional assessments is to identify gaps in data information and the best ways in which to proceed with data gathering and evaluation.

Project objective

The *BBS Targeted Flora Survey and Mapping Project* was established to provide biodiversity information on the flora of the Brigalow Belt South Bioregion (BBSB) for use in the design of regional conservation and resource mangement strategies.

Methods

This project involved data collation and audit to identify floristic data gaps and compile autecological data on significant taxa. Targeted field surveys of priority taxa were undertaken to confirm species localities and collect additional site information. PATN analysis of systematic data and a review of API mapping provided information on significant plant communities. Predictive modelling of priority taxa and plant communities identified potential habitat areas and an assessment of vegetation cover identified potential core habitat areas and corridors.

Key results

This study has established that the flora of the BBSB is surprisingly diverse, with at least 2,075 native taxa. The vegetation of the bioregion is also regarded as complex, with at least 75 woody and 109 herbaceous communities identified by the project from various sources. The plant communities range from Snow Gum forests to rainforest, to sclerophyll woodland, mallee and heath. Communities more widespread in far western NSW are also represented, including Poplar Box-Belah semi-arid woodland and River Red Gum-Coolabah forest. New plant species continue to be discovered and this report lists seven taxa awaiting formal description. At least 100 other species are considered to be rare or threatened. Several areas of rare plant concentrations have been identified in the vicinity of the Warrumbungles, Kaputar National Park, Warialda State Forest and Severn State Forest.

In addition to the research findings that directly relate to the flora and vegetation of the BBS, this study has applied state-of-the-art analytical techniques to the modelling of plant community distributions, including Generalised Additive Modelling (GAM) and Generalised Dissimilarity Modelling (GDM). The striking correspondence between the outputs of these quite different modelling techniques demonstrates the power of the geostatistical approach to the study of plant-environment relationships.

1. INTRODUCTION

1.1 BACKGROUND

The NSW Government initiated the Western Regional Assessment (WRA) process within the Brigalow Belt South Bioregion (BBS) in 1999, in order to guide future planning and encourage partnerships to protect the environment. The Resource and Conservation Assessment Council (RACAC) is coordinating the assessment which also involves the National Parks and Wildlife Service (NPWS), State Forests of NSW (SF), the Department of Land and Water Conservation (DLWC) and the Department of Mineral Resources (DMR), as well as local and regional stakeholders. The Western Regional Assessment is a broad-based process applying to areas not already covered by NSW forest agreements. The WRA considers environmental, economic and social values of forest and non-forest land systems focusing on conservation, land management and regional planning (RACAC web site, 2001).

The BBS assessment process is being implemented in two stages. Stage 1 was concluded in February 2000 and was concerned with the assessment of State Forest, National Park and Vacant and Reserved Crown land south of Narrabri within the BBS (Stage 1 project reports may be viewed and downloaded at the RACAC web site http://www.racac.nsw.gov.au/). Stage 2 of the assessment is focussed mainly on forest and woodland ecosystems across all land tenure within the entire BBS. Stage 2 assessments include fauna, flora, vegetation, cultural heritage, socio-economic, and environmental factors.

1.2 THE TARGETED FLORA PROJECT

1.2.1 Project Objectives

The *BBS Targeted Flora Survey and Mapping Project* was established to provide biodiversity information on the flora of the BBS for use in the design of regional conservation and resource mangement strategies through the following avenues:

- Assessment of conservation values across the landscape (eg. high conservation values)
- Identification of a Comprehensive, Adequate and Representative Protected Area Network (CAR Reserve System)
- Development of conservation criteria, targets and protocols
- Identification of how management and fire history has affected species and their habitat.

As detailed in the project specification (WRA 16), the objectives of the Targeted Flora Survey and Mapping Project Project are to:

- Provide new data using targeted flora surveys on the distribution and, if possible, abundance of specified flora for use in verifying future habitat mapping, species and habitat modelling.
- Collect information on specified flora and their habitat to fill as many gaps as possible, focusing on rare and threatened (using Rare or Threatened Australian Plants (ROTAP) list of Briggs and Leigh (1996). (ROTAP), regionally significant, overstorey dependant species or communities and old growth components.
- Collate information on the known and predicted regional distribution of each targeted species to provide regional context to the project.
- Assist in the identification of High Conservation Values (HCV).
- Assist the identification of a Comprehensive, Adequate and Representative (CAR) Protected Area Network.
- Assist in developing conservation protocols as part of Ecologically Sustainable Forest Management (ESFM).

The following project aims were formulated in order to meet these specific project objectives:

- Collate all readily available information on the vascular flora and vascular plant communities of the Greater BBS and (where appropriate) store this information in an accessible digital format.
- Compile a list of all vascular plant species known to occur with the bioregion.
- Identify vascular plant species listed on the *Commonwealth Environment Protection and Biodiverity Conservation Act 1999* (EPBC Act), the NSW *Threatened Species Conservation Act 1995* (TSC Act) or the Rare or Threatened Australian Plants (ROTAP) list of Briggs and Leigh (1996).
- Identify vascular plant species of conservation priority at a bioregional level using explicit criteria and/or expert botanical input.
- Undertake targeted rare plant surveys in order to validate existing locality records, collect autecological information, and to locate previously undiscovered rare plant populations.
- Where possible, undertake appropriate analyses in order to model the distribution of rare plant species.
- Undertake appropriate analyses in order to identify, characterise and map the vascular plant communities of the bioregion.
- Undertake appropriate research in order to identify any vascular plant communities of conservation priority that occur within the bioregion, including any communities listed on the EPBC Act or the TSC Act or otherwise considered to be of conservation priority by Specht *et al.* (1995) or other botanical experts.
- Identify areas of priority for the conservation of plant biodiversity within the BBS.

1.2.2 Project Resourcing

The Resource and Conservation Assessment Council (RACAC) contributed $49,120 to the Targeted Flora Survey and Mapping Project (TFP). Stage 1 was completed in February 2000 and produced a draft strategy for targeted flora surveys. A total of $43,809 remained unspent at the completion of Stage 1, and these funds were rolled-over to Stage 2. This funding was supplemented by the NSW National Parks and Wildlife Service (NPWS) in recognition of the importance of the project for biodiversity conservation and bioregional planning. NPWS have provided significant in-kind support to the TFP. This support included resources from the WRA Unit for scientific research and review, data entry and analysis, documentation, administration, 4WD survey vehicle, survey equipment, field work expenses, and GIS assistance. Additional support was provided by expert botanical input from the NPWS Western Directorate, NPWS Northern Directorate, and specialist analytical input from the NPWS GIS Research and Development Unit based at Armidale.

Other than the results of targeted rare plant surveys specifically undertaken for this project, survey data was collated from pre-existing datasets, including data recently acquired as part of the RACD Joint Vegetation Mapping Project (JVMP). As such, expenses associated with field surveys were relatively modest. In addition, the various analytical approaches adopted to meet project objectives were in part designed to mimise project costs.

1.3 ABOUT THIS REPORT

This report details the aims, methods and results of the Targeted Flora Survey and Mapping Project (TFP) in three discrete chapters. Chapter 1 provides an overview of the project and the natural environments of the BBS. Chapter 2 deals specifically with plant species inventory, mapping, and analysis, whilst Chapter 3 addresses issues of regionally significant plant communities.

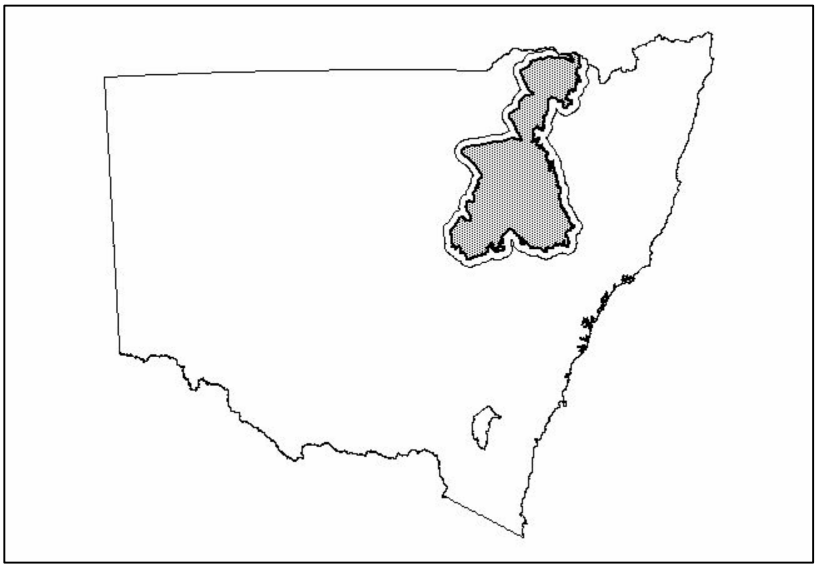
1.4 THE BRIGALOW BELT SOUTH BIOGEOGRAPHIC REGION

1.4.1 Location and Boundaries

The BBS Biogeographic Region was first described by Morgan and Terry in 1992 in their publication ‘Nature Conservation in Western New South Wales’. The boundaries of the region were later revised by Thackway and Cresswell (1995) as part of the bioregionalisation of Australia. According to Thackway and Cresswell, the BBS is the sixth largest bioregion in Australia, comprising an area of 279,496km^2 and extending from north-western NSW into southern Queensland.

The WRA Assessment deals specifically with the NSW component of the BBS, which measures 52,458 km^2 in area (6.5% of the state). For the purpose of analysis, data collation and reporting, a 15km buffer has been applied to the BBS; the BBS and 15km buffer is hereinafter referred to as the Greater BBS (Figure 1).

Figure 1: **Location of the BBS South Bioregion in NSW**

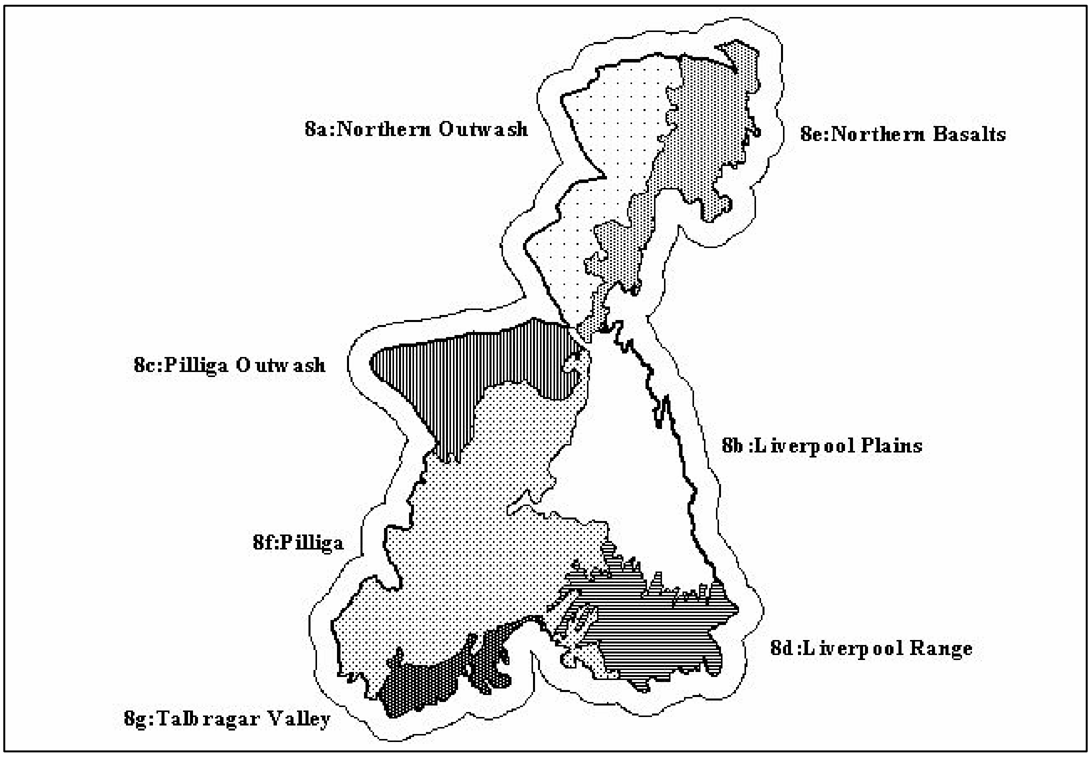


Notes: The BBS South Bioregion is shaded and surrounded by a 15 km buffer used for data analysis and modelling.

1.4.2 Geographic Provinces

The BBS equates to the Northern Sandstones described by Morgan and Terrey (1992) who separated the region into seven provinces on the basis of functional and geological differences (Table 1: Figure 2). The major differences are between those provinces formed on alluvial and colluvial deposits, those dominated by basalts, and those formed largely on Mesozoic bedrock. Areas dominated by sandstone have relatively infertile soils and large areas of native forest. Whilst the steeper basalt areas also have native forest, the more undulating areas and alluvial and lower slope areas with a basaltic influence, have been widely cleared and cultivated. A more detailed description of the provinces and environments of the BBS can be found in the Brigalow Belt South Bioregion Scoping Report (NPWS, 2002).

Figure 2: **Provinces within the BBS South Bioregion**
After Morgan and Terrey (1992).



Notes: The BBS has been subdivided into provinces by Morgan and Terry (1992), principally on the basis of geology and geomorphology. The Northern Outwash, Liverpool Plains and Pilliga Outwash provinces are characterised by alluvial and colluvial deposits. The Pilliga and Talbragar Valley provinces are characterised by Mesozoic sediments. The Northern Basalt and Liverpool Range provinces are characterised by Tertiary basalts.

TABLE 1: PROVINCES OF THE BBS (NORTHERN SANDSTONES)

Province	Description	Dominant Lithology
Northern Outwash	Gently Sloping fans, grey clays	Alluvials and colluvials
Liverpool Plains	Plains, black earths	
Pilliga Outwash	Plains, deep sandy texture-contrast soils	
Liverpool Range	High ranges	Basalt
Northern Basalt	Undulating, sandstone in valleys	
Pilliga	Coarse sediments, sandy soils	Mesozoic sediments
Talbragar Valley	Fine to medium sediments, red loams	

1.4.3 Climate

Rainfall

The BBS experiences an annual mean rainfall from about 550 mm in the west at Gilgandra to 823 mm on the eastern edge of the bioregion at Murrurundi. On the north - south gradient, annual mean rainfall is 587 mm in Dubbo, 651 mm at Narrabri and 659 mm at Texas on the Queensland border. Substantial rainfalls can occur at any time of the year but there is a peak in summer and a smaller peak in winter. The dominance of the summer rainfall decreases to the south, with the exception of Murrurundi on the higher altitudes of the south east. At Dubbo, the distribution of rainfall throughout the year is relatively even with the lowest rainfall in April.

Temperature

Monthly mean temperatures range from a maximum of 33^{o}C in January to a minimum of 3^{o}C in July but daily maximum can reach 45^{o}C and stay above 40^{o}C for several days. Minimum temperatures can be as low as -9^{o}C. Frosts are common with up to 100 days of frost each winter possible in the southern areas. Occasional snowfalls occur on the tablelands (RACD, 2000a). Temperatures vary with altitude throughout the bioregion and have a large daily variation. For example, the Liverpool and Warrumbungle Ranges have lower annual mean temperatures than the rest of the bioregion, as do some of the isolated volcanic peaks between the two ranges.

1.4.4 Topography

Elevation within the BBS varies from 1 240 m above sea level in the east to 100 m above sea level in the west. The highest land area is the Liverpool Range, a western extension of the Great Dividing Range that crosses the area from east to west south of Tamworth and Coonabarabran and joins the Warrumbungle Range in otherwise gently undulating and flat country. The Liverpool range is rugged on the northern edge with slopes up to 45 degrees and altitude from 600 to 1 200 m above sea level. The southern edge of the range has a more moderate slope of approximately 7 degrees. The Warrumbungles range from approximately 1100m above sea level to approximately 480m above sea level with slopes ranging from approximately 12 degrees on the northern side to 6 degrees in the south.

The majority of the bioregion has a slope of 0-10 degrees, with hillier areas such as the Warrumbungles, the Liverpool range and the lower slopes of Mount Kaputar having slopes up to 55 degrees.

1.4.5 Geology and geomorphology

The BBS is underlain by ancient fractured crystalline rocks covered by sedimentary layers deposited during the Triassic and Jurassic periods. In the Miocene epoch the area was subjected to igneous activity and subsequent movements of the earth’s crust (NWCMC, 1996).

The Mesozoic sediments that dominate the Brigalow Belt are the south-eastern extremity of the Great Artesian Basin (GAB). These sandstone beds form a generally undulating to low hilly landscape with some higher areas covered by Tertiary lava flows (Morgan and Terrey 1992).

In the south western portion of the bioregion, the sedimentary deposits are the sandstones and mudstones of the Purlewaugh Beds of the lower and middle Jurassic period and the quartz Pilliga Sandstones of the upper Jurassic period. The Pilliga Sandstones are the major intake bed for the GAB. During this period of sedimentary deposition, the GAB to the west and north-west was subsiding and forming vast lakes. The landscape was then gradually eroded and uplifted and became one of worn sandstone ridges and mesas, surrounded by vertical cliffs and isolated by deep broad river valleys which were slowly being eroded away.

The volcanic activity in the Tertiary period then covered the whole area with vast lava flows and associated volcanic formations. The subsequent 13 million years of weathering reduced these vast flows to a few resistant volcanic formations – Liverpool Range, Warrumbungle Range and Nandewar Range (in the Nandewar bioregion) and many small conical hills. This weathering of the basalt ranges has produced the rich alluvium which has become the fertile floodplains now used extensively for cropping (Fairley, 1991).

1.4.6 Dominant Soil Types

North of Narrabri most of the bioregion has coarsely cracking grey and brown clays with some deep black cracking clays and red-brown earths in the north east. South of Narrabri there are four predominant soil types:

- deep black cracking clays over most of the low elevation eastern half with shallow black self mulching clays on the Liverpool Ranges
- massive red and yellow earths in most of the western half
- areas of red brown earths and loams along the Castlereagh and Talbragar Rivers
- shallow loams in the Warrumbungle Ranges.

The soils which developed directly on the basic igneous rocks such as basalt and tuff are generally finer textured with uniform to gradational profiles. These range from kraznozems and chocolate soils in the wetter parts to euchrozems and red, grey and black cracking clays on the drier western slopes. Over the Pilliga Sandstones there are mostly poor sandy or gravelly soils, sandy loams, duplex clays and sand or yellow earths, which are often skeletal. Along the major rivers the soils are deep black, grey or red clays and fertile, fine to medium textured soils on levees and more recent alluvium (Banks 1995, 1998 *in* RACD, 2000a).

Deep, highly fertile black earths have developed on the basic alluvia and colluvia on the wide valleys below the basaltic ranges, including the Liverpool Plains. These are interspersed with red earths, red brown earths, solodics and sometimes euchrozems on the sandstone outcrops. On the riverine plains of the west of the bioregion the soils have been derived from the Quaternary alluvia and have formed moderately fertile deep grey and brown cracking clays.

1.4.7 Hydrology

River catchments which intersect the BBS include the Namoi, Castlereagh, Macintyre, Macquarie, Gwydir and Hunter. The area of these catchments, and the percentage of each which intersect the BBS are shown in Table 2. Identified wetland types, number of each wetland type and area of identified wetlands within the catchments intersecting the BBS are shown in Table 3. The Namoi River catchment covers by far the greatest area of the bioregion (40%) and contains the largest number and area of identified wetlands of all catchments within the BBS.

TABLE 2: CATCHMENTS INTERSECTING THE BBS

Catchment Area	Catchment Area (ha)	Area Intersecting with BBS (ha)	% Catchment Area Within BBS	% of BBS Covered by Catchment
Namoi River	4 205 447	2 116 364	50%	40%
Castlereagh River	1 742 205	889 136	51%	17%
Macintyre River	2 424 432	703 323	29%	13%
Macquarie River	7 476 966	625 647	8%	12%
Gwydir River	2 660 999	568 450	21%	11%
Hunter River	2 150 122	347 558	16%	7%

TABLE 3: IDENTIFIED WETLANDS, TYPES AND AREA WITHIN BBS (SOURCE: KINGSFORD ET AL, 1999)

Catchment Area	Wetland Type	No Wetlands	Area (ha)	% under Crown Reserve
Namoi River including Cockburn River, Manila River, Mooki River, and Peel River	Reservoir	47	476	2%
	Freshwater Lake	4	6 924	1%
	Floodplain Wetlands	26	4 676	45%
	Namoi Totals	77	12 077	18%
Macintyre River including Barwon River, Boomi River, Dumaresq River, and Severn River	Reservoir	4	176	0%
	Floodplain Wetlands	62	7 255	6%
	Macintyre Totals	66	7 431	6%
Gwydir River including Horton River, and Mehi River	Reservoir	23	544	0.4%
	Floodplain Wetlands	27	3 385	5%
	Gwydir Totals	50	3 929	5%
Macquarie River including Bell River, Bogan River, Bogar River, Coolburragundy River, Cudgegogn River, Little River, and Talbragar River	Reservoir	5	95	0%
	Freshwater Lake	1	132	0%
	Floodplain Wetlands	1	25	5%
	Macquarie Totals	7	252	3%
Castlereagh River	Reservoir	19	65	0%
	Castlereagh Totals	19	65	0%
	BBS Totals	219	23 754	12%

The total area of identified wetlands within the BBS is approximately 24 000 ha and includes 219 floodplain wetlands, reservoirs, and lakes. 64% of all wetlands in the BBS consist of a total of 116 floodplain wetlands, with five freshwater lakes accounting for 30% of the area of wetland in the BBS and 98 reservoirs accounting for 6% of the total area of wetlands in the BBS (Table 4). Freshwater lakes in the BBS include Goran Lake in the Namoi River catchment, which covers an area of 6 800 ha, and is the largest freshwater lake in the Bioregion. Other lakes in the BBS include Yarrie Lake, also in the Namoi catchment and covering an area of 61 ha, and Old Harbour Lagoon in the Macquarie catchment, covering an area of 130 ha.

TABLE 4: WETLANDS BY PROVINCE WITHIN THE BBS (SOURCE: KINGSFORD ET AL, 1999)

Province	Wetland Type	Name of Major Wetlands	Wetland Area (ha)	% Province
Liverpool Plains	Freshwater Lake	Lake Goran	6 863	0.73%
	Reservoir		271	0.03%
		TOTALS	7 134	0.76%
Northern Basalts	Floodplain Wetlands		2 648	0.43%
	Reservoir		123	0.02%
		TOTALS	2 771	0.45%
Northern Outwash	Floodplain Wetlands		7 991	1.14%
	Reservoir		608	0.09%
		TOTALS	8 599	1.23%
Pilliga	Floodplain Wetlands		25	0.001%
	Freshwater Lake	Old Harbour Lagoon	132	0.008%
	Reservoir		88	0.005%
		TOTALS	245	0.014%
Pilliga Outwash	Floodplain Wetlands		4 676	0.87%
	Freshwater Lake	Yarrie Lake	61	0.01%
	Reservoir		260	0.05%
		TOTALS	4 998	0.93%
Talbragar Valley	Reservoir		7	0.003%
		TOTALS	7	0.003%

Great Artesian Basin

The GAB covers approximately 1.7 million km^2 (approximately one fifth of the continent) and covers the majority of Queensland, and parts of the Northern Territory, South Australia and New South Wales (GABCC, 1998; DNR, 2001).

The BBS lies within the Surat Basin (sub-basin of GAB) in the south east of the GAB and covers a small section of the basin. The major aquifers of the GAB which fall within the BBS are the Upper and Lower Pilliga Sandstone Aquifers (GABCC, 1998). Depth of sediments in the GAB within the majority of the BBS vary between 0 and 1 200 m, with one area up to 1 800 m deep along the New South Wales – Queensland border. Groundwater within the GAB flows from areas of higher topography (such as the recharge zones within the BBS) towards lower areas or discharge zones (springs) to the west of the bioregion (GABCC, 1998).

1.4.8 Broad Vegetation Patterns

Overview

There are four key studies which provide a broader context for subsequent, more detailed considerations of plant biodiversity within the BBS, namely, the continental synthesis of Doing (1981), the Australian phytogeographic regionalisation of Specht *et al.* (1995), the AUSLIG vegetation map of the continent (Australian Surveying and Land Information Group, 1990) and the ecogeographic characterisation of the botanical subdivisions of NSW by Harden (2002). Each of these studies will be discussed briefly in the following paragraphs in relation to the boundaries of the BBS.

Australian Floristic Regions and Provinces

Doing (1981) discusses the plant geography of the Australian floristic kingdom according to a series of mapped botanical regions and provinces. The BBS straddles the Western Slopes Province (Ess) and the Western Plains Province (Esp). Doing describes the Western Slopes Province as semi-humid, warm to cool temperate (or sub-mediterranean in some years) with the following characteristic species: *Eucalyptus albens, E. blakelyi, E. bridgesiana, E. macrorhyncha and E. melliodora.* The Western Plains Province is described as semi-arid, sub-tropical to Mediterranean, with the following endemic eucalypts: *E. largiflorens, E. microcarpa* and *E. woollsiana.*

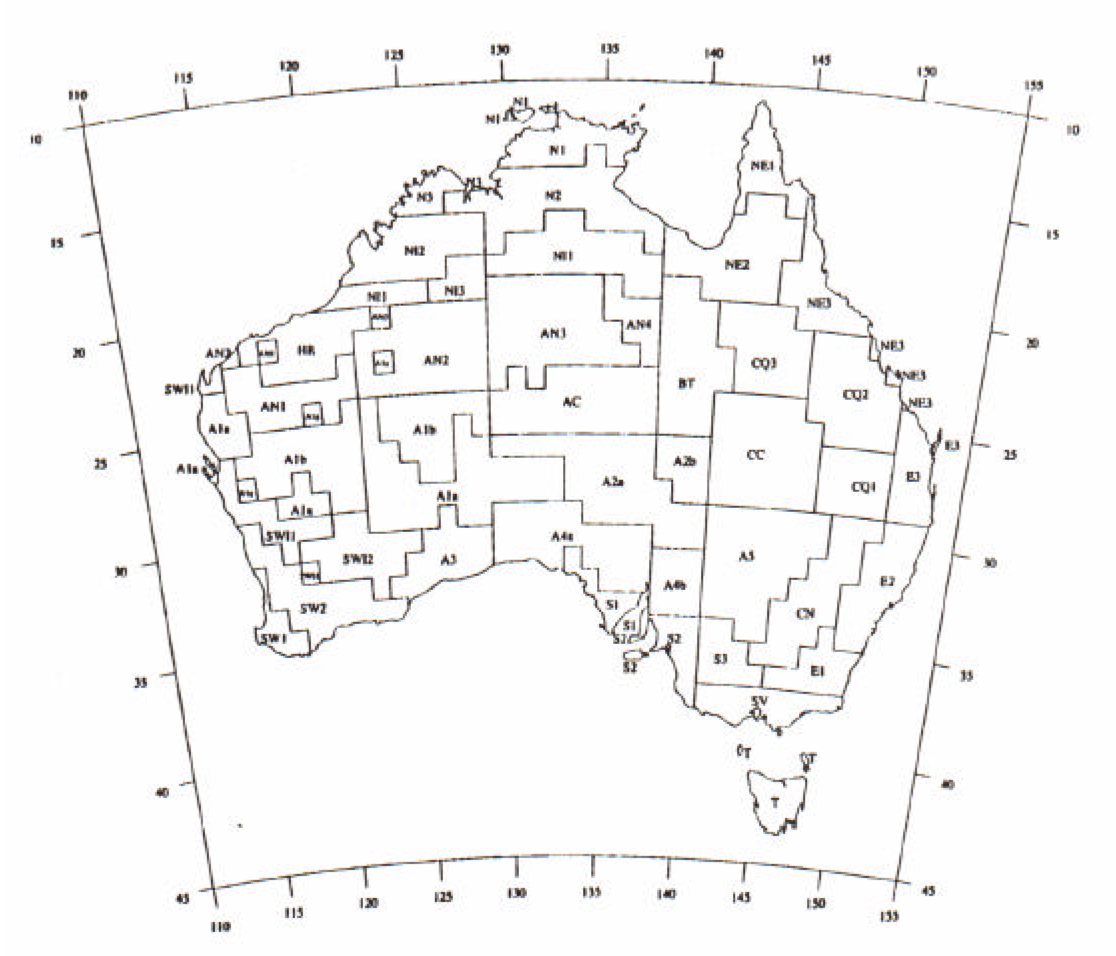
Conservation Atlas Plant Communities and Phytogeographic Regions

In a landmark study, Specht *et al.* (1995) present the results of a continent-wide assessment of Australian plant communities: the *Conservation Atlas of Plant Communities in Australia*. The Atlas provides an inventory of objectively determined plant communities based on statistical analysis of some 4729 floristic lists, using the TWINSPAN ordination and polythetic-divisive classificatory program. A total of 343 major floristic groups (including 60 understorey groups) were identified. Subsequent literature review identified subunits within the TWINSPAN groups and ultimately yielded a total of 921 floristic groups (including 108 understorey communities) for the continent, each of which are profiled in the Atlas. Specht *et al.* also present the results of a floristic analysis of 1 x 1 degree grid cells across the entire continent in order to objectively define phytogeographic regions. These regions are illustrated below in Figure 3. The BBS lies predominantly within the Central NSW region (CN) and partly within the Eastern region (E2)

A Vegetation Map of Australia

In 1990 AUSLIG published an atlas of Australia’s natural resources in several volumes, one of which dealt entirely with the continent’s vegetation. This volume included two vegetation maps, one showing the present vegetation and one showing the presumed natural (pre-clearing) vegetation. The vegetation of the BBS portion of both of these maps is illustrated Figure 4 and summarised in Table 5.

Figure 3: Phytogeographic Regions Identified by *Specht et al. (1995)*



Legend

Region Groups	**Regions**
Arid Southern	A1a, A1b, A2a, A2b, A3, A4a, A4b, A5
Arid Central	AC
Arid Northern	AN1, AN2, AN3, AN4
Barkly Tableland	BT
Channel Country	CC
*Central NSW	CN
Central Qld.	CQ1, CQ2, CQ3
*Eastern	E1, *E2, E3
Hamersley Range	E
Northern	N1, N2, N3
North Eastern	NE1, NE2, NE3
Northern Inland	NI1, NI2, NI3
Southern	S1, S2, S3
Southern Victoria	SV
South Western	SW1, SW2
South Western Inland	SWI1, SWI2
Tasmania	T
* BBS	

Figure 4: Broad Vegetation Patterns of the BBS

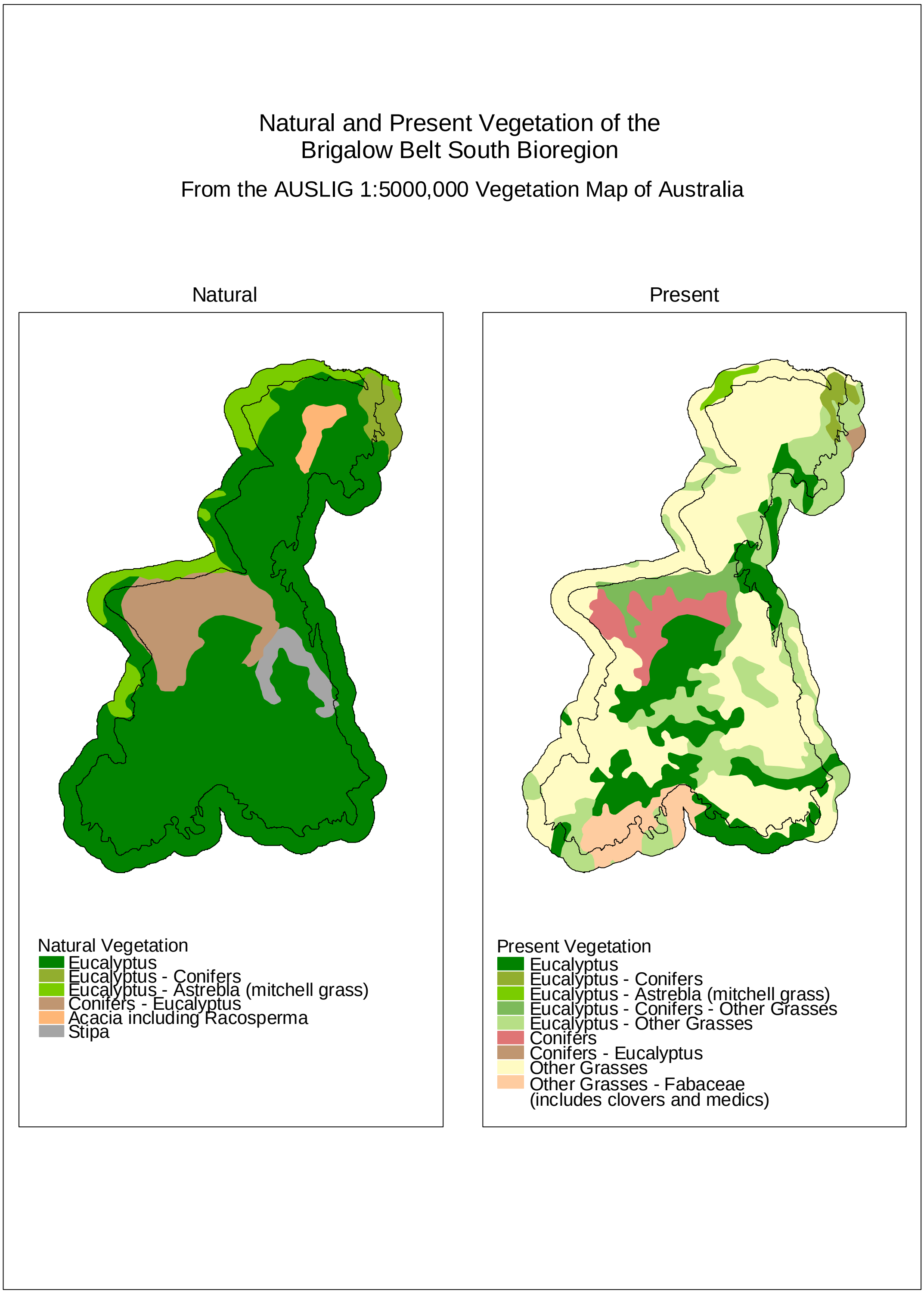


TABLE 5: BROAD VEGETATION PATTERNS IN THE BBS: PAST AND PRESENT AFTER AUSLIG (1990)

Category	Pre-clearing area (ha)	Present area (ha)	% Reduction
Eucalyptus - Conifers	165726	79971	51.8
Eucalyptus	5820069	1360966	76.6
Stipa	210424	0	100
Eucalyptus - Astrebla (mitchell grass)	602084	60592	89.9
Acacia including Racosperma	107184	0	100
Conifers - Eucalyptus	749304	25375	96.6

New South Wales Botanical Subdivisions

The vegetation of NSW is described by Harden (2000) in relation to the key physiographic features of the State as follows. New South Wales, including the Australian Capital Territory, can be separated into 5 main ecogeographic and floristic divisions: (1) Coastal; (2) Tableland; (3) Western Slopes; (4) Western Plains: and (5) Far Western Plains. These divisions are principally defined by the eastern belt of elevated tableland which profoundly influences both temperature and rainfall. In very general terms, the northern portion of NSW experiences more rainfall in summer, the southern portion experiences more rainfall in winter, whilst intermediate zones have relatively evenly distributed rainfall. Complete winter dormancy of the vegetation is found only in the highest parts of the tableland, although in most of the Tablelands Division and parts of the Western Slopes there is a pronounced depression of growth in the colder months (Harden, 1990).

On the basis of this climatic variation, the 5 main divisions can be further divided into a total of 13 subdivisions. As illustrated in Figure 5, the Greater BBS includes roughly equivalent areas of the North Western Plains (NWP), North Western Slopes (NWS) and Central Western Slopes (CWS), in addition to two small areas of the Northern Tablelands (NT). The characteristics of each subdivision are outlined in the following paragraphs after Harden (1990:xix-xx).

Northern Tablelands

The Tablelands Division, including the constituent northern, central and southern subdivisions (NT, CT, ST), experiences cool to cold winters, infrequent light summer and severe winter frosts, occasional light to heavy snowfalls and moderate to high precipitation, with annual rainfall between 500 to 2000 mm. In the west, the Tablelands is divided from the Western Slopes Division by an altitudinal line varying from 600 m above sea level in the south to 800 m in the north, but falling below these altitudes in some places in order to include the more exposed districts. The north to south continuity of the Tablelands Division is broken by the relatively low altitude of the Great Divide in the Hunter River Valley, where the Northern Tablelands subdivision (NT) is separated from the Southern Tablelands (ST) by the easterly extension of the Central Western Slopes (CWS).

Plant growth within the Tablelands Division experiences a pronounced depression during the colder months with complete winter dormancy at only the highest elevations. The vegetation chiefly consists of dry sclerophyll forest or more open grassy woodland dominated by species of eucalypt of moderate size. Areas at high elevation are covered by tall wet sclerophyll forest with some more sheltered sites supporting cool temperate rainforest dominated by Antarctic beech (*Nothofagus moorei*). As noted above, only two relatively small areas of the Northern Tablelands fall within the Greater BBS, namely, Coolah Tops (Liverpool Range) and Mount Kaputar (Nandewar Range).

North Western and Central Western Slopes

The Western Slopes Division is generally drier and warmer than the Tablelands, with annual rainfall between 370 to 750 mm, moderate winter frosts and little or no snow. The Division, including the constituent northern, central and southern subdivisions (NWS, CWS, SWS), encompasses all of the Slopes country to the west of the Tablelands but also projects eastward to meet the Coastal Division in the Hunter River Valley. Physiographically, the Western Slopes Division includes hilly, undulating and plains country and important agricultural, pastoral and forest areas. Lighter sandy and stony soils generally support dry sclerophyll forest, whilst soils of intermediate loamy texture once supported a tall woodland of eucalypt or cypress pine *(CalIitris* species), but much of this vegetation has been cleared for cropping and grazing. The heavier, chiefly black, alluvial soils and those soils developed from basic igneous rocks once supported grassy woodland but this vegetation has also been extensively cleared (Harden, 1990:xix-xx). Much of the southern portion of the Greater BBS occurs within the North Western Slopes subdivision whilst the most southern portion of the bioregion (south of the Liverpool / Warrumbungle Range) lies within the Central Western Slopes subdivision.

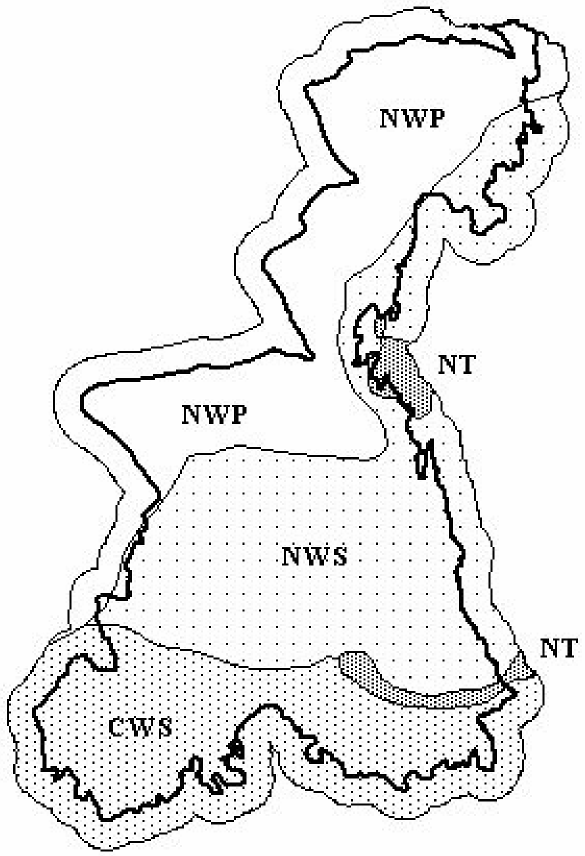
North Western Plains

The Western half of the State experiences a semi-arid to arid climate with a rainfall of 150-500 mm per annum and light to moderate frosts. The irregularity of the rainfall is often more important than its total amount, its effectiveness depending largely upon its seasonal distribution. Plants of this division are therefore mostly drought-resistant perennials or drought-escaping ephemerals.

The North Western Plains is subdivided into the Western Plains and Far Western Plains Divisions by a more or less arbitrary straight line drawn from Balranald in the south, passing west of Bourke and continuing north to the Queensland border. Each of these two divisions is again divided into northern (NWP, NFWP) and southern portions (SWP, SFWP). The greater part of these divisions is flat plains country, but there is some undulating land with scattered stony ridges or low plateaus, and occasional hills up to 500m.

The heavier clay soils are deep and nutrient-rich supporting communities usually dominated either by perennial grasses or chenopod shrubs which are associated with a rich assemblage of other species, including many ephemerals. Lighter sandy soils are more variable in depth and richness but are usually covered by low open forest or woodland in which species of *Acacia* and *Casuarina* tend to dominate in the west, with eucalypts and *Callitris* being more prominent to the east, and mallee eucalypts common in the south. Stock grazing is widespread though some dryland farming is practised toward the east, and elsewhere under irrigation. The north-western part of the Greater BBS falls within the North Western Plains subdivision.

Figure 5: Botanical Subdivisions of the BBS



Notes: The outside boundary of the above figure denotes the limit of a 15 km buffer around the BBS South Bioregion (bold line). The Bioregion includes portions of the following New South Wales botanical subdivisions: Northern Tablelands (NT); North Western Slopes (NWS); Central Western Slopes (CWS); and North Western Plains (NWP). Coolah Tops to the south and the Nandewar Range (including Mount Kaputar) to the north account for the areas of the Northern Tablelands which lie within the Bioregion.

2. PLANT SPECIES

2.1 OVERVIEW

2.1.1 Australia's Threatened Flora

Australia has more vascular plant species than 94% of countries worldwide and 85% of the world's total endemic plant taxa (Wilderness Society 1999; DEST 1994; Benson 1990). Since European settlement, Australia has witnessed the extinction of 68 vascular plant species (ANBG, 1998). Currently, Australia has 1072 nationally threatened vascular plants, 372 endangered and 700 vulnerable plant species (Commonwealth 1998 cited in Wilderness Society 1999). The number of threatened vascular plants within Australia is higher than any country on earth (Kirkpatrick 1994 cited in Briggs & Leigh 1996).

2.1.2 The Importance of Floristic Data

Knowledge of the plant species that are native to a particular region (floristic data) is fundamental to our understanding of the evolution and persistence of natural ecosystems. Particular plant species often play a pivotal role in structuring ecological communities and in sustaining ecological processes. Individual plant species or groups of species may even dominate entire landscapes, thereby contributing profoundly to our sense of place and belonging (as in the case of Australia's wattles and eucalypts, the coolabah tree in Waltzing Matilda, the State's floral emblems, or local icon species like the river red gum, *Eucalyptus camaldulensis*). In addition to their current or potential (economic) utility to human society, individual plant species may serve as reliable indicators of faunal composition, moisture availability, rock type or soil properties (such as soil depth and fertility). The acquisition of floristic data is therefore a matter of considerable importance from a cultural, economic and scientific perspective.

2.1.3 Review of Project Objectives

This chapter describes the methods used to collate and analyse floristic data for the BBS and addresses three key objectives of the Targeted Flora Survey and Mapping Project, namely:

- Collect information on specified flora and their habitat to fill as many gaps as possible, focusing on rare and threatened (ROTAP), regionally significant, overstorey dependant species or communities and old growth components.

- Collate information on the known and predicted regional distribution of each targeted species to provide regional context to the project.

- Provide new data using targeted flora surveys on the distribution and, if possible abundance of specified flora for use in verifying future habitat mapping, species and habitat modelling.

The following project tasks were formulated to meet these specific objectives:

Data Audit and Compilation

- Collate all readily available information on the vascular flora and vascular plant communities of the Greater BBS and (where appropriate) store this information in an accessible digital format.
- Compile a list of all vascular plant species known to occur with the bioregion.

Review Conservation Status to Identify Significant Plant Species

- Identify vascular plant species listed on the *Commonwealth Environment Protection and Biodiverity Conservation Act 1999* (EPBC Act), the NSW *Threatened Species Conservation Act 1995* (TSC Act) or the Rare or Threatened Australian Plants (ROTAP) list of Briggs and Leigh (1996).
- Identify vascular plant species of conservation priority at a bioregional level using explicit criteria and / or expert botanical input.

Conduct Targeted Surveys

- Undertake targeted rare plant surveys in order to validate existing locality records, collect autecological information, and to locate previously undiscovered rare plant populations.

Undertake Research and Analysis (Habitat Modelling)

- Where possible, undertake analyses in order to model the distribution of rare plant species.
- Undertake analyses in order to identify, characterise and map the vascular plant communities of the bioregion.
- Undertake research in order to identify any vascular plant communities of conservation priority that occur within the bioregion, including any communities listed on the EPBC Act or the TSC Act or otherwise considered to be of conservation priority by Specht *et al.* (1995) or other botanical experts.

2.2 DATA AUDIT AND COMPILATION

2.2.1 Available Datasets

Data sources
Floristic data are available in several different forms, each of which differs in its utility for the purposes of species inventory, numerical analysis and distribution modelling. In general, the most important sources of floristic data include individuals (especially botanists) species lists (both published and unpublished), herbaria and biological survey databases. The limitations and utility of each data source is outlined in the following paragraphs.

Individuals. Individuals, especially those regularly involved in biological surveys, are a potential source of plant locality data not available from any other source. The acquisition of these data often requires ongoing liaison to address issues of payment, intellectual property rights, the intended use of the data, data storage and third-party access. In modelling, this type of information is particularly useful in evaluating model outputs.

Species lists. Many published and unpublished plant species lists for particular geographic areas also serve as a source of plant locality data. Whilst these lists can add to a regional inventory of plant species, their utility for conservation purposes is often limited by the lack of precise plant location data. The occurrence of a plant species is usually recorded relative to the subject geographic area rather than a specific map coordinate. Occasionally however, these lists do include species by site data with sites attributed by their precise map location.

Herbaria. Herbarium records are the most reliable source of a species' occurrence, in one sense, as each record is supported by an actual specimen. However, many herbaria do not contain precise plant location data and, as a consequence, the utility of these data for conservation purposes (eg. predictive habitat modelling) is often limited. In addition, many herbaria have yet to completely transfer their records into a digital format, which again limits the utility of this data particularly for modelling and bioregion-wide analyses. Herbarium records do however, contribute to a regional inventory of plant species and can be useful as a presence only data source for modelling if the level of spatial prescision is known to be acceptibly high.

Survey Databases. Biological survey databases are the primary source of floristic data used for the purposes of bioregional assessment and distribution modelling. Typically, these databases have been specifically designed to store, manipulate and export large quantities of spatially referenced digital data. Survey databases frequently develop what could be termed ‘emergent properties’ due to the nature of the stored data, inconsistencies between (and within) datasets, and the frequently complex relationships between the constituent data tables. These emergent properties make data extraction an often arduous process requiring considerable expertise and an intimate knowledge of the structure and composition of the database. The data contained within survey databases are usually systematic, ie, the location of sites has usually been determined by prior planning or analyses in order to adequately sample the vegetation. They also inform on where species are present and absent. As such they are the most useful source for modelling.

2.2.2 Data Collation

Priorities. Due to time constraints, data collation for the floristic inventory component of the TFP concentrated on the rapid acquisition of large digital datasets, especially those containing systematic floristic site data. A total of 116,563 records were collated for the Greater BBS, which includes 3,310 systematic sites. Those datasets acquired or accessed for the TFP are listed below in Table 6.

TABLE 6: FLORISTIC DATA ACQUIRED OR ACCESSED FOR THE TARGETED FLORA PROJECT

Data Source / Database	Code	Records in Greater BBS
Royal Botanic Gardens (Sydney)	Rbg	234
National Herbarium (Canberra)	Can	53
Queensland Herbarium	Qld	52
New England Herbarium (Armidale)	Une	8
Melbourne Herbarium	Mel	11
Sydney Herbarium	Syd	141
NPWS YETI Database	YETI db	103831
NPWS Atlas of NSW Wildlife	Atlas	12201
SF Flora	Sf Flora	32
TOTAL		116563

Herbaria. Herbarium data were acquired from the Royal Botanic Gardens (Sydney), Royal Botanic Gardens (Melbourne Herbarium), National Herbarium (Canberra), Queensland Herbarium, and New England Herbarium (Armidale). All data acquired from herbaria contained locality information on individual specimen collections (e.g. latitude/longitude or easting/northing) as well as the recorder and date of collection. Some herbaria provided additional information on the reliability and accuracy of locality records. As previously noted, most herbaria do not contain records with precise plant location data because historically, approximate locality information was considered sufficient. With the recent introduction and now widespread use of differential geographic positioning systems (GPS), the precision of plant locality records are improving. At present however, most herbarium specimen locations can only be considered approximate and as such are of limited utility for modelling purposes. The processed used to audit herbarium records for modelling is described on page 93 of this report under 'data processing'. In total, herbaria ultimately supplied 499 records or 0.43% of the total number of locality records acquired for the TFP.

Biological Databases. Two biological databases were accessed for the TFP, namely, the NPWS YETI and Atlas databases. The YETI database (Bedward and Ellis, 2001) stores *systematic* floristic site data (principally quadrat data) whilst the Atlas database stores *opportunistic* records (point locations for individual species). The Atlas database contains species locality information, including both latitude/longitude and easting/northing, along with information on the accuracy of the location (Table 7). The YETI database stores a suite of floristic and environmental data in five main tables: *Sites*, *Physical Attributes*, *Disturbance*, *Floristics* and *Vegetation Structure* (Tables 8 to 11). The sites table includes fields for easting/northing and location accuracy. The processed used to audit YETI and Atlas records for modelling is described on page 93 of this report under 'data processing'. YETI and Atlas databases ultimately provided the bulk of locality records acquired for the TFP (99.54%) with a combined total of some 116,032 records within the BBS. A list of all systematic surveys used to produce the regional floristics list is outlined in Table 12.

TABLE 7: ATLAS DATABASE FIELDS

Field	Description
Data Source	Where the data originated (eg. Systematic surveys, individuals).
Sighting	Code for the site number where each species was recorded?
Species Code	A code for the species.
Family	The family of the species.
Family sort	Unknown
Scientific name	The scientific name of the species.
Common name	The common name of the species.
Legal status	Unknown
First date	The first date when the species was discovered.
Last date	Last date the species was collected.
Surname	Last name of person who firstly identified the species?
Observation	Type of observation for fauna records (e.g. scats)
Count	Number of species observed/recorded at each site.
Reliability	Code for the reliability of the species identification?
Location	Description of the location of the site.
Description	Site description.
Latitude	Latitude in decimal
Longitude	Longitude in decimal
AMG Zone	AMG zone for the site.
AMG Easting	AMG 6 – digit easting for the site.
AMG Northing	AMG 7 - digit northing for the site.
Accuracy	Code for the accuracy of locating the site?
Conservation	Code for the conservation status of each species.
Extent Type	Code for the distribution of a species.

TABLE 8: YETI DATABASE FIELDS – SITES TABLE

Field name	Description
Site number	Identification code for the site.
Locality description	Description of the location of the site.
Latitude	Derived from the easting value.
Longitude	Derived from the northing value.
Zone	AMG zone for the site.
Easting	AMG 6 – digit easting for the site.
Northing	AMG 7 - digit northing for the site.
Accuracy	Logarithmic code for the accuracy of locating the site.
Tenure	Tenure of the land where the site is located.
Conservation area code	Code for the reserve or forest the site is in.
NPWS district code	Code for the district/region the site is in.
Local Government area	Local Government Area code.
Map number	Australian Map Grid number.
Botanical division	The code for the region the site is in.
Land system	Code for the land system the site is in.
Land unit	Unknown
Recorder	Code for the person(s) recording the site.
Date	Date of the record.
Aerial photography	Aerial photo details including run, number and print.
Satellite imagery	Landsat, Spot or NOAA imagery of the site including Path, Row and Date.
Stratification	Abbreviation for the sampling stratification this site represents.
Site marker	Type and position of marker used to relocate the site.

TABLE 9: YETI DATABASE FIELDS – VEGETATION STRUCTURE TABLE

Field name	Description
Stratum	The stratum the species occurs in.
Lower height	Height (m) to the bottom of the stratum.
Upper height	Height (m) to the top of the stratum.
Percentage cover	Percentage foliage cover for that particular stratum.
Dominants	Code for the dominant species in that stratum.

TABLE 10: YETI DATABASE FIELDS – PHYSICAL ATTRIBUTES TABLE

Field name	Description
Date	Date of the record.
Recorder	Code for the person(s) recording the site.
Comments	Notes on the physical condition of the site.
Altitude	Height above sea level (m)
Slope	Slope of the site in degrees (°)
Aspect	Orientation of the site in degrees (°)
Horizon azimuths N	Angle to the Northern horizon.
NE	Angle to the North-eastern horizon.
E	Angle to the Eastern horizon.
SE	Angle to the South-eastern horizon
S	Angle to the Southern horizon.
SW	Angle to the South-western horizon
W	Angle to the Western horizon.
NW	Angle to the North-western horizon.
Horizon visibility	Degree of visibility to the horizon (good, fair or poor).
Morpho-terrain	Category of the landscape for the site location.
Element	Landform element within 20 m of the site (Speight, 1990).
Pattern	Landform pattern within 300 m of the site (Speight, 1990).
Average annual rainfall	Mean annual rainfall in millimetres from the nearest recording station.
Average annual temperature	Mean annual temperature in degrees Celsius from the nearest recording station.
Lithology	Broad geology recorded at the site.
Geological map code	Mapped geological units for the site.
User defined geological code	User generated geological code for the site.
Geology observed at the site	Geological units as observed in the field.
Soil type	Great soil group of the site.
Soil depth	Code for the depth of the soil.
Microrelief	Soil relief up to a few metres about the plane of the land surface (McDonald *et al.* 1990).
Geomorphological action	Code for the degree of gradational or anti-gradational activity at the site (Speight, 1990).
Surface texture	Broad soil surface texture.
Amount of outcropping	Exposed area of rock that is continuous with underlying bedrock, recorded in percentage (McDonald *et al.* 1990).
Amount of surface rock	Amount of surface rock at the site, recorded in percentage.
Runoff from the site	The rate at which water runs off the soil surface (e.g. slow, rapid) (McDonald *et al.* 1990).
Flood frequency	Long-term average of inundation, recorded in years (McDonald *et al.* 1990).
Typical flood duration	Annual duration of an inundation event recorded in years (McDonald *et al.* 1990).
Typical flood depth	Annual maximum depth of water in an inundation event (McDonald *et al.* 1990).
Distance to nearest watercourse	Distance from site to nearest watercourse.
Watercourse name	Name of nearest watercourse to site.

TABLE 11: YETI DATABASE FIELDS – DISTURBANCE TABLE

Field name	Description
Fire time	Time (yrs) since the last fire.
Fire accuracy	Estimate of confidence intervals (yrs) of the time since last fire.
Fire severity	Estimate of the severity of the last fire in the site.
Fire observation type	Source of fire data: estimates or historical records.
Logging time	Estimate of the time since the last logging event (yrs).
Logging accuracy	Estimate of confidence intervals (yrs) of the time since last logging.
Logging intensity	Estimate of the intensity of vegetation removal from the site.
Logging assessment type	Source of logging data: estimates or historical records.
Clearing time	Estimate of the time since the last clearing event (yrs).
Clearing accuracy	Estimate of confidence intervals (yrs) of the time since last clearing.
Clearing severity	Estimate of the severity of vegetation removal from the site.
Clearing assessment type	Source of clearing data: estimates or historical records.
Grazing time	Time (yrs) since last grazing event.
Grazing accuracy	Estimate of confidence intervals (yrs) of the time since grazing.
Grazing severity	Estimate of the severity of vegetation removal from the site.
Grazing assessment type	Source of grazing data: estimates or historical records.
Other type	Other type of disturbance (e.g. feral animals, erosion).
Other time	Time (yrs) since the last disturbance.
Other accuracy	Estimate of confidence intervals (yrs) of the time since last disturbance.
Other severity	Estimate of the severity caused by the disturbance to the site.
Other observation type	Source of other disturbance data: estimates or historical records.

2.2.3 Data Management

In overview, data management for the TFP relied on records within the *Atlas* and *YETI* databases. For the purposes of regional floristic inventory, all floristic data were ultimately processed within the ESRI ArcView GIS, which requires latitude and longitude fields (or easting and northing fields) associated with each site record. The ArcView GIS allowed reporting on an areal basis and therefore facilitated the compilation of the regional species list. Figure 6 provides a diagrammatic overview of the TFP data management system.

YETI is infrequently updated, and consequently, one of the main management issues with using this database was with regard to new species and nomenclatural changes. To overcome this problem, new species were added to the YETI database by assigning a unique species code in the CAPS Code and Taxon tables.

Table 12: Systematic Surveys contained in the YETI database

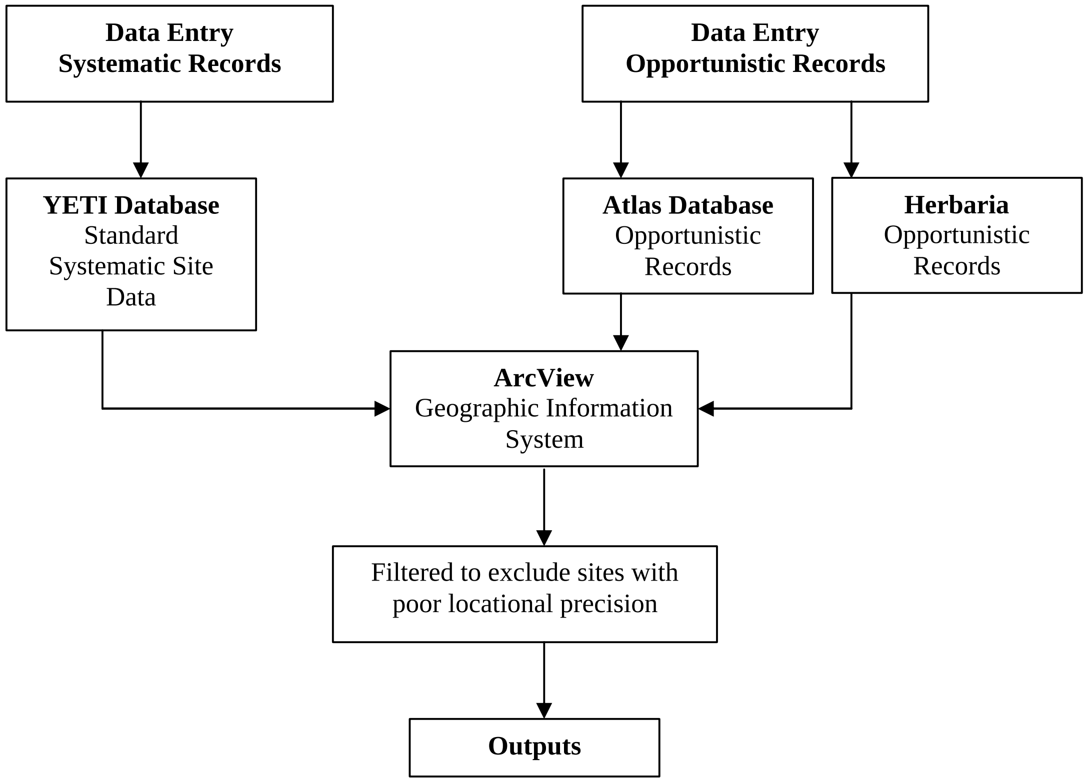
Survey	Survey ID	No. of Sites in BBS and 15k Buffer	Total No. of Sites	Principal (Surveyor)	Quadrat size	Nested Quadrat (Y/N)	Licensed surveys
Arakoola National Park Vegetation Survey	AraKoola	50	50	John Hunter (Consultant Botanist)	20 x 20m	N	Unrestricted
BBS (from the BOG database)	BBS	61	61	Department of Land and Water Conservation (DLWC)	Unspecified	-	Unrestricted
WRA BBS Community Surveys	BBSComm	33	33	National Parks Association, Friends of Pilliga, Nature Conservation Council	20 x 20 m	-	Unspecified
Data collected for Joint Vegetation Mapping Project	BBSINV	133	133	DLWC	Unspecified	-	Unspecified
Binnaway Nature Reserve	BIN NR 97	30	30	Marianne Porteners (Contract Botanist)	20 x 20m	N	Unrestricted
Vegetation Survey of Coolah Tops including Coolah Tops National Park and Warung State Forest	COOLAH 93	50	50	Doug Binns-State Forest Ecologist	20 x 50m	Y	Unrestricted
Dapper Nature Reserve Vegetation Survey	DAP	10	10	Roger Lembit Amanda Byant - NPWS	20x20 m	N	Unrestricted
Flora quadrat data collected for the Darling Riverine Plain Bioregional Assessment	DRP 2000	11	63	Katie Maric	20 x 20m in 20 x 50m plot	Y	Unrestricted
BBS Study - State Forest and Nature Reserves of the Dubbo region	DUBBO 99	37	37	Doug Beckers - NPWS Eric Whiting - Contract Botanist	20 x 20 m, 20 x 50 m	Y	Unrestricted
Floyd's Rainforest Survey - "Australian Rainforests in NSW" Vols 1&2	FLOYDRF	2	2	Alex Floyd	Unspecified	-	Unrestricted
BBS Study - Goonoo State Forest Survey	GOONOO 99	70	70	Doug Beckers - NPWS Eric Whiting - Contract botanist.	20 x 20m, 20 x 50m	Y	Unrestricted
WRA JVMP Systematic Vegetation Surveys	JVMPDB1	170	170	Doug Binns	20 x 50 m, 20 x 20 m, 5 x 20 m	Y	Unrestricted

Survey	Survey ID	No. of Sites in BBS and 15k Buffer	Total No. of Sites	Principal (Surveyor)	Quadrat size	Nested Quadrat (Y/N)	Licensed surveys
WRA JVMP Systematic Vegetation Surveys	JVMPEA	85	85	Ecology Australia	20 x 20 m	N	Unspecified
Flora Survey for Kwiambal NP and surrounds.	MAC	73	73	John T Hunter	20x50 m	N	Unrestricted
Moree Plains Grasslands survey of Moree Plains Shire and Walgett Shire east of the Barwon River	MOREEGRASS*	76	200	John Hunter (Consultant Botanist) Judi Earl	Unspecified	-	Unspecified
Survey of the subalpine areas of Mt Kaputar NP	MTKAPA 97	30	30	Marianne Porteners (Contract Botanist)	20 x 20m	N	Unspecified
Mt Kaputar south	MTKAP2000	90	90	Unknown	Unspecified	-	Unspecified
Vegetation survey of riparian zones within the Namoi River catchment, north-west New South Wales	NAMOI 95	38	49	Doug Beckers NPWS	Unspecified	N	Unrestricted
Nandewar (from the BOG database)	NAN	54	54	DLWC	Unspecified	N	Unrestricted
WRA JVMP Systematic Surveys	NVMP-INV	363	363	DLWC	20 x 20m	N	Unspecified
BBS Study - Narrabri region State Forests	Narrom 99	16	16	Doug Beckers - NPWS Rob McCosker - Contract Botanist	20 x 50 m	N	Unrestricted
North Coast Private Property Joint Project with DLWC	NCPP	15	19	P. Gilmour / K. Maric	20x20 m and 50x20 m	Y	Unspecified
Northern Wheatbelt Vegetation Survey	NWB	282	958	Dom Sivertsen-NSW NPWS	20 x 20 m	N	Unrestricted
The biology and management of Ooline	OOLINE	26	32	John Benson (Royal Botanic Gardens)	Ooline not scored but individuals counted.	N	Unrestricted
Hunter Valley Remnant Surveys	PEAKE	1	1	Travis Peake	20x20 m	N	Unspecified
Pilliga Nature Reserve Vegetation Survey	PIL	98	98	Dominic Sivertsen - Elizabeth Ashby Bill Johnson, Mark Fisher, Annie Etheridge	20 x 20 m	N	Unspecified

Survey	Survey ID	No. of Sites in BBS and 15k Buffer	Total No. of Sites	Principal (Surveyor)	Quadrat size	Nested Quadrat (Y/N)	Licensed surveys
Pilliga Nature Reserve	pil nr 90	36	36	Lindsay Holme, Brian Stone	Unspecified	-	Unspecified
BBS Study - Pilliga Nature Reserve	PIL Nra 99	54	54	Doug Beckers NPWS J D Alexander - contract botanist	20 x 20 m, 20 x 50 m	Y	Unrestricted
BBS Study - Pilliga Nature Reserve	PIL NRB 99	35	35	Doug Beckers - NPWS Doug Binns - State Forest Ecologist	20 x 20 m, 20 x 50 m	Y	Unspecified
Forestry survey of the Pillga forests	PIL SF 95	180	180	Doug Binns- State Forest Ecologist	20 x 50 m	N	Unrestricted
South Brigalow Belt Study - Pilliga State Forests	PILL b 99	40	40	Doug Binns - State Forest Ecologist Doug Beckers - NPWS	20 x 20 m, 20 x 50 m	Y	Unspecified
Pilliga State Forest Survey - part of BBSal Assessment	PILLC 99	87	91	Matt White Geoff Carr	20 x 20 m, 20 x 50 m	Y	Unspecified
BBS Study - Pilliga State Forest	PILLIGA 99	85	85	Doug Beckers - NPWS Matt White / Geoff Carr- Contract Botanist	20 x 20 m, 20 x 50 m	Y	Unspecified
South Brigalow Belt Study - Liverpool Plains region State Forests	PLAINSF 99	45	46	Doug Beckers - NPWS Douglas Binns - State Forest Ecologist	20 x 20 m, 20 x 50 m	Y	Unspecified
WRA JVMP Systematic Vegetation Surveys	RM JVMP	164	164	Rob McCosker	20 x 20m	N	Unrestricted
South Mount Kaputar NP vegetation survey	STH KAP 98	50	50	Marianne Porteners- Botanist	20 x 20 m	N	Unspecified
Towarri NP (Liverpool Range) Vegetation survey	Towarri99	22	22	Sue Robertson Travis Peake	20 x 20 m	N	Unspecified
WRA JVMP Systematic Surveys	TPJVMP	14	14	Travis Peake	20 x 20 m	N	Unspecified
Threatened flora surveys contracted by	TSUTFS0001 (Targflor01)	10	45	NSW NPWS TSU staff: Geoff	20 x 20 m	N	Unrestricted

Survey	Survey ID	No. of Sites in BBS and 15k Buffer	Total No. of Sites	Principal (Surveyor)	Quadrat size	Nested Quadrat (Y/N)	Licensed surveys
NPWS WD Threatened Species Unit, in 4 areas of state				Robertson, Lesley Forward			
Weetalibah Nature Reserve Survey	WEET NR 97	16	16	Marianne Porteners-Botanist	20 x 20 m	N	Unspecified

Figure 6: Overview of the TFP Floristic Data Management System



2.2.4 Compilation of Regional Floristics

All herbaria data were received in Microsoft Excel format. To store data in Arcview, all fields were formatted and saved as a dbase file. All systematic surveys from YETI were extracted by selecting the appropriate fields within Microsoft Access and exporting the entire dataset into Arcview as a dbase file. Atlas data were extracted from the Atlas database into Microsoft Excel where all fields were formatted, saved as a dbase file and imported into Arcview.

All floristic files imported into Arcview were firstly converted into point locality shape files. As all files contained floristic information for NSW or areas outside the BBS, files were clipped to the BBS 15km buffer to remove any records outside the study area. To avoid several different floristic files, all files were merged into one. To achieve this all files were formatted in Microsoft Excel to have the same field names. This prevented loss of any information. A common problem with using multiple datasets to create regional floristic lists is with the variations in nomenclature. To overcome such problems descriptors such as variety and subspecies were converted into a standard "var." and "subsp.". This taxonomic conversion allowed any duplicates to be removed from the floristics list.

A regional floristics list for the Greater BBS was compiled by searching and extracting data from the NPWS Atlas database, YETI database and herbarium data. The collated data were then sorted to produce a draft regional floristics list of the Greater BBS which was subsequently checked then reviewed by expert botanists to ensure data quality and consistency.

2.2.5 Data Checking Procedures

Existing survey data

The primary checking procedure that was implemented for existing survey data was based on visually reviewing AMG coordinates using Arcview GIS. Sites were identified for which eastings or northings were incorrect to the extent that they were not displayed within the known geographical range of the survey they belonged to. This level of inaccuracy was likely to be the result of error in data recording or data entry. Such sites were corrected where possible, and were otherwise excluded from future use.

Review of the Regional Flora List

A number of checking procedures were used to ensure high quality floristic data for the BBS. An initial checking procedure was conducted on the draft regional floristics list as part of the expert review process (section 2.2.11), where experts were asked to comment on the reliability of species records. Expert comments were used to revise the regional floristics list and records identified as erroneous were subsequently removed.

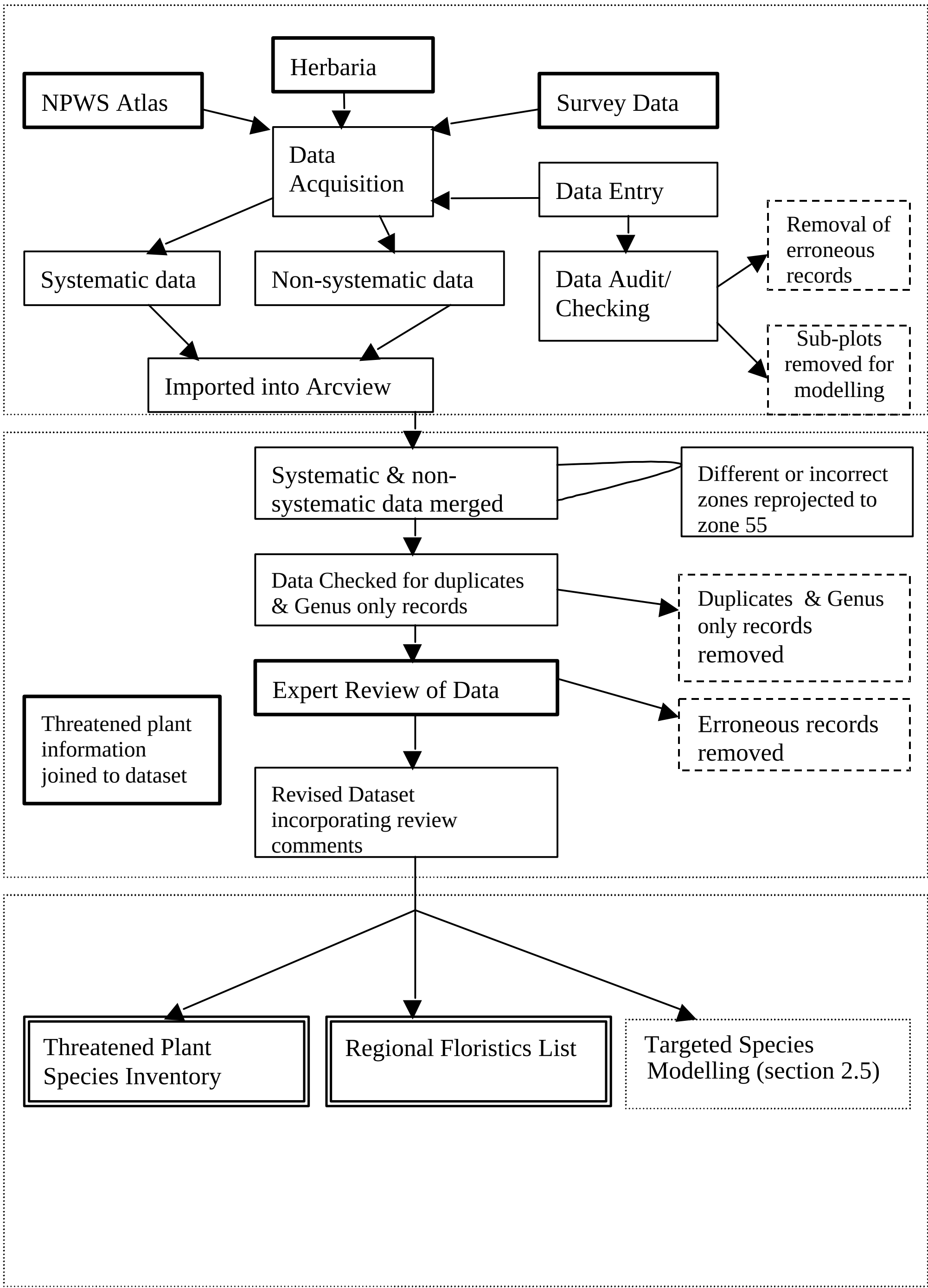
Checking Procedures

Checking procedures were necessary for identifying data entry errors, both in databases and on original field proformas (Figure 7). For new surveys (eg. JVMP surveys) all data were checked according to the following procedures:

1. Entered data were cross-referenced with field proformas by data entry staff;
2. The accuracy of grid references was checked using Arcview to compare the map sheet number, tenure and conservation code.
3. Data were checked to ensure that the site reference correlated with Arcview's grid, tenure and conservation layers.
4. Data printouts highlighting missing information or discrepancies on field proformas were sent to the relevant survey team for amendment.
5. Amended data from step 3 were entered into the appropriate databases.

All data extracted from YETI were checked to determine consistency with plot size (20 x 20 m). If nested plots were used, only the data from within the 'standard' (20 x 20 m) plot was included in the data extract; the remaining data that occurred within the additional nested quadrat area were excluded from the PATN analysis and modelling. All site data (irrespective of plot size) were used to derive the regional floristics list.

Figure 7: Data Checking Procedures of the Targeted Flora Project



2.2.6 Plant Species Inventory

Appendix 1 is an attributed checklist of the native and exotic vascular plant species of the BBS based on 116,563 plant locality records. This list of the bioregional flora represents the outcome of the data collation and reporting processes previously discussed (this list is not guaranteed to be free from errors or omissions and should be regarded as a working inventory). Proposed modifications to the bioregional flora list based on expert input are detailed in the following section. Further field and GIS-based research is required before these proposed modifications can be incorporated. The appended checklist is organised alphabetically by genus and species with the standard information fields detailed in Table 14.

According to the species checklist, the BBS supports 2,458 vascular plant taxa within 154 families, including 1,749 dicots, 644 monocots, 52 ferns, 8 cycads, 4 conifers and 1 fork fern (Table 13). The most well represented families are the Poaceae (N=344), Fabaceae (N=280), Asteraceae (N=250) and Myrtaceae (N=126). Other well represented families include the Cyperaceae (N=84), Orchidaceae (N=82), Chenopodiaceae (N=67), Rutaceae (N=50), Euphorbiaceae (N=49), Lamiaceae (N=46) and Solanaceae (N=40). A significant number of these taxa have only been recorded within 10 or less systematic sites (Figure 8).

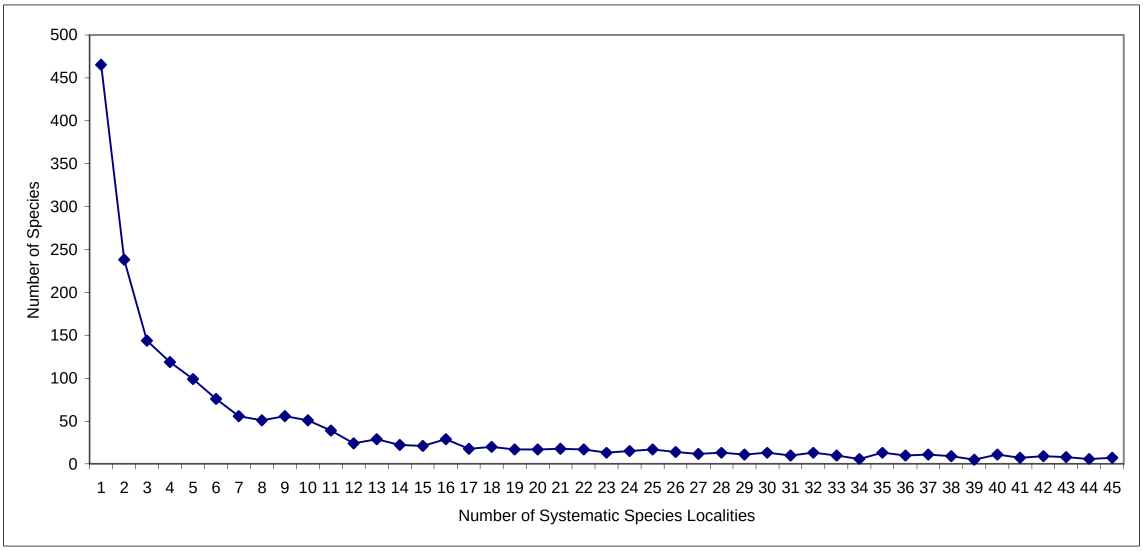
TABLE 13: VASCULAR PLANT FAMILIES AND TAXA (NUMBER IN BRACKETS)

CONIFEROPSIDA Cupressaceae (4) Coniferopsida Total (4)
CYCADOPSIDA Zamiaceae (8) Cycadopsida Total (8) **FILICOPSIDA** Adiantaceae (12) Aspleniaceae (5) Azollaceae (2) Blechnaceae (7) Cyatheaceae (1) Davalliaceae (3) Dennstaedtiaceae (4) Dicksoniaceae (2) Dryopteridaceae (5) Grammitaceae (1) Marsileaceae (3) Ophioglossaceae (2) Platyzomataceae (1) Polypodiaceae (1) Pteridaceae (2) Taenitidaceae (1) Filicopsida Total (52)
LILIIDAE Agavaceae (1) Alismataceae (1) Alliaceae (1) Amaryllidaceae (3) Anthericaceae (14) Araceae (2) Asparagaceae (1) Asphodelaceae (6) Centrolepidaceae (2) Colchicaceae (3) Commelinaceae (4) Cyperaceae (84) Eriocaulaceae (1) Haemodoraceae (1) Hydrocharitaceae (2) Hypoxidaceae (4) Iridaceae (7) Juncaceae (30) Juncaginaceae (1) Lemnaceae (2) Lomandraceae (15) Luzuriagaceae (2) Najadaceae (1) Orchidaceae (82) Philydraceae (1) Phormiaceae (12) Poaceae (344) Pontederiaceae (1) Potamogetonaceae (3) Ripogonaceae (1) Smilacaceae (1) Typhaceae (2) Uvulariaceae (1) Xanthorrhoeaceae (7) Xyridaceae (1) Liliidae Total (646)
MAGNOLIIDAE Acanthaceae (7) Aizoaceae (5) Amaranthaceae (25) Amygdalaceae (2) Anacardiaceae (1) Apiaceae (37) Apocynaceae (6) Araliaceae (4) Asclepiadaceae (15) Asteraceae (250) Bignoniaceae (1) Boraginaceae (16) Brassicaceae (33) Cactaceae (9) Campanulaceae (14) Capparaceae (4) Caryophyllaceae (29) Casuarinaceae (10) Celastraceae (7) Chenopodiaceae (67) Chloanthaceae (3) Clusiaceae (3) Convolvulaceae (13) Crassulaceae (7) Cucurbitaceae (6) Dilleniaceae (15) Droseraceae (5) Ebenaceae (1) Elatinaceae (1) Epacridaceae (35) Euphorbiaceae (49) Eupomatiaceae (1) Fabaceae (Caesalpinioideae) (18) Fabaceae (Faboideae) (157) Fabaceae (Mimosoideae) (105) Fumariaceae (4) Gentianaceae (4) Geraniaceae (11) Goodeniaceae (35) Haloragaceae (21) Icacinaceae (1) Lamiaceae (46) Lauraceae (5) Lentibulariaceae (1) Linaceae (2) Lobeliaceae (8) Loganiaceae (3) Loranthaceae (18) Lythraceae (2) Malvaceae (35) Martyniaceae (1) Meliaceae (3) Menispermaceae (1) Menyanthaceae (1) Monimiaceae (4) Moraceae (3) Myoporaceae (11) Myrsinaceae (2) Myrtaceae (126) Nitrariaceae (1) Nyctaginaceae (3) Olacaceae (1) Oleaceae (10) Onagraceae (7) Oxalidaceae (7) Papaveraceae (5) Passifloraceae (2) Phytolaccaceae (1) Pittosporaceae (11) Plantaginaceae (8) Polygalaceae (4) Polygonaceae (26) Portulacaceae (10) Primulaceae (2) Proteaceae (35) Ranunculaceae (16) Rhamnaceae (17) Rosaceae (15) Rubiaceae (27) Rutaceae (50) Salicaceae (2) Sambucaceae (1) Santalaceae (10) Sapindaceae (24) Sapotaceae (1) Scrophulariaceae (28) Simaroubaceae (1) Solanaceae (40) Stackhousiaceae (3) Sterculiaceae (8) Stylidiaceae (4) Surianaceae (1) Thymelaeaceae (17) Tremandraceae (1) Ulmaceae (1) Urticaceae (6) Verbenaceae (14) Violaceae (7) Viscaceae (3) Vitaceae (4) Winteraceae (1) Zygophyllaceae (6) Magnoliidae Total (1749)
PSILOPSIDA Psilotaceae (1) Psilopsida Total (1)
Grand Total (2458)

TABLE 14: FIELDS IN THE BIOREGIONAL VASCULAR PLANT SPECIES LIST

Spreadsheet Field	Explanation
Species	This field includes the published scientific name of the species or the most commonly applied unpublished scientific name. Some of the listed species are undescribed taxa.
Common name	This field is incomplete and only sporadically includes the common or vernacular name associated with the species, generally after Harden (1990-1993).
Family	This field includes the vascular plant family (and sometimes the subfamily) within which the species is taxonomically grouped.
Origin	This field specifies whether the taxon is native to the Australian continent or has been introduced to the continent within the last 200 years. It is possible that in some cases this classification has been applied inconsistently.
Records	This field specifies the number of opportunistic and systematic locality records known for the species within the Greater BBS. These figures are based on the datasets, data management and reporting procedures detailed in the previous section.
Source	This field lists the floristic databases (e.g. Atlas) or herbaria (e.g. syd.) from which the relevant locality records have been sourced.
Provinces	This field specifies the occurrence of the species within the Greater BBS according to the number of geographic provinces within which locality records fall. The 15 km buffer which surrounds the BBS and defines the limit of the Greater BBS is treated as a province for the sake of this tallied figure.
Province and Records	This field subdivides and tallies the total number of locality records into the geographic provinces within which they occur. The province name is abbreviated as: NO (Northern Outwash); NB (Northern Basalt); P (Pilliga); PO (Pilliga Outwash); LP (Liverpool Plains); LR (Liverpool Range); TV (Talbragar Valley); 15 km (the buffer which surrounds the BBS and defines the limit of the Greater BBS).
Status	This field codifes the conservation of the species according to the following scheme: C-1 - Taxa listed on the NSW Threatened Species Conservation Act (TSC) or the Commonwealth Environmental Protection and Biodiversity Conservation Act (EPBC); C-2 - Taxa not classified as C-1 but otherwise listed on the Australian Rare or Threatened Plant List (ROTAP) of Briggs and Leigh (1996); C-3 - Taxa rarely recorded (<5 records) or only known from a single province (restricted); C-5 – Taxa not classified as C-1, C-2 or C-3.
Distribution	This field provides an indication of the bioregional distribution of the species according to the number of geographic provinces within with it has been recorded: *restricted* taxa have only been recorded within a single province; taxa classified as *not restricted* have been recorded in 2 to 4 provinces; *widespread* taxa have been recorded in 5 or more provinces.
Abundance	This field provides an indication of the abundance of the species according to the total number of locality records within the Greater BBS: taxa with <5 localities are classified as rarely recorded; taxa with 5 to 19 records are classified as occasionally recorded; taxa with 20 to 49 records are classified as comomonly recorded
ROTAP	This field includes the Australian Rare or Threatened Plant List (ROTAP) codes of Briggs and Leigh (1996).
TSC	This field specifies the status of the species under the NSW Threatened Species Conservation Act (TSC Act) as either endangered or vulnerable.
EPBC	This field specifies the status of the species under the Commonwealth Environment Protection and Biodiversity Conservation Act (EPBC Act) as either endangered or vulnerable.

Figure 8: Recorded frequency of Species in Systematic Sites within the BBS.



Note: The x axis has been truncated at the 45 locality level

2.2.7 Exotic Species

Approximately 16% of the vascular flora of the Greater BBS (383 taxa) is considered to be introduced or exotic. This classification includes all species introduced to Australia since European settlement but does not include species that are native to other Australian states or regions that have since become naturalised within the Greater BBS. The most abundant weeds (>100 records) are listed in Table 15 (N=68) in order of decreasing abundance. As a general guide, the average number of records per exotic taxon is about 38. Most exotic taxa (about 58%) have less than 10 records and very few (about 2%) have more than 200 records.

2.2.8 Native Species

Approximately 84% (2,075 taxa) of the vascular flora of the BBS is considered native to the Australian continent. The most abundant native species within the bioregion (>400 records) are listed in Table 16 (N=42) in order of decreasing abundance. As a general guide, the average number of records per native taxon is about 46. Most native taxa (about 64%) have less than 20 records and very few (about 5%) have more than 200 records.

TABLE 15: ABUNDANT EXOTIC SPECIES OF THE GREATER BBS (>100 RECORDS)

Species	Records
Sonchus oleraceus	507
Hypochaeris radicata	491
Hypochaeris glabra	356
Conyza bonariensis	320
Cirsium vulgare	319
Opuntia stricta var. stricta	292
Conyza albida	289
Rapistrum rugosum	271
Medicago polymorpha	235
Bidens pilosa	192
Petrorhagia nanteuilii	182
Anagallis arvensis	181
Lycium ferocissimum	162
Chondrilla juncea	159
Verbena officinalis	158
Lactuca serriola	144
Cyclospermum leptophyllum	141
Oxalis corniculata	140
Opuntia aurantiaca	138
Carthamus lanatus	136
Taraxacum officinale	134
Malvastrum americanum	126
Verbena bonariensis	124
Bromus catharticus	122
Silybum marianum	122
Trifolium repens	114
Hyparrhenia hirta	109
Bidens subalternans	101

TABLE 16: ABUNDANT NATIVE SPECIES OF THE GREATER BBS (>400 RECORDS)

Species	Records
Callitris glaucophylla	1489
Melichrus urceolatus	1065
Lomandra multiflora subsp. *multiflora*	1064
Cheilanthes sieberi subsp. *sieberi*	943
Hibbertia obtusifolia	904
Callitris endlicheri	880
Eucalyptus crebra	848
Cymbopogon refractus	721
Geijera parviflora	689
Desmodium brachypodum	671
Glycine tabacina	646
Dichondra repens	641
Desmodium varians	638
Pomax umbellata	636
Austrostipa scabra subsp. *scabra*	615
Calytrix tetragona	615
Oxalis perennans	601
Glycine clandestina	573
Cyperus gracilis	572
Cassinia arcuata	564
Lepidosperma laterale	520
Sonchus oleraceus	507
Eucalyptus albens	503
Allocasuarina luehmannii	493
Chrysocephalum apiculatum	482
Calotis cuneifolia	479
Enteropogon acicularis	478
Dichelachne micrantha	472
Dichondra species A	466
Chloris truncata	458
Angophora floribunda	456
Brunoniella australis	448
Gahnia aspera	448
Cheilanthes distans	446
Lomandra longifolia	435
Wahlenbergia communis	435
Austrostipa verticillata	426
Persoonia sericea	422
Pimelea neo-anglica	413
Notelaea microcarpa var. *microcarpa*	412
Calotis lappulacea	407

2.2.9 Plant Species Richness

New South Wales

To place the plant species richness of the Greater BBS into a broader context, NSW is the third most diverse Australian State with 4,677 vascular plant species (Table 17). The native flora of the Greater BBS amounts to approximately 40% of the State total and, in sheer numbers, exceeds the total for Tasmania (1627).

NSW Botanical Subdivisions and Other Natural Regions

In relation to other regions within NSW where comparative figures are available (*viz.* the eastern botanical subdivisions), the Greater BBS has the largest number of native taxa and the third lowest number of introduced species (Table 18). The BBS also has a larger number of native taxa than regions within Western Australia and most regions within Queensland. However, on a species per unit area basis, plant species richness in the BBS is lower than all of the eastern NSW botanical subdivisions.

Geographic Provinces and Plant Diversity

Within the Bioregion, plant species richness is concentrated within particular geographic provinces, as detailed below in Table 19. The Northern Basalts and the Talbragar Valley provinces have the greatest plant species richness on a per unit area basis, whilst the Liverpool Plains and Pilliga provinces have the lowest species richness. An exponential trendline fitted to the species-area curve (Figure 9) highlights the relatively low values recorded for the Northern Outwash and Liverpool Plains provinces.

TABLE 17: PLANT SPECIES RICHNESS OF AUSTRALIAN STATES AND TERRITORIES AFTER HNATIUK (1990)

State	Native	Naturalised	Total
Greater BBS	2,075	383	2,458
Tasmania	1,627	570	2,197
South Australia	2,748	927	3,657
Victoria	2,773	820	3,593
Northern Territory	3,293	262	3,555
New South Wales	4,677	1,253	5,930
Western Australia	7,463	853	8,316
Queensland	7,535	1,161	8,696

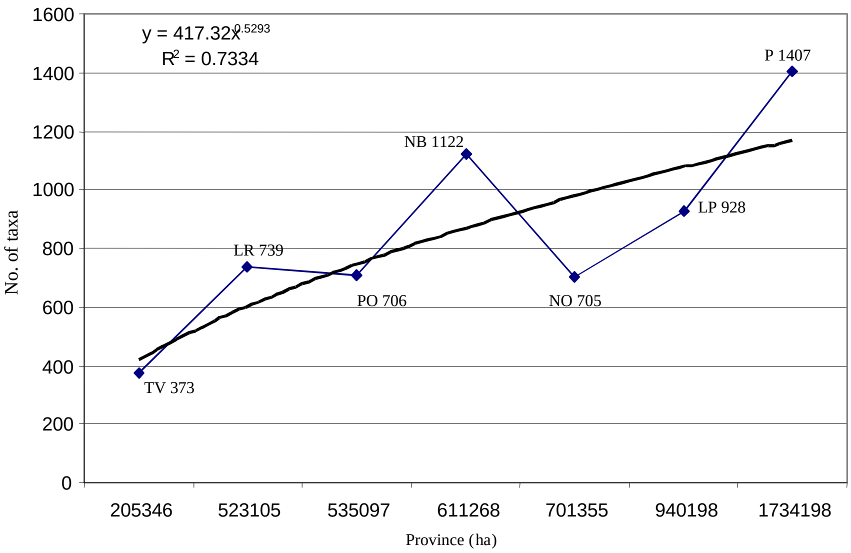
TABLE 18: REGIONS AND PLANT BIODIVERSITY AFTER NPWS (1994)

State	Region	No. of families	No. of genera	No. of Native Species	No. of Introduced Species	Area (ha)	Native Species / Area (ha) x 10^{-4}
NSW	Greater BBS	151	723	2,075	383	7,744,358	2.68
	North Coast	209	898	1,885	736	5,470,650	3.45
	Northern Tablelands	158	523	1,177	355	3,019,972	3.90
	Central Coast	181	602	1,234	830	1,705,839	7.23
	Central Tablelands	150	515	1,302	449	2,198,686	5.92
	South Coast	164	553	1,176	373	1,131,607	10.39
	Southern Tablelands	146	481	1,202	463	4,234,579	2.84
QLD	Cook (Cape York)	227	1,286	3,445	325	n/a	n/a
	North Kennedy	206	1,012	2,375	256	n/a	n/a
	Port Curtis	173	772	1,437	271	n/a	n/a
	Wide Bay	183	799	1,364	380	n/a	n/a
	Moreton	194	953	1,849	709	n/a	n/a
WA	Eyre	102	412	1,957	145	n/a	n/a
	Avon	94	405	1,752	252	n/a	n/a

TABLE 19: GEOGRAPHIC PROVINCES OF THE BBS AND PLANT SPECIES RICHNESS (PROVINCES ARE LISTED IN ORDER OF DECREASING SPECIES RICHNESS)

Province	Code	No. of Taxa	No. of Records	No. of Surveys	Province Area (ha)	Taxa/Area (ha) x 10^{-4}
Northern Basalts	NB	1,122	13,988	462	611,268	18.36
Talbragar Valley	TV	373	1,322	35	205,346	18.16
Liverpool Range	LR	739	8,187	210	523,105	14.13
Pilliga Outwash	PO	706	9,436	234	535,097	13.19
Northern Outwash	NO	705	6,364	193	701,355	10.05
Liverpool Plains	LP	928	11,350	254	940,198	9.87
Pilliga	P	1,407	35,267	938	1,734,198	8.11
BBS 15K Buffer		1,713	30,649	984	2,493,808	6.87

Figure 9: BBS Species-Area Curve based on Geographic Province Totals



2.2.10 Relatively Well Sampled Areas

Whilst much of the Greater BBS remains poorly sampled on a geographic basis (refer Figures 10 and 11), there are 13 geographic areas that are relatively well sampled, as listed below in Table 20. All of these areas are within crown tenure (i.e. National Park, Nature Reserve or State Forest). The most intensely surveyed of these areas is the relatively small Gamilaroi Nature Reserve which has, on average, one survey site every 23.4 hectares. Mount Kaputar National Park and Pilliga Nature Reserve account for a total of 12.7% of all systematic sites within the Greater BBS. The 13 relatively well sampled areas account for 27.4% of all systematic sites within the Greater BBS. The least intensively surveyed is Goulburn River National Park which averages one survey site every 9877 hectares. This figure may be unreliable, as the National Park falls almost entirely outside of the bioregion (it occurs in the 15k buffer around the bioregion). Little work was therefore carried out to locate previous survey data for this area. Coomore Creek State Forest was the next least intesively surveyed area with one site every 4201 hectares.

TABLE 20: RELATIVELY WELL SURVEYED GEOGRAPHIC AREAS

Geographic Area	Type of Reservation	Area (ha)	No of Sites	Sites / Area	Area / Sites	% of All Sites within the Greater BBS
Somerton	State Forest	761	12	0.016	63.42	0.4
Coolah Tops	National Park	10415	76	0.007	137.04	2.3
Goonoo	State Forest	28998	90	0.003	322.20	2.7
Warrumbungle	National Park	13039	61	0.005	213.75	1.8
Pilliga	Nature Reserve	83168	208	0.003	399.85	6.3
Mt Kaputar	National Park	37971	211	0.006	179.96	6.4
Terry Hie Hie	State Forest	5867	29	0.005	202.31	0.9
Mission	State Forest	1265	7	0.006	180.71	0.2
Gamilaroi	Nature Reserve	117	5	0.043	23.40	0.2
Warialda	State Forest	3986	49	0.012	81.35	1.5
Arakoola	Nature Reserve	3162	100	0.032	31.62	3.0
Kwiambal	National Park	1363	38	0.028	35.87	1.2
Severn	State Forest	4598	18	0.004	255.44	0.5

Figure 10: Systematic Survey Sites in the Greater BBS

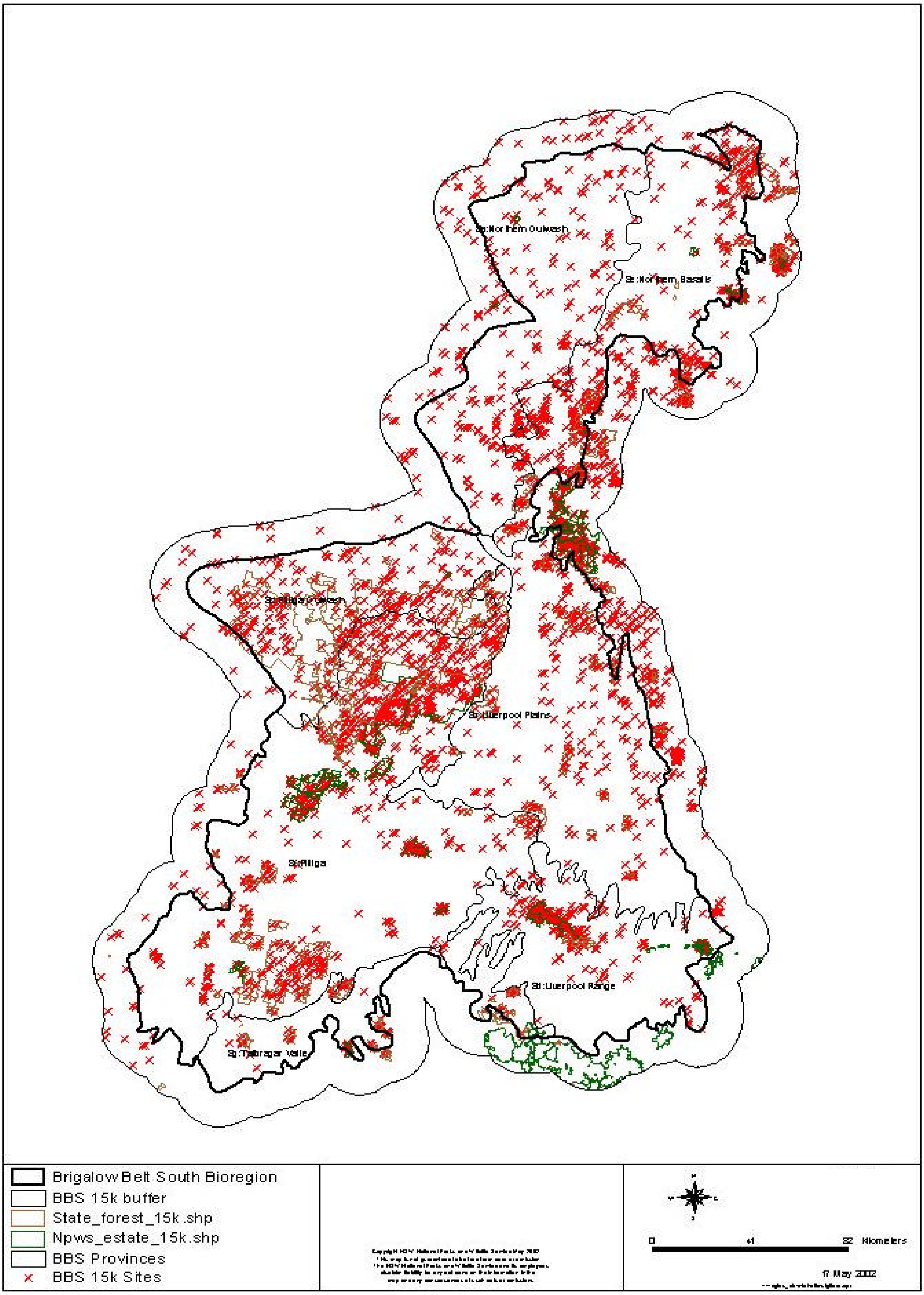
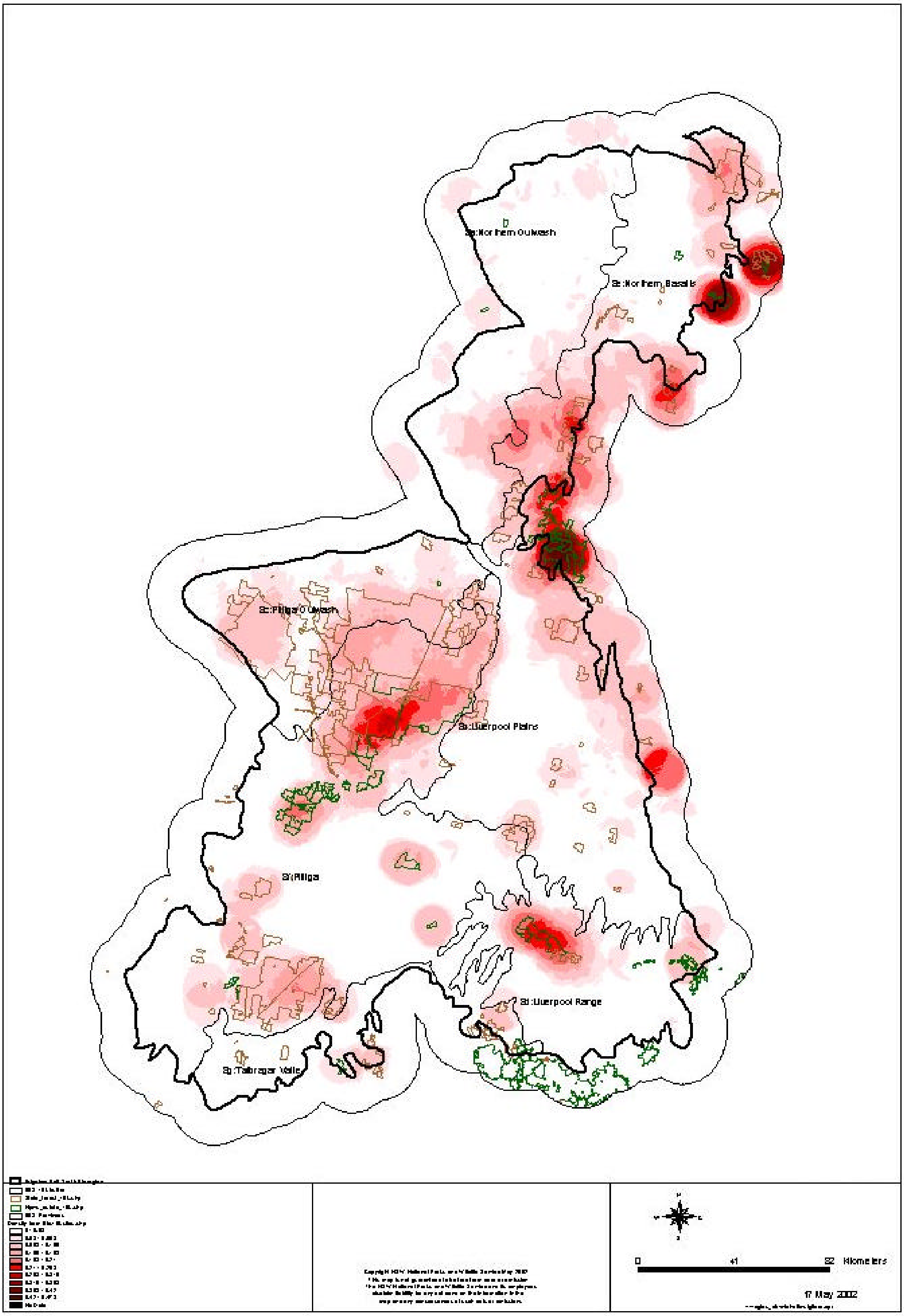


Figure 11: Systematic Survey Site Density in the Greater BBS



2.2.11 Expert Review of Regional Floristics

The purpose of this review was to capture expert knowledge of rare plant geography and ecology in the BBS. The review process involved individuals with botanical expertise in the BBS and representatives from State Forests, DLWC, and NPWS, in addition to one independent expert (Table 21). Initially, an Expert Review Workshop was scheduled for 13th February 2002, however due to limited availablility, input from experts was received via email.

The WRA Unit supplied each expert botanist with an Information Package to comment on, which included a map of the BBS, rare plant species list, spreadsheet of rare plant localities, rare plant locality maps, autecological summary tables, survey priority form and target area form. Feedback from the experts was used to provide recommendations for ongoing research and future targeted rare plant surveys.

Review of Regional Floristics List

Botanical experts were asked to comment on the regional floristics list and to identify any spurious records or species of significance, including species outside of their known geographic range, nomenclatural inaccuracies and inconsistencies, and species which should be prioritised for field survey.

Review of Species Locality Records

Experts were asked to assign identification reliability codes next to each priority species record to indicate the accuracy of species identification (Table 22). Experts were also asked to assign spatial precision classes to each rare plant record as a guide to the level of positional accuracy (Table 23).

Review of Conservation Status

From examining species locality records, experts were asked to identify which species they considered currently not at threat from extinction in the BBS (and therefore removed from the TFP priority species list), and species that require upgrading their conservation status to ensure protection against extinction (e.g. rare upgraded to endangered). Experts were also asked to make comments on the accuracy of current species protection codes.

Review of Autecological Information

As basic autecological data are unavailable for a significant number of rare plant species, flora experts were invited to add to (or otherwise modify) autecological information provided in the review package.

A summary of the outcomes of expert review comments is provided in Tables 24 and 25.

TABLE 21: LIST OF DEPARTMENTS AND EXPERTS INVOLVED IN THE VALIDATION PROCESS

Name	Department	Location
Geoff Robertson	NPWS – Western Directorate	Dubbo
Paul Sheringham	NPWS – Northern Directorate	Coffs Harbour
Doug Binns	State Forests	Coffs Harbour
Steve Lewer	DLWC	Dubbo
Marianne Porteners	Independent Consultant	Lily Field

TABLE 22: LIST OF IDENTIFICATION RELIABILITY CODES

Identification Reliability Codes	
A	Definitely correct identification
B	Probably correct identification
X	Probably incorrect identification
Z	Definitely incorrect identification
?	Taxonomic uncertainty

TABLE 23: LIST OF SPATIAL PRECISION CLASS CODES

Spatial Precision Class Codes	
1	<100m
2	100 – 500 m
3	500 – 2000 m
4	> 2000 m
5	Delete / Quarantine

TABLE 24: ERRONEOUS SPECIES IDENTIFIED WITHIN THE REGIONAL FLORISTICS LIST

Species	Botanist	Comment
Acacia adunca	Paul Sheringham	Not on current ROTAP list
Acacia barringtonesis	Paul Sheringham	Werrikimbe, Gibraltar Range.
Acacia irrorata subsp. irrorata	Paul Sheringham	Coastal species, may occur within Liverpool Range buffer.
Acacia pycnostachya	Paul Sheringham Steve Lewer	Endemic to the Northern Tablelands
Acrotriche latifolia	Paul Sheringham	Taxon not recognised in NSW Flora, possible new taxon?
Amphibromus whitei	Steve Lewer	Presumed extinct in Australia.
Boronia pinnata	Paul Sheringham	Coast and Central Tablelands.
Boronia ruppii	Steve Lewer	Restricted to the Woodsreef area
Brachyscome readeri	Paul Sheringham	South Western Plains
Caladenia tessellata	Geoff Robertson	Questionable record
Callistemon shiressii	Paul Sheringham	Gosford.
Calotis glandulosa [1]	Geoff Robertson	Questionable record
Corymbia intermedia	Paul Sheringham	North Coast
Crinum pendunculatum	Paul Sheringham	River lily is distributed on the coast.
Cryptocarya dorrigoensis	Paul Sheringham	Questionable record
Cynanchum elegans [1]	Geoff Robertson	Questionable record
Dillwynia cinerascens	Paul Sheringham	South Western Plains
Diuris aequalis	Geoff Robertson, Paul Sheringham	Kananga species, probably a incorrect record or poor specimen id
Diuris pedunculata [1]	Geoff Robertson	Type collection 1803 near Hawksbury, later collecitons near Scone and Bendemeer
Eriostemon myoporoides subsp. Epilosus	Paul Sheringham	Granite endemic to Boonoo Boonoo, Torrington.
Eucalyptus bancroftii	Paul Sheringham	North coast.
Eucalyptus codonocarpa	Paul Sheringham	Endemic to the Gibraltar Range, Cathedral Rock
Eucalyptus siderophloia	Paul Sheringham	North and central coast.
Eucalyptus tindaliae	Paul Sheringham	North coast and Northern Tablelands.
Grammitis stenophylla	Paul Sheringham	North coast to south coast.
Grevillea longifolia	Paul Sheringham	Sydney Basin (i.e. Heathcote NP).
Hakea pulvinifera	Steve Lewer Geoff Robertson	Endemic to the Lake Keepit area.
Hemigenia purpurea	Paul Sheringham	Sydney, Blue Mountains.
Homoranthus virgatus	Paul Sheringham	Coastal heath north from Taree.
Indigofera efoliata	Steve Lewer	Likely extinct in NSW
Lepidium hyssopifolium	Geoff Robertson, Paul Sheringham Steve Lewer	Tablelands species
Leucopogon deformis	Paul Sheringham	Coastal heath north from Hawks Nest.
Micromyrtus minutiflora	Paul Sheringham Geoff Robertson	Sydney endemic, Cumberland Plain.
Mirbelia confertiflora	Geoff Robertson	Not a ROTAP, Northern Tablelands
Persoonia nutans	Geoff Robertson, Paul Sheringham	Questionable record
Phebalium glandulosum ssp. eglandulosum	Paul Sheringham	Endemic to Torrington
Pultenaea canescens	Paul Sheringham	Blue Mountains, ACT.
Pultenaea parviflora	Geoff Robertson, Paul Sheringham	Questionable record
Pultenaea pedunculata	Geoff Robertson, Paul Sheringham	Questionable record
Pultenaea petiolaris	Paul Sheringham	North coast species, i.e. Grafton
Pultenaea stuartiana	Paul Sheringham	Torrington endemic
Sida rohlenae var. rohlenae	Paul Sheringham	Questionable record
Tetratheca ericifolia	Paul Sheringham	Coast, central and Southern Tablelands.
Tristaniopsis laurina	Paul Sheringham	Coast and Central Tablelands.
Westringia glabra	Paul Sheringham	Wollomombi Gorge

1. Taxa listed by Harden (1990-1993) as occurring within botanical subdivisions that fall within the BBS.

TABLE 25: LIST OF TAXONOMIC ISSUES IDENTIFIED BY THE EXPERT REVIEW PROCESS FOR THE BBS REGIONAL FLORISTICS LIST

Species	Botanist	Comment
Angophora costata	Paul Sheringham*	Records for this species are probably Angophora leiocarpa, which used to be included as a subspecies in A. costata.
Bertya opponens	Steve Lewer	At present the accepted name is Bertya sp. Cobar-Coolabah
Boronia rosmarinifolia	Paul Sheringham*	Specimens from NWS and CWS are included in Boronia glabra.
Galatica sp. B	Paul Sheringham*	Now Galatica tenuifloia subsp. var lucida
Hakea dactyloides	Paul Sheringham*	Now named Hakea graniticola subsp. laevipes
Kunzea ambiguua	Paul Sheringham*	Kunzea sp. D
Eriostemon ericifolius	Chapman (2001)	Synonym: Philotheca ericifolius
Eriostemon myoporoides subsp. epilosus	Chapman (2001)	Synonym: Philotheca myoporoides ssp. epilosa
Leionema viridiflorum	Chapman (2001)	Synonym: Phebalium viridiflorum
Xylomelum pyriforme	Paul Sheringham*	All western records of this species should be Xylomelum cunninghamianum.

1. Taxa listed by Harden (1990-1993) as occurring within botanical subdivisions that fall within the BBS.
* Review comments received after data analysis and therefore not identified within the BBS regional floristic list.

2.3 SIGNIFICANT PLANT SPECIES

2.3.1 Determining Conservation Priority

A suite of criteria and threatened plant listings are available that may serve as a starting point for the developmernt of a plant species priority list for the BBS. Table 26 lists some of the sources of conservation status information available for Australian plant species and indicates their relevance to the Greater BBS study area. Table 27 lists the many criteria that may be applied to determine the conservation significance of vascular plant species. Many of these criteria can be amalgamated for the purposes of bioregional assessments, as detailed in Table 28.

2.3.2 Identifying Rare or Threatened Species

Due to project constraints, the conservation status of plant species within the Greater BBS was only assessed relative to the three most important threatened plant listings: (1) the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)[1]; (2) the NSW Threatened Species Conservation Act 1995 (TSC Act); and (3) the Rare or Threatened Australian Plants list of Briggs and Leigh (1996) (Table 29). According to these listings, this assessment has identified **C1** (Critically Threatened) and **C2** (Threatened) species (refer Table 28). It is recommended that future research significantly expand the number of species subject to conservation assessment following the approach of Pressey *et al.* (1990) and Richards *et al.* (1998) using a broader range of criteria than so far applied (eg. Table 27).

[1] The EPBC has replaced the Endangered Species Protection Act 1992

TABLE 26 CONSERVATION STATUS DATA FOR NSW VASCULAR PLANT SPECIES (SELECTED REFERENCES ONLY)

Abbreviations	Conservation Status Data – Scientific or Legislative List Note: many lists are subject to ongoing revision.
ANZECC	Australian and New Zealand Environment and Conservation Council (ANZECC) Endangered Flora Network (June 1993). Threatened Australian Flora. A list compiled by the ANZECC Endangered Flora Network. Australian Nature Conservation Agency. A listing of nationally extinct, endangered and vulnerable taxa.
EPBC Act	Taxa listed on the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). This Act replaces the Commonwealth Endangered Species Protection Act (ESP Act). Taxa may be listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent.
TSC Act	Extinct, endangered and vulnerable taxa listed on the NSW Threatened Species Conservation Act 1995 (as amended).
NP&W Act	‘Protected Native Plants’ listed on the National Parks and Wildlife Act 1974 (as amended). It is illegal to collect the listed species without an appropriate licence.
Fisheries Act	Protected plant species (mangroves) listed under the Fisheries Management Act 1994 (as amended). Specifically, *Aegiceras corniculatum* (River Mangrove), *Avicennia marina* (Grey Mangrove), *Bruguiera gymnorrhiza* (Large-leaved Mangrove), *Excoecaria agallocha* (Milky Mangrove) and *Rhizophora stylosa* (Red Mangrove).
ROTAP	Briggs, J, D. and Leigh, J. H. (1996). Rare or Threatened Australian Plants. CSIRO, Collingwood, Victoria. A national list of extinct, endangered, vulnerable, rare and poorly known species.
NEFBS	Sheringham, P. *et al.* (1997). Significant Vascular Plants of the NEFBS Study Area. Unpublished NPWS working list. The latest significant plant list for all vegetation communities within the NEFBS study area. Now largely superseded by Richards *et al.* (1998).
Upper NE NSW	Sheringham, P. and Westaway, J. (1997). Significant Vascular Plants of Upper North East New South Wales. A Report by the NSW National Parks and Wildlife Service for the Natural Resources Audit Council. NSW NPWS, Sydney. Now largely superseded by Richards *et al.* (1998).
IAP	Interim Forestry Assessment Process (IAP) Panel Recommendations. Taxa considered endangered or vulnerable (within the NEFBS study area) by the IAP flora expert panel. Resource and Conservation Assessment Council. (1996). Draft Interim Forestry Assessment Report. New South Wales Government, Sydmey. Now largely superseded by Richards *et al.* (1998).
Pressey *et al.*	Pressey, R.L., Cohn, J.S. and Porter, J.L.. (1990). Vascular Plants with Restricted Distributions in the Western Division of New South Wales. *Proceedings of the Linnean Society N.S.W.,* **112** (2), pp. 213 – 227.
Richards *et al.*	Richards, P. G.; DeVries, R. J.; and Flint, C. (1998). Vascular Plants of Conservation Significance in North-Eastern New South Wales: Inventory and Assessment. Unpublished draft report, NSW National Parks and Wildlife Service, CRA Unit, Northern Zone. Expert review of the conservation status of 1724 taxa.
Quinn *et al.*	Quinn, FC, Williams, JB, Gross, CL & Bruhl, JJ (1995). Report on rare and threatened plants of north-eastern New South Wales. Report prepared for New South Wales National Parks and Wildlife Service and Australian Nature Conservation Agency.
Benson & McDougall	Benson, D., and McDougall, L. (1991). *Rare bushland plants of western Sydney*. Sydney Royal Botanic Gardens.
Mills	Mills, K. (1988). Conservation of Rainforest Plant Species. Illawarra Region of New South Wales. Inventory, Assessment and Recommendations for Management. A report prepared for the National Parks and Wildlife Service.
Richards	Richards, P. (1996). Significant Plants of the Glen Innes Forest Management Area. State Forests of New South Wales, Northern Region. Ecological Profiles.

TABLE 27 CONSERVATION SIGNIFICANCE CRITERIA FOR VASCULAR PLANTS

Code	Significance Categories and Criteria
X	Presumed Extinct. Taxa presumed extinct at a National (Xn), State (Xs) or Bioregional (Xb) level. Taxa not collected or otherwise verified over the past 50 years despite thorough searching in all known or likely habitats, or whose known wild populations have been destroyed more recently. Taxa extinct in the wild but otherwise conserved (such as in botanical gardens) may be denoted as (cX).
E	Endangered. Taxa in danger of extinction unless the circumstances and factors threatening their abundance, survival or evolutionary development cease to operate. Taxa facing an extremely high risk of extinction in the wild in the immediate future may be termed Critically Endangered (CE).
V	Vulnerable. Taxa likely to move into the endangered category within the next 25 years, unless the factors threatening their abundance, survival or evolutionary development cease to operate. Priority is given to taxa which are listed as vulnerable nationally, as identified on the EPBC Act, the TSC Act or the ROTAP list of Briggs and Leigh (1996).
A	Conservation-dependent. Taxa that are the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.
B	Protected. Taxa protected from commercial exploitation or destruction under statute, other than those lised as endangered, critically endangered, vulnerable or conservation dependent.
Q	Reservation status. The extent to which taxa are conserved within national parks, nature reserves or other areas specifically set aside under statute for the conservation of biological diversity. Q denotes that at least one population is reserved. The number of reserved populations rather than the number of individuals should be used to denote reservaton status above this (eg. Q2) minimum even though the definition of a population may be the subject of some uncertainty.
R	Rare. Taxa with small world populations that are not presently endangered or vulnerable but which may have a relatively high risk of extinction. Such taxa may be identified with reference to the ROTAP list of Briggs and Leigh (1996), State or regional rare plant lists, or with reference to explicit criteria such as geographic range, habitat specificity, local population size, total number of populations, relative abundance or the frequency of records in collections.
D	Declining. Taxa known (or strongly suspected) to be adversely affected by prevailing land uses, through either a significant decrease in their abundance or a significant reduction in their geographic range.
K	Poorly known. Undescribed taxa or taxa whose habitat, distribution and ecology are very poorly known.
T	Recently described. Taxa recently described (<5 years) or recently segregated (new species within an existing genus or new subspecies or varieties within an existing species).
N	Nomads – mobile, opportunistic or ephemeral taxa. Taxa in which the populations, or components of populations, regularly or irregularly occupy different areas of the landscape because of changes in resource or habitat availability, or due to the creation and maintenance of resource or habitat patches.
M	Growth-stage dependent. Taxa dependent on a particular forest growth stage. These stages include the regrowth, mature and over-mature (senescent) growth stages (taxa may be denoted as rM, mM or sM respectively).
S	Taxa whose distributions do not correlate with any ecosystem.
P	Phylogenetically distinct. Taxa whose taxonomic position means that its potential loss will lead to a significant loss of biological diversity, such as in the case of monospecific genera.
G	Taxa with complex spatial patterns of genetic variation.
B	Bioregional endemics. Taxa with more than 75% of their known range within a single biogeographic region or which have a total range of 100,000 square kilometres or less.
J	Disjunct. Taxa whose populations have become physically separated over time due to a break in a formerly continuous distribution or through long-distance dispersal over a barrier and, as a consequence, are morphologically or structurally distinct and have diverged genetically from parent stocks or are otherwise presumed to be genetically isolated from other populations.
L	At the limits of their range. The occurrence of individuals or populations of a taxon at or near their geographic or ecological limits or tolerances.
Y	Geographically restricted. Taxa with an Australian geographic range of <100 km or that are otherwise restricted to an explicitly defined, small geographic area.
F	Functionally important. Keystone taxa whose disappearance from an ecosystem or plant community results, either directly or indirectly, in the loss of several other species or in major ecological changes to tropic relationships, hydrology, succession or disturbance regimes.
I	Indicators. Taxa whose population response broadly reflects the response of a range of species to environmental changes resulting from particular land uses (uI) or whose niche encompasses the niche of a suite of other species (nI).
C	Economically or culturally important. Taxa of medicinal, agricultural or other economic value or species of scientific, social or cultural value. This category includes 'icon', 'flagship' or 'charismatic' species (like the Wollemi Pine).
H	Poorly collected. Taxa with a very small number of survey and/or herbarium records.
X	Cryptic. Taxa that are particularly difficult to locate and / or identify, due to their life form, phenology or other specific circumstances.

This table is a synthesis of a suite of conservation status categories derived from Commonwealth and State legislation, various threatened plant listings and other relevant scientific literature. The codes associated with a particular significance category may not correspond with pre-existing conservaton status classifications.

TABLE 28 BIOREGIONAL CONSERVATION PRIORITY – COMPOSITE CLASSES

Code	Priority Class and Criteria
C1	Critically Threatened. Identified as a highest priority taxon; Presumed Extinct, Endangered or Vulnerable (as listed on the NSW Threatened Species Conservation Act and the Commonwealth Endangered Species Protection Act, and as identified during the Interim Forestry Assessment); only those species considered of highest conservation or scientific concern; threatened species identified in National or State legislation or related policy documents; taxa considered by the Flora Expert Panel to warrant formal listing on National or State legislation as a Critically Threatened taxon.
C2	Threatened. Identified as a high priority taxon; taxa otherwise considered Potentially Threatened, Threatened, Rare, Uncommon or Poorly Known (ROTAP taxa or as noted in the Flora of NSW) or Declining Regionally (according to Sheringham et al.); taxa considered by the Flora Expert Panel to warrant listing as Threatened but not as Critically Threatened on National or State legislation.
C3	Regionally Significant. Identified as a priority taxon of regional conservation significance; taxa otherwise considered Regionally Endemic; Regionally Uncommon; or that have a disjunct distribution (IAP; Sheringham et al.; Flora of NSW); taxa considered by the Flora Expert Panel to have regional conservation significance but not warranting listing as a Threatened or Critically Threatened taxon.
C4	Economically, Culturally or Scientifically Important. Identified as a priority taxon; otherwise considered Economically, Culturally or Scientifically Important (according to various sources); includes taxa that reach their distributional limits within the region (eg. Sheringham et al.); taxa considered by the Flora Expert Panel to have economic, cultural or scientific importance but not National, State or Regional conservation significance.
C5	Not Priority. Not currently identified as a priority taxon according to any of the above criteria.

TABLE 29: RARE OR THREATENED AUSTRALIAN PLANT CODES AFTER BRIGGS AND LEIGH (1996)

Distribution (1, 2 or 3).	
1	The taxon is known from only one collection.
2	The geographic range of the taxon in Australia less than 100 km.
3	The geographic range of the taxon in Australia is greater than 100 km.
+	Overseas occurrence (included if the taxon has a natural occurrence overseas).
Conservation Status (X, E, V, R or K).	
X	Presumed extinct: taxon not collected or otherwise verified over the past 50 years despite thorough searching in all known of likely habitats, or of which all known wild populations have been destroyed more recently.
E	Endangered: taxon in serious risk of disappearing from the wild within 10-20 years if present land use and other threats continue to operate. This category includes taxa with populations possibly too small (usually less than 100 individuals) to ensure survival even if present in proclaimed reserves.
V	Vulnerable: taxon not presently Endangered, but at risk over a longer period (20-50 years) of disappearing from the wild through continued depletion, or which occurs on land whose future use is likely to change and threaten its survival.
R	Rare: taxon which is rare in Australia (and hence usually in the world) but which currently does not have any identifiable threat. Such species may be represented by a relatively large population in a very restricted area or by smaller populations spread over a wide range or some intermediate combination of distribution pattern.
K	Poorly known: taxon that is suspected, but not definitely known, to belong to one of the above categories (presumed extinct, endangered, vulnerable, rare). At present, accurate field distribution data information is inadequate.
Reservation status and size class of all reserved populations (C, a, i, -, or t)	
C	Reserved: indicates taxon has at least one population within a National Park, other proclaimed conservation reserve or in an area otherwise dedicated for the protection of flora. The taxon may or may not be considered adequately conserved within the reserve(s), as reflected by the conservation status assigned to it. Where applicable, the 'C' symbol immediately follows the conservation status symbol in the written code.
a	1000 plants or more are known to occur within a conservation reserve(s).
i	Less than 1000 plants are known to occur within a conservation reserve(s).
-	Reserved population size is not accurately known.
t	Total known population reserved.

2.3.3 Inventory of Rare or Threatened Plant Species

TSC, EPBC and ROTAP Taxa

Preliminary botanical research has identified 100 rare or threatened species that occur within the Greater BBS, or 4% of the total vascular flora recorded for the study area (Figure 12). The 100 significant plant species include 24 species listed as endangered (Table 30); 24 species listed as vulnerable (Table 31); 76 ROTAP species (Table 32); and 2 species considered extinct (Table 34).

Concentrations of Significant Species

The highest concentrations of significant plant species records are located in the vicinity of the Warrumbungles, Kaputar National Park, Warialda State Forest, and Severn State Forest areas (Figure 13). Site locations for significant speces were reported by tenure to determine the level of formal reservation for rare or threatened species known to occur in the BBS. The results indicate that the largest number of rare or threatened plant species have been recorded on private property throughout the BBS. A significant number of rare or threatened plant species records have also been recorded within Mount Kaputar National Park, Travelling Stock Reserves (TSR), Warrumbungles National Park, Goulburn River National Park, Pilliga East State Forest, Goonoo State Forest, Arakoola Nature Reserve, Pilliga Nature Reserve, other crown land, and Deriah State Forest (Figure 14).

Significant Species with Uncertain Status

Within the BBS there are 14 species whose bioregional status is uncertain (Table 33). Such species were identified by expert botanical review, Sydney's Royal Botanic Garden's electronic plant inventory, Plant Net and from using the Floras of NSW. Records within the BBS may be attributed to species mis-identification or species range extensions. Targeted research needs to be undertaken to confirm the taxonomic and conservation status of these species.

TABLE 30 TAXA LISTED AS ENDANGERED ON THE NSW THREATENED SPECIES CONSERVATION ACT (TSC)

Taxon	Family	ROTAP	TSC	EPBC
Acacia jucunda	Mimosaceae		TSC-E	
Astrotricha roddii	Araliaceae	3VCa	TSC-E	EPBC-E
Boronia granitica	Rutaceae	3VC-	TSC-E	EPBC-E
Capparis loranthifolia var. loranthifolia	Capparaceae		TSC-E	
Cynanchum elegans	Asclepiadaceae	3Eci	TSC-E	EPBC-E
Cyperus conicus	Cyperaceae		TSC-E	
Desmodium campylocaulon	Fabaceae		TSC-E	
Digitaria porrecta	Poaceae	3E	TSC-E	EPBC-E
Diuris pedunculata	Orchidaceae	2E	TSC-E	EPBC-E
Haloragis stricta	Haloragaceae		TSC-E	
Indigofera efoliata	Fabaceae	2E	TSC-E	EPBC-E
Lepidium monoplocoides	Brassicaceae	3ECi	TSC-E	EPBC-E
Monotaxis macrophylla	Euphorbiaceae		TSC-E	
Phyllanthus maderaspatanus	Euphorbiaceae		TSC-E	
Platyzoma microphyllum	Platyzomataceae		TSC-E	
Polygala linariifolia	Polygalaceae		TSC-E	
Pomaderris queenslandica	Rhamnaceae		TSC-E	
Swainsona recta	Fabaceae	3ECi	TSC-E	EPBC-E
Tylophora linearis	Asclepiadaceae	3E	TSC-E	EPBC-E
Zieria ingramii	Rutaceae	2V	TSC-E	EPBC-E

TABLE 31 TAXA LISTED AS VULNERABLE ON THE NSW THREATENED SPECIES CONSERVATION ACT

Taxon	Family	ROTAP	TSC	EPBC
Asperula asthenes	Rubiaceae	3VC-	TSC-V	EPBC-V
Bertya sp Cobar-Coolabah	Euphorbiaceae	2V	TSC-V	EPBC-V
Bothriochloa biloba	Poaceae	3V	TSC-V	EPBC-V
Cadellia pentastylis	Surianaceae	3RCa	TSC-V	EPBC-V
Calotis glandulosa	Asteraceae	3VC-	TSC-V	EPBC-V
Dichanthium setosum	Poaceae		TSC-V	EPBC-V
Goodenia macbarronii	Goodeniaceae	3VC-	TSC-V	EPBC-V
Homoranthus darwinioides	Myrtaceae	3VCa	TSC-V	EPBC-V
Kennedia retrorsa	Fabaceae	2VCa	TSC-V	EPBC-V
Lasiopetalum longistamineum	Sterculiaceae	2VC-	TSC-V	EPBC-V
Lepidium aschersonii	Brassicaceae	3VCa	TSC-V	EPBC-V
Ozothamnus tessellatus	Asteraceae	2VC-	TSC-V	EPBC-V
Persoonia marginata	Proteaceae	2V	TSC-V	EPBC-V
Philotheca ericifolia (Eriostemon ericifolius)	Rutaceae	3RC-	TSC-V	EPBC-V
Picris evae	Asteraceae	3V	TSC-V	EPBC-V
Prostanthera cineolifera	Lamiaceae	2K	TSC-V	EPBC-V
Prostanthera cryptandroides	Lamiaceae	2RC-t	TSC-V	EPBC-V
Prostanthera discolor	Lamiaceae	2VC-	TSC-V	EPBC-V
Pterostylis cobarensis	Orchidaceae	3V	TSC-V	EPBC-V
Rulingia procumbens	Sterculiaceae	3V	TSC-V	EPBC-V
Swainsona murrayana	Fabaceae	3VCi	TSC-V	EPBC-V
Swainsona sericea	Fabaceae		TSC-V	
Thesium australe	Santalaceae	3VCi+	TSC-V	EPBC-V

TABLE 32 RARE OR THREATENED TAXA OF THE GREATER BBS

Species	Family	ROTAP	TSC	EPBC
Acacia ausfeldii	Mimosaceae	3RCa		
Acacia dangarensis	Mimosaceae	2RC-t		
Acacia forsythii	Mimosaceae	2RC-t		
Asperula asthenes	Rubiaceae	3VC-	TSC-V	EPBC-V
Asperula charophyton	Rubiaceae	3RCa		
Asterolasia hexapetala	Rutaceae	2RC-		
Astrotricha roddii	Araliaceae	3VCa	TSC-E	EPBC-E
Bertya sp Cobar-Coolabah	Euphorbiaceae	2V	TSC-V	EPBC-V
Boronia granitica	Rutaceae	3VC-	TSC-E	EPBC-E
Boronia rubiginosa	Rutaceae	2RCa		
Bothriochloa biloba	Poaceae	3V	TSC-V	EPBC-V
Cadellia pentastylis	Surianaceae	3RCa	TSC-V	EPBC-V
Calotis glandulosa	Asteraceae	3VC-	TSC-V	EPBC-V
Cynanchum elegans	Asclepiadaceae	3Eci	TSC-E	EPBC-E
Derwentia arenaria	Scrophulariaceae	3RC-		
Digitaria porrecta	Poaceae	3E	TSC-E	EPBC-E
Discaria pubescens	Rhamnaceae	3RCa		
Diuris pedunculata	Orchidaceae	2E	TSC-E	EPBC-E
Diuris tricolor	Orchidaceae	3K		
Dodonaea macrossanii	Sapindaceae	3R		
Dodonaea rhombifolia	Sapindaceae	3RCa		
Eleocharis blakeana	Cyperaceae	3RC-		
Eriostemon myoporoides subsp. epilosus	Rutaceae	3RC-		
Eucalyptus conjuncta	Myrtaceae	2K		
Eucalyptus elliptica	Myrtaceae	3KC-		
Eucalyptus nandewarica	Myrtaceae	3RCa		
Euphrasia orthocheila	Scrophulariaceae	3RC-		
Gonocarpus longifolius	Haloragaceae	3RC-		
Goodenia macbarronii	Goodeniaceae	3VC-	TSC-V	EPBC-V
Grevillea johnsonii	Proteaceae	2RCi		
Hibbertia kaputarensis	Dilleniaceae	2RC-		
Homopholis belsonii	Poaceae	3R		EPBC-V
Homoranthus cernuus	Myrtaceae	2RCa		
Homoranthus darwinioides	Myrtaceae	3VCa	TSC-V	EPBC-V
Isotropis foliosa	Fabaceae	3KC-		
Kennedia retrorsa	Fabaceae	2VCa	TSC-V	EPBC-V
Lasiopetalum longistamineum	Sterculiaceae	2VC-	TSC-V	EPBC-V
Leionema viridiflorum (Phebalium viridiflorum)	Rutaceae	3RCa		
Lepidium aschersonii	Brassicaceae	3VCa	TSC-V	EPBC-V
Lepidium monoplocoides	Brassicaceae	3ECi	TSC-E	EPBC-E
Lomandra patens	Lomandraceae	3RCa		
Olearia gravis	Asteraceae	3KC-		
Ozothamnus adnatus	Asteraceae	3KC-		
Ozothamnus tessellatus	Asteraceae	2VC-	TSC-V	EPBC-V
Persoonia cuspidifera	Proteaceae	3K		
Persoonia marginata	Proteaceae	2V	TSC-V	EPBC-V
Persoonia terminalis subsp. recurva	Proteaceae	3R		
Phebalium obcordatum	Rutaceae	3RCa		
Philotheca ericifolia (Eriostemon ericifolius)	Rutaceae	3RC-	TSC-V	EPBC-V
Picris eichleri	Asteraceae	3KC-		
Picris evae	Asteraceae	3V	TSC-V	EPBC-V
Pimelea ciliolaris	Thymelaeaceae	2RC-		
Pomaderris pauciflora	Rhamnaceae	3RC-		
Prasophyllum campestre	Orchidaceae	3RC-		
Prostanthera cineolifera	Lamiaceae	2K	TSC-V	EPBC-V

Species	Family	ROTAP	TSC	EPBC
Prostanthera cruciflora	Lamiaceae	2RC-t		
Prostanthera cryptandroides	Lamiaceae	2RC-t	TSC-V	EPBC-V
Prostanthera discolor	Lamiaceae	2VC-	TSC-V	EPBC-V
Pseudanthus divaricatissimus	Euphorbiaceae	3RCa		
Pterostylis cobarensis	Orchidaceae	3V	TSC-V	EPBC-V
Pterostylis woollsii	Orchidaceae	3RC-		
Rulingia hermanniifolia	Sterculiaceae	3RCa		
Rulingia procumbens	Sterculiaceae	3V	TSC-V	EPBC-V
Senecio macranthus	Asteraceae	3RC-		
Swainsona murrayana	Fabaceae	3VCi	TSC-V	EPBC-V
Swainsona recta	Fabaceae	3ECi	TSC-E	EPBC-E
Thesium australe	Santalaceae	3VCi+	TSC-V	EPBC-V
Tylophora linearis	Asclepiadaceae	3E	TSC-E	EPBC-E
Zieria ingramii	Rutaceae	2V	TSC-E	EPBC-E
Zieria odorifera	Rutaceae	3RCi		

TABLE 33 RARE OR THREATENED TAXA WHOSE BIOREGIONAL STATUS IS UNCERTAIN

Taxon	Notes	EPBC	TSC	ROTAP
Acacia barringtonensis	Werrikimbe, Gibraltar Range.	3RCa		
Acacia pycnostachya	NT endemic; occurrence in Greater BBS requires confirmation; survey priority.	EPBC-V	TSC-V	2V
Atkinsonia ligustrina	Confined to a small area in the Blue Mtns			2RCa
Boronia ruppii	Restricted to the Woodsreef area		TSC-E	
Caladenia tessellata	Occurs south from Swansea	EPBC-V	TSC-V	3V
Callistemon shiressii	Gosford	3RC-		
Cryptocarya dorrigoensis	Confined to the Dorrigo Plateau.			2RCa
Diuris aequalis	Occurs from Braidwood to Kanangra and Liverpool.	EPBC-V	TSC-E	3VC-
Geijera paniculata	Only recorded for Lismore and Wardell districts.		TSC-E	
Grammitis stenophylla	North coast to South coast		TSC-E	
Grevillea longifolia	Sydney Basin (Heathcote NP)	2RC-		
Hakea pulvinifera	Endemic to Lake Keepit area	2ECi	TSC-E	EPBC-E
Indigofera efoliata	Likely extinct in NSW	2E	TSC-E	EPBC-E
Lepidium hyssopifolium	Occurrence in Greater BBS requires confirmation; survey priority.	EPBC-E	TSC-E	3ECi+
Liparis simmondsii	Doubtfully recorded from the upper Brunswick River, NSW			3KC-
Micromyrtus minutiflora	Sydney endemic, Cumberland plain	2V	TSC-V	EPBC-V
Persoonia nutans	Restricted to the Cumberland Plain	EPBC-E	TSC-E	2ECi
Phebalium glandulosum ssp. eglandulosum	Endemic to Torrington	EPBC-V	TSC-E	2VCi
Pultenaea parviflora	Restricted to the Cumberland Plain.	EPBC-V	TSC-E	2E
Pultenaea pedunculata	Restricted to the Cumberland Plain and near Merimbula.		TSC-E	
Pultenaea stuartiana	Torrington endemic	EPBC-V	TSC-V	3VC-
Sida rohlenae			TSC-E	
Westringia glabra	Wollomombi Gorge			2RC-

Figure 12: Site Locations of Significant Plant Species within the Greater BBS

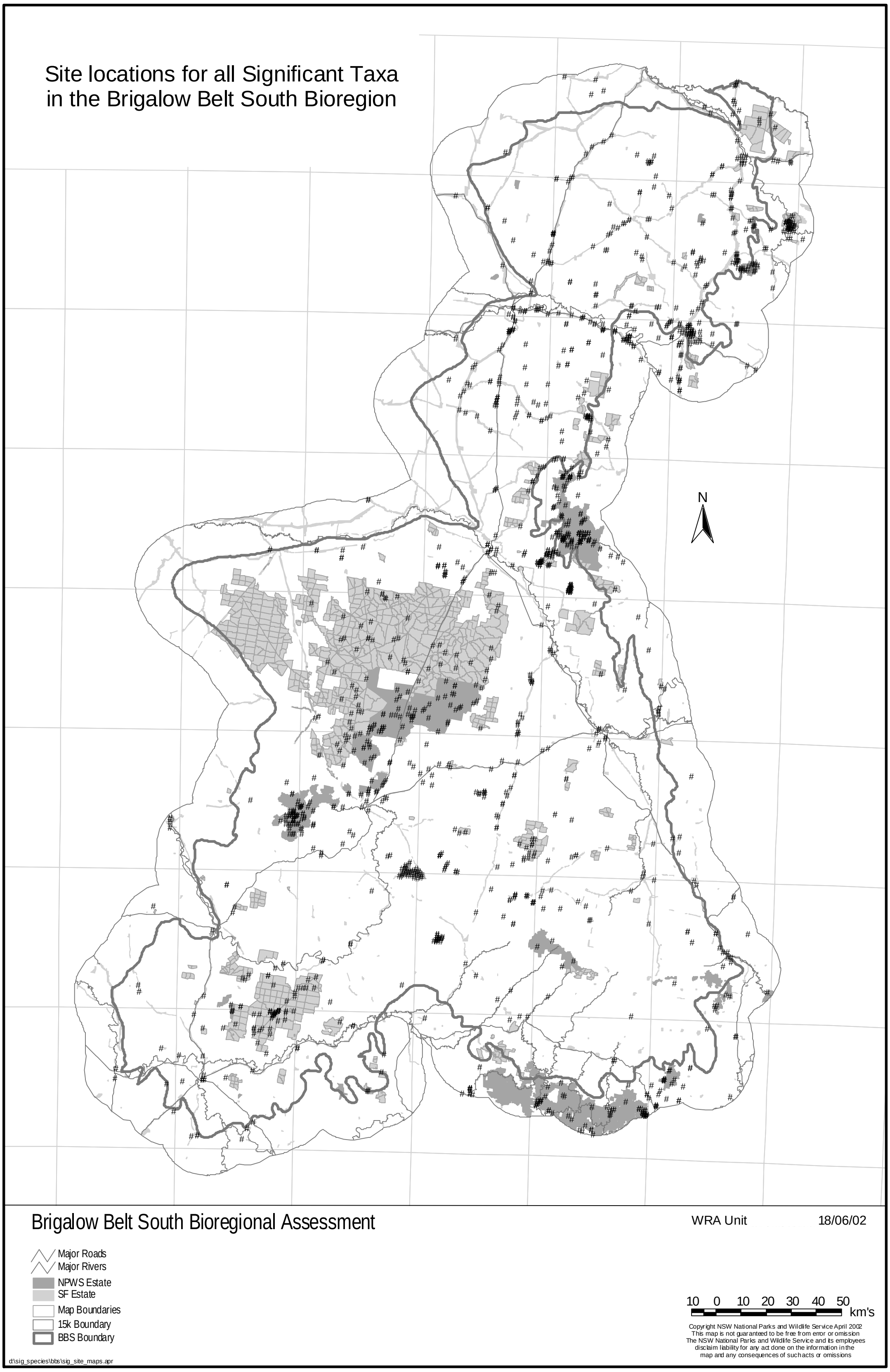
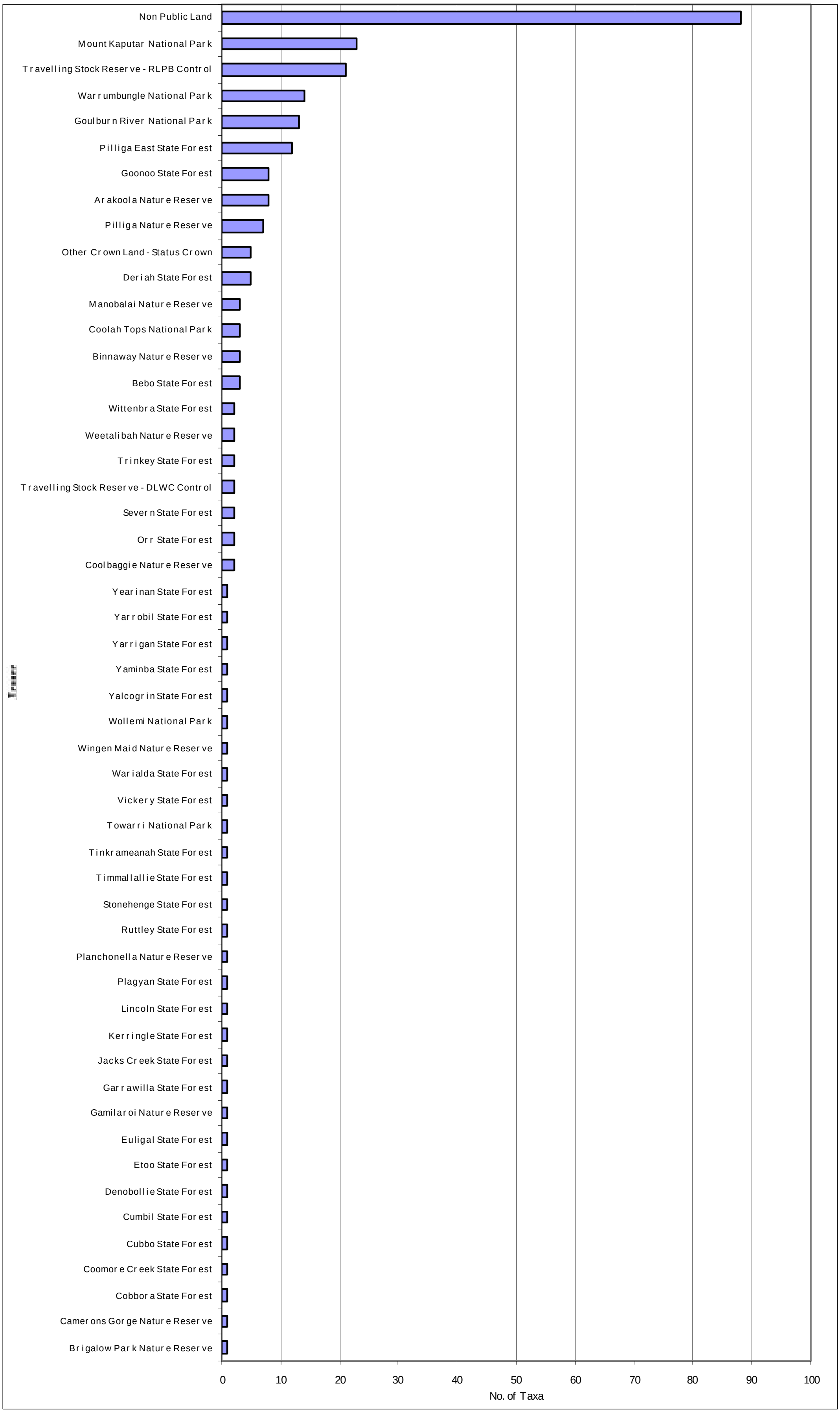


Figure 13: Concentrations of Significant Plant Species Locality Records

Figure 14: Occurrence of Rare or threatened plant species records in the BBS



2.3.4 Undescribed Taxa

Within the Greater BBS there are seven undescribed taxa recorded from systematic surveys that are likely to be threatened (Table 36). *Dianella sp. aff. Longifolia (Pilliga)* is an undescribed species from NSW and Victoria, that occurs from at least the Pilliga in the north to the Victorian Riverina (Carr unpubl. Data). Conservation status has been recorded as highly depleted and probably warranting a 'rare' status (Carr pers. com., 2002). *Dianella sp. aff. Revoluta (Pilliga)* is an undescribed species known from the Pilliga north to Yetman and Terry Hie Hie and may be a 'rare' species (Carr pers. com., 2002). *Dianella sp. aff. Tarda* is also an undescribed species known only from the Pilliga and up to around 20 km south of Baradine, considered 'rare' (Carr pers. com., 2002). *Oxalis aff. exilis* is another undescribed species related to *Oxalis exilis* that occurs withing the BBS (Carr, pers. com. 2002). *Platysace sp. aff. ericoides (Pilliga)* is an undescribed species occurring within the Pilliga (Carr pers. com., 2002). *Plectranthus sp. aff. parviflorus (Pilliga)* distribution and conservation status are unknown, but it is likely to be at least 'rare'(Carr pers. com., 2002). *Ptilotus aff. erubescens* has a distribution within the Pilliga and further south in the BBS and is likely to be 'rare' or 'endangered' (Carr pers. com., 2002).

TABLE 36 UNDESCRIBED TAXA THAT MAY BE RARE OR THREATENED WITHIN THE BBS

Taxon	Family	Author	No. of Records	BBS Province
Dianella sp. aff. Longifolia (Pilliga)	Phormiaceae	R.Br.	1	Pilliga
Dianella sp. aff. Revoluta (Pilliga)	Phormiaceae	R.Br.	45	Pilliga, Pilliga Outwash
Dianella sp. aff. tarda	Phormiaceae	P.F. Horsfall & G.W. Carr	7	Pilliga, Pilliga Outwash
Oxalis aff. exilis	Oxalidaceae	A. Cunn	1	Liverpool Range
Platysace sp. aff. ericoides (Pilliga)	Apiaceae	(Sieber ex Spreng.) Norman sens. Lat.	Opportunistic record	?Pilliga, ?Pilliga Outwash
Plectranthus sp. aff. parviflorus (Pilliga)	Lamiaceae	Forst. & Forst.	Opportunistic record	?Pilliga, ?Pilliga Outwash
Ptilotus aff. Erubescens	Amaranthaceae	R. Br.	2	Liverpool Range

2.3.5 Autecology of Significant Flora

Data Requirements

Knowledge of species autecology is important to ensure adequate species conservation. Autecology, also known as physiological ecology, is the study of organisms at the level of individuals, populations and species. At the species level, autecology specifically refers to species biology, habitat, life history, population demography, threatening processes and disturbance response. Most autecological information is derived from targeted species surveys or from expert knowledge. Such data are considered a 'minimum data set' essential for species conservation.

State of Knowledge for Significant Taxa

Existing information of species autecology was derived from expert botanical review of threatened species, ecological profiles (Porteners, in prep), and the Flora of NSW (Harden, 1990-1993). The availability of autecological data for the threatened species known to occur in the BBS is listed in Table 37. The most common autecological information for threatened species is taxonomic (94%) and habitat data (91%). Ecological profiles are available for 44% of species and 33% have population information. Recovery plans have been written for only 4% of the threatened species in the Greater BBS. Despite some level of information on most taxa, the 'minimum data set' required for effective plant species conservation in the BBS is currently unavailable.

Targeted Research

Autecological information acquired from botanical experts was used as the basis for targeted species research, which aimed to fill data gaps and critical deficiencies in existing autecological knowledge. Targeted research involved the compilation of ecological profiles for threatened species within the Greater BBS. However, due to time constraints only species listed under the *TSC Act* 1995 were reviewed.

To compile ecological profiles, apart from expert review comments, information on species autecology was obtained from various journals, unpublished NPWS reports, draft and finalised recovery plans, regional floras (eg. Flora of NSW and Flora of Australia), and electronic databases on the internet, such as the Australian Plant Name Index and Wattleweb.

A species' ecological profile provides a way of reviewing present knowledge of a species. Its primary aim is to outline a species autecology and to identify knowledge gaps, so future research can target deficient areas. The main components of an ecological profile are outlined on pages 69-71, however this level of information is not available for all the priority species targeted for research. In such situations, a more concise profile format was adopted which lists the following information: conservation status, species biology, taxonomy, distribution, and bibliographic references. Where sufficient information was available, the concise species profiles also provide information on species habitat, life history, threatening processes, critical habitat components, management recommendations and management actions. These concise profiles are subject to ongoing revision as additional information becomes available.

Format of Species Profiles

Species profiles are presented in appendix 5 in alphabetical order by genus. Common names are derived from Harden (1990-93), Cunningham *et al.* (1992) or publications listed in the reference list for the species. Autecological information is presented in each Species Profile under the following headings:

Current Conservation Status
The conservation status of each taxon is described in the national, Commonwealth, State and regional contexts:

TSC Act Status
The NSW Threatened Species Conservation Act was introduced in 1995 (and updated to 16th March 2001) to protect both flora and fauna species listed on the various schedules. Any species recognised under the Act require special management action by the National Parks and Wildlife Service. They are ranked as:

Endangered:	species that are likely to become extinct in NSW unless action is taken to stop their decline
Vulnerable:	species that are likely to become endangered in NSW unless action is taken to stop their decline
Presumed Extinct:	species not recorded in NSW for at least 50 years

EPBC Act Status
Some species also have a Commonwealth listing under the *Environment Protection and Biodiversity Conservation Act 1999* (superseding the ***Endangered Species Protection Act*** introduced in 1992). They are ranked as:

Endangered:	species that are likely to become extinct unless the circumstances and factors threatening abundance, survival or evolutionary development cease to operate
Vulnerable:	species that are likely to become endangered within the next 25 years unless the circumstances and factors threatening abundance, survival or evolutionary development cease to operate
Presumed Extinct:	species not definitely recorded in nature during the preceding 50 years

ROTAP Status
Nationally listed rare or threatened plant species as nominated by Briggs and Leigh are listed in *Rare or Threatened Australian Plants* (ROTAP) (Briggs & Leigh 1996):

Presumed Extinct:	taxon not recorded over the past 50 years, or of which all known wild populations have been destroyed more recently
Endangered:	taxon in serious risk of disappearing from the wild within 10-20 years if present land use and other threats continue to operate
Vulnerable:	taxon not presently Endangered but at risk over a longer period (20-50 years) of disappearing from the wild through continued depletion
Rare:	taxon rare in Australia but with no current identifiable threat
Poorly Known:	axon that is suspected to belong to one of the above categories but is not definitely known based on present information

Western Division of NSW Status

Regional ratings are provided in *Vascular plants with restricted distributions in the Western Division of New South Wales* (Pressey, Cohn & Porter 1990). Codes describe the distribution and protection priorities of the species:

Category 1: occurring only in the Western Division (as defined in the above publications) with a restricted distribution

Category 2: occurring only in New South Wales with a restricted distribution within and outside the Western Division

Category 3: restricted distribution in the Western Division and also occurring interstate with a small to wide range and few to many records

Category 4: disjunct occurrences in the Western Division with main population elsewhere in New South Wales or interstate

Species Biology

This is a general description of the plant including habit and growth form, size and morphology of leaves, inflorescences, flowers and fruit, and unusual or distinguishing characteristics. The diagnostic features of the taxon are also listed where appropriate.

Taxonomy

The current taxonomy and taxonomic history of the species is summarised with chronological citation of the authors of the original descriptions and more recent treatments. Type specimens are also listed and taxonomic relationships discussed between species (including associated species and affinities) and within species if applicable (subspecies, varieties and other infraspecific groupings). Synonymous or previously misapplied names are listed and the derivations of the specific epithets are explained. The *Australian Plant Name Index* was consulted for taxonomic history (Chapman 1991).

Distribution

Current distribution of the taxon within New South Wales and interstate is given. NSW distribution is indicated by occurrence within the botanical subdivisions used in the *Flora of NSW* (Harden 1990-93, 2001-2002). Subdivisions or States into which the species is believed to have been introduced are indicated by an asterisk. The localities of original collections are noted and the sources of any distribution maps referenced.

Habitat

The preferred habitat of the taxon is described with detailed information on landforms, geology, soil preferences, nutrient requirements, vegetation community associations and associated or indicator plant species.

Life History

The plant life-cycle, phenology, seed biology, ecology, disturbance regimes and population structure are summarised from both the published literature and herbarium record notes.

Threatening Processes

The processes currently impacting on populations of the plants under investigation are summarised. Threatening processes affecting both the habitat and individual plants include the land use practices of grazing, clearing, burning, irrigation, forestry activity and agricultural development. Grazing by feral animals, introduced stock and often native herbivores, and the impacts of rabbit populations, are ubiquitous and major threats. Poor or absent seed regeneration, a lack of seedling recruitment in populations, insect predation, dieback, inappropriate fire regimes and clearing are further processes impacting on vulnerable species, resulting in the decline or demise of populations.

Critical Habitat Components
Knowledge of the particular habitat requirements of the species is crucial for the future management of populations. These critical habitat components are summarised and discussed if sufficient information is available.

Previous Management Recommendations
A listing of all previous management recommendations for the species is supplied. These include research strategies such as floristic survey, population mapping and ecological monitoring. Trials to test the effects of fire on plant species and vegetation are often recommended, with the establishment of permanent experimental plots for burning, seedling regeneration and seasonal monitoring. Protective management measures such as fencing of populations and caging of plants are also appropriate in many cases.

Previous or Current Conservation Management Actions
This heading includes any management actions and regimes that have been previously trialed or are currently being implemented for the conservation of the species. The existence of any species recovery or management plans is noted. The conservation reserves in which populations are known to occur are listed and the reserved population sizes estimated.

References
Direct references are cited in the accepted scientific manner at the end of each Species Profile. References identified but which have not been referred to in the text are also presented and marked with an asterisk. All cited and non-cited references are summarised in a Bibliography at the back of the report.

Table 37: Availability of Autecological Data for Priority Species

Species	Taxonomic	Distribution	Population	Habitat	Life History	Disturbance response	Threatening Processes	Land Tenure	Species Profile	Recovery Plan	Predictive Model
Acacia ausfeldii	✓	✓		✓				SF, NP,PL			
Acacia barringtonensis	✓	✓		✓				NP			
Acacia dangarensis	✓	✓		✓				NP			
Acacia forsythii	✓	✓		✓				CR, CL, PL			
Acacia jucunda	✓	✓	S	✓	DK	?	A	SF, PL	✓		
Acacia pycnostachya	✓	?		✓	LK	?	A	PL	✓		
Amphibromus whitei	✓	?		?				CR			
Asperula asthenes	✓	✓	?	✓	LK	?	?	PL	✓		
Asperula charophyton	✓	✓		✓				PL			
Asterolasia hexapetala	✓	✓		✓				NP,PL			
Astrotricha roddii	✓	✓	S	✓	LK	?	A	CL, CR, SF	✓		GAM
Atkinsonia ligustrina	✓	?		✓				PL			
Bertya sp Cobar-Coolabah	✓	✓	S, C, M	✓	DK	✓	A,B	SF,	✓	✓	
Boronia granitica	✓	✓	C	✓	LK	?	A,B	PL	✓	✓	
Boronia rubiginosa	✓	✓		✓				PL, NR, NP			
Boronia ruppii	✓	✓	?	✓	LK	?	?	CR	✓		
Bothriochloa biloba	✓	✓	S	✓	LK	✓	A,B	TSR, PL, CL, SF, NR,	✓		GAM
Cadellia pentastylis	✓	✓	S, C, M	✓	DK	✓	A,B	TSR, PL, CR, SF, CL	✓		GLM
Caladenia tessellata	✓	?	?	✓	?	?	?	PL	-		
Callistemon shiressii	✓	✓		✓				NP			
Calotis glandulosa	✓	✓	S, C	✓	LK	✓	A	TSR, PL	✓		
Capparis loranthifolia var. loranthifolia	✓	✓		✓				PL			
Cryptocarya dorrigoensis	✓	?		✓				NP			
Cynanchum elegans	✓	✓	C, S	✓				PL, NP			
Cyperus conicus	✓	✓	?	✓	LK	✓	A	TSR, PL,	✓		
Derwentia arenaria	✓	✓	C	✓				PL, NP			GAM
Desmodium campylocaulon	✓	✓	D,C, M,S	✓	DK	✓	A,B	TSR, PP, NR, CL	✓		GAM
Dianella sp. aff. Longifolia (Pilliga)	?	?	?	?	?	?	?	TSR			
Dianella sp. aff. Revoluta (Pilliga)	?	✓	?	?	?	?	?	NR, SF			
Dianella sp. aff. tarda	?	✓	?	?	?	?	?	SF, NR			
Dichanthium setosum	✓	✓	S	✓	LK	✓	A	PL, TSR, CL, CR, NR	✓		
Digitaria porrecta	✓	✓	C,S	✓	DK	✓	A,B	PL, CL, TSR, CR	✓		GAM
Discaria pubescens	✓	✓	C	✓	DK	?	A	PL,CR, NP,		✓	

Species	Taxonomic	Distribution	Population	Habitat	Life History	Disturbance response	Threatening Processes	Land Tenure	Species Profile	Recovery Plan	Predictive Model
								TSR			
Diuris aequalis	✓	?	?	✓	?	?	?	NP	-		
Diuris pedunculata	✓	✓	C	✓	LK	?	A,B	PL	✓		
Diuris tricolor	✓	✓	C,S	✓	DK	?	A	PL, TSR, SF	✓		
Dodonaea macrossanii	✓	✓		✓				TSR, CR, PL, SF,			
Dodonaea rhombifolia	✓	✓		✓				NP,			
Eleocharis blakeana	✓	✓		✓				PL, TSR			
Eucalyptus conjuncta	✓	✓		✓				PL, CR			
Eucalyptus elliptica	✓	✓		✓				PL, NP			
Eucalyptus nandewarica	✓	✓		✓				PL, NP			GAM
Euphrasia orthocheila	✓	✓		✓				NP			
Geijera paniculata	✓	✓		✓				SF,			
Gonocarpus longifolius	✓	✓		✓				PL, NR, NP			
Goodenia macbarronii	✓	✓	S	✓	DK	✓	A	NP, TSR, SF, PL, NR			GAM
Grammitis stenophylla	✓	✓	?	✓	?	?	?	NP	✓		
Grevillea johnsonii	✓	✓		✓				NP, PL,			
Grevillea longifolia	✓	✓		✓				TSR			
Hakea pulvinifera	✓	✓	C,D,S	✓	DK	✓	A,B	CR, PL	✓	✓	
Haloragis stricta	✓	?		✓				PL			
Hibbertia kaputarensis	✓	✓		✓				PL, NP, CL			GLM
Homopholis belsonii	✓	✓		✓				SF, PL, CL, TSR, NR			GAM
Homoranthus cernuus	✓	✓	?	✓	LK	?	?	NP	-		
Homoranthus darwinioides	✓	✓	S	✓	LK	?	A	SF, PL, NP,	✓		GAM
Indigofera efoliata	✓	✓	?	✓	LK	?	A,B	PL, CL,	✓		
Isotropis foliosa	✓	✓		✓				CL			
Kennedia retrorsa	✓	✓	?	✓	LK	?	A	NP	✓		
Lasiopetalum longistamineum	✓	✓	?	✓	LK	?	?	NP	✓		
Lepidium aschersonii	✓	✓	C,S	✓	DK	✓	A,B	CL, PL, CR	✓		
Lepidium hyssopifolium	✓	?	D,C,S	✓	DK	✓	A,B	NR	✓		
Lepidium monoplocoides	✓	✓	C,S	✓	DK	✓	A,B	PL, SF, TSR	✓		
Liparis simmondsii	✓	?		✓				PL			
Lomandra patens	✓	✓		✓				NR			
Macrozamia pauli-guilielmi	✓	✓		✓				PL, NP, TSR			
Micromyrtus minutiflora	✓	✓	?	✓	LK	?	A	PL	✓		
Monotaxis macrophylla	✓	✓	S	✓	DK	✓	A	SF	✓		
Olearia gravis	✓	✓		✓				CL, CR, SF			GAM
Oxalis aff. Exilis	?	?	?	?				TSR			
Ozothamnus adnatus	✓	✓	S,C,D	✓				PL,			

Species	Taxonomic	Distribution	Population	Habitat	Life History	Disturbance response	Threatening Processes	Land Tenure	Species Profile	Recovery Plan	Predictive Model
								NR, NP			
Ozothamnus tessellatus	✓	✓	?	✓	LK	?	A	NP, PL	✓		
Persoonia cuspidifera	✓	✓		✓	LK			CL, SF, NR, PL, CR, NP, TSR			GAM
Persoonia marginata	✓	✓	?	✓	LK	?	?	NP	✓		
Persoonia nutans	✓	?	C	✓	LK	?	A,B	PL	✓		
Persoonia terminalis subsp. recurva	✓	✓		✓				PL, CR, CL, TSR, SF, NR			GLM
Phebalium glandulosum subsp. Eglandulosum	✓	?	?	✓	LK	?	?	PL	✓		
Phebalium obcordatum	✓	✓		✓				NR, PL			
Phebalium viridiflorum	✓	✓		✓				NP, PL, CL			
Philotheca ericifolia	✓	✓	D,C,S, M	✓	DK	✓	A	NR, PL, SF,	✓		GLM
Philotheca myoporoides ssp. epilosa (Eriostemon myoporoides ssp. epilosus)	✓	✓		✓				PL			
Phyllanthus maderaspatanus	✓	✓	S	✓	LK	✓	A	PL, TSR,	✓		
Picris eichleri	?	?		?				NP			
Picris evae	✓	✓	S	✓	DK	?	A	?	✓		
Pimelea ciliolaris	✓	✓						PL			
Platysace sp. Aff. ericoides (Pilliga)	?	?	?	?	?	?	?	?			
Platyzoma microphyllum	✓	✓	S	✓	DK	✓	A	SF	✓		
Plectranthus sp. aff. Parviflorus (Pilliga)	?	?	?	?	?	?	?	?			
Polygala linariifolia	✓	✓	S	✓	LK	?	A	TSR, CL, CR, PL, SF	✓		GAM
Pomaderris pauciflora	✓	✓		✓				PL			
Pomaderris queenslandica	✓	✓	S	✓	LK	?	A	PL, NP, NR, SF	✓		
Prasophyllum campestre	✓	✓		✓				PL			
Prostanthera cineolifera	✓	✓	?	✓	LK	?	?	PL	✓		
Prostanthera cruciflora	✓	✓		✓				PL, SF, NP, CL			
Prostanthera cryptandroides	✓	✓	?	✓	LK	?	?	PL	✓		
Prostanthera discolor	✓	✓	?	✓	LK	?	?	PL	✓		
Pseudanthus divaricatissimus	✓	✓		✓				CR, PL, SF			
Pterostylis cobarensis	✓	✓	S	✓	DK	?	A	NP, PL	✓		
Pterostylis woollsii	✓	✓		✓				NR			
Ptilotus aff. Erubescens	?	?	?	?	?	?	?	TSR			
Pultenaea parviflora	✓	?	?	✓	?	?	A	PL	✓		
Pultenaea pedunculata	✓	?	?	✓	LK	?	?	PL	✓		
Pultenaea stuartiana	✓	?		✓				PL			
Rulingia hermanniifolia	✓	✓		✓				NP			

Species	Taxonomic	Distribution	Population	Habitat	Life History	Disturbance response	Threatening Processes	Land Tenure	Species Profile	Recovery Plan	Predictive Model
Rulingia procumbens	✓	✓	D,C,S	✓	DK	✓	A,B	SF, PL, CR, NR, NP	✓		GAM
Senecio macranthus	✓	✓		✓				NP			
Sida rohlenae	✓	✓	S	✓	LK	?	A	PL	✓		
Swainsona murrayana	✓	✓	S	✓	DK	✓	A,B	TSR, PL, NR, CR	✓		
Swainsona recta	✓	✓	C	✓	DK	✓	A,B	PL, CR	✓		
Swainsona sericea	✓	✓		✓				CL, PL			
Thesium australe	✓	✓	C,S	✓	DK	✓	A,B	PL, TSR, CL, CR, NR	✓		
Tylophora linearis	✓	✓	S	✓	LK	?	A	SF, TSR	✓		
Westringia glabra	✓	?		✓				PL			
Zieria ingramii	✓	✓	S,C,D	✓	DK	✓	A,B	SF, CR	✓		GLM
Zieria odorifera	✓	✓		✓				CL, PL, NP			

2.4 TARGETED FLORA SURVEYS

2.4.1 Overview

A key objective of the Targeted Flora Survey and Mapping Project was to undertake targeted flora surveys of rare or threatened plant species throughout the BBS. The following methods were used to meet this objective:

(1) develop and apply decision rules to select priority species
(2) develop an appropriate survey methodology to record target species distribution, abundance and habitat
(3) validate as many existing locality records as practical
(4) search for new populations of rare or threatened flora species
(5) make recommendations for the conservation of each species or community
(6) identify the needs for any further flora surveys within the BBS.

2.4.2 Survey Methods

Develop a Rule Set to Prioritise Surveys

Due to the large number of locality records for significant plant taxa in the BBS (931 locality records), a rule set was developed to prioritise survey efforts. This rule set focussed on issues of flowering time, age and reliability of the records, access constraints and efficiency of survey efforts. The resulting list would consist of species that were most likely to be to be encountered during the field surveys.

- Prioritise species listed on the TSC Act and secondly, species listed on the EPBC Act and ROTAP species.
- Prioritise sites that can be readily accessed (eg. National Parks, State Forests, Nature Reserves, Travelling Stock Routes etc.).
- Prioritise species with <10 validated records to assist modelling efforts.
- Quarantine species records that have unreliable locality information, including records that have locality coordinates rounded off and records older than 10 years (these records were subject to expert review).
- Prioritise species likley to be in flower during the survey period.

After applying this rule set, the number of records was reduced to 205, comprising a total of 29 species (Table 38).

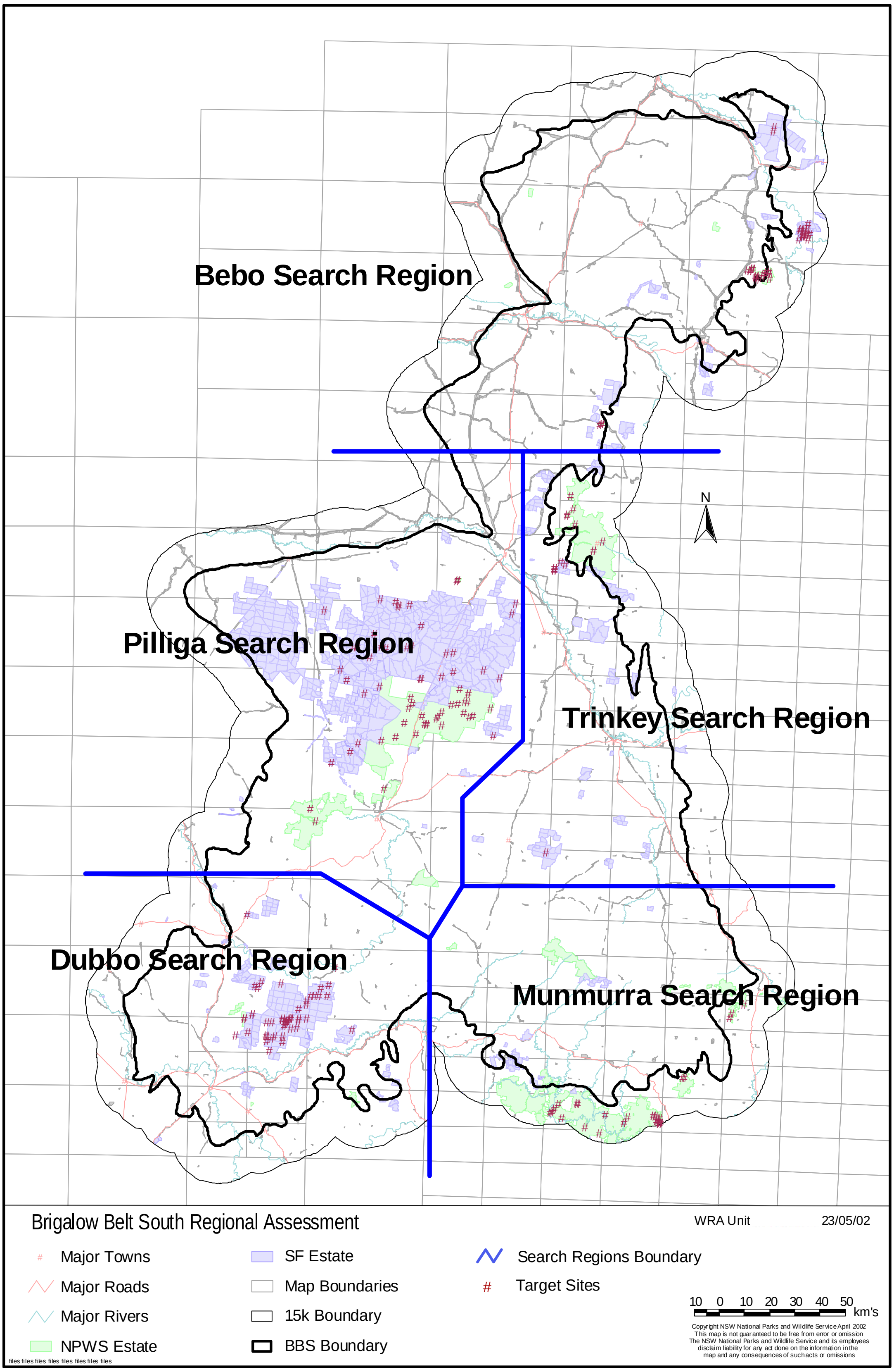
TABLE 38: PRIORITY SPECIES FOR TARGETED SURVEYS

Species	EPBC *	TSC *	ROTAP *	Existing Records
Acacia jucunda		E1		1
Astrotricha roddii	E	E1	3VCa	17
Bertya opponens		V	2V	1
Bothriochloa biloba	V	V	3V	4
Cadellia pentastylis	V	V	3RCa	11
Cyperus conicus		E1		1
Dichanthium setosum	V	V		2
Goodenia macbarronii	V	V	3VC-	38
Homoranthus darwinioides	V	V	3VCa	15
Kennedia retrorsa	V	V	2VCa	6
Lasiopetalum longista	V	V	2VC-	4
Lepidium aschersonii	V	V	3VCa	2
Lepidium monoplocoides	E	E1	3ECi	2
Monotaxis macrophylla		E1		1
Ozothamnus tessellatus		V		5
Persoonia marginata	V	V	2V	2
Philotheca ericifolia		V	3RC-	23
Platyzoma microphyllum		E1		1
Polygala linariifolia		E1		5
Pomaderris queenslandica		E1		9
Pterostylis cobarensi	V	V	3V	1
Rulingia procumbens	V	V	3V	32
Swainsona murrayana	V	V	3VCi	1
Thesium australe	V	V	3VCi+	3
Tylophora linearis	E	E1	3E	1
Zieria ingramii	E	E1	2V	13
Total				201

Identify Search Regions

To identify areas for survey, maps were produced showing priority species localities, tenure, roads, rivers and woody vegetation. These survey maps were used to delineate search regions in order to maximise survey efficiency so that individual survey trips incorporated as many sites as possible that were within close proximity to each other. The distribution of priority species records allowed the division of the bioregion into five search regions, namely Bebo, Pilliga, Dubbo Munmurra and Trinkey (Figure 15).

Figure 15: Target Search Regions and Sites for Priority Taxa



Field Survey Guidelines

Sites for priority species were surveyed in order to determine if the species was persisting at the site (ie. validation) and to record population and autecological data. Site validation also provided the opportunity to develop an 'intuitive' model of the potential habitat for the priority species to aid additional opportunistic searches in the BBS (Sheringham and Westaway, 1997; Elith *et al.* 1998).

Where possible, voucher specimens were collected for identification purposes and subsequently lodged with the National Herbarium of New South Wales at the Royal Botanic Gardens (Sydney). Some specimens have also been lodged with the NPWS Western Directorate Herbarium (Dubbo). After assigning field identifications for the targeted species, a population assessment was conducted. Species identifications were later validated and confirmed by NPWS and State Forests botanists. Along with population mapping, information was also collected on the species autecology, including:

- demographic counts examining the age structure of each population (eg. percentage of seedlings, immature, mature and senescent individuals)
- reproductive status (eg. the percentage of individuals that are vegetative, in bud, flower, fresh fruit and old fruit)
- associated dominant species and habitat structure information
- information on threat types, fire response and population health.
- The proforma used to assess rare and threatened populations is provided in Appendix 6.

Validation of Existing Site Records

Targeted survey fieldwork began in February 2002 and lasted approximately 12 weeks, followed by data collation, analysis, and map production. The time available for field work limited the number of species with sufficient reproductive material to allow positive botanical identification.

Prior to survey work, AMG coordinates for priority species localities were entered into a handheld Global Positioning System (GPS). The GPS was then used to locate the recorded target species localities in the field. Once at a site, flagging tape was used to mark the centre of the site. Searches for priority species were conducted from this point using two methods, namely, a parallel line search followed by a timed search of the species preferred habitat. Available biological and ecological information was used to narrow down the search area, thereby focussing field time to search areas in which the target species is most likely to occur.

Parallel and Timed Searches for Priority Species

Parallel line searches were conducted to locate existing or modelled populations. The configuration of parallel lines was based on the accuracy rating for individual targeted species locations. These configurations were:

- Two 100m lines 20m apart for species with accuracy of 10m or less,
- Two 200m lines 50m apart for species with accuracy of 100m or less,
- Two 1km lines 250m apart for species with accuracy of 1km or less.

If the parallel line search was unsuccessful, a timed wandering search of preferred habitat was conducted. Search times include stops to take specimens and confirm identifications. Search times were:

- 15 minutes for species with accuracy of 10m or less,
- 30 minutes for species with accuracy of 100m or less,
- 40 minutes for species with accuracy of 1km or less.

If the target species was present, the populations were mapped, counted (see below) and autecological data collected (Appendix 6). Opportunistic records were also assessed where they occurred while travelling to, from and around the target sites.

Opportunistic Searches

Opportunistic searches were conducted in vegetation communities and landscapes where a target species had the potential to occur. These sites where chosen on an opportunistic basis while traversing the bioregion, and were based on known autecological information and intuitive models developed from visiting existing rare and threatened plant localities. Opportunistic searches were largely located along minor forest roads and tracks.

Population Mapping

Where the population perimeter was easily defined the population was drawn onto the appropriate 1:25 000 or 1:50 000 topographic mapsheet for digitising into a Geographical Information system (GIS). Points for use in refining boundaries were gathered by traversing the population perimeter and periodically entering AMG coordinates into a handheld GPS unit as way-points. Where preliminary observations indicated populations were less than one kilometre in diameter, or where time constraints allowed, a different technique was used in which the boundaries of the populations were traversed with a GPS to collect 'track' data of the perimeter. The output from this technique was a shapefile of the population, which provided a more precise boundary and eliminated the need for digitising. It could not be used in all cases due to the field time required to track boundaries of larger populations.

The GPS track data and for each targeted species was downloaded into ArcView © (Version 3.1) and then combined with boundaries which were estimated from way points and topographic maps. This information was subsequently used to produce distribution maps for species' populations**.**

Population Counts

After the extent of the population had been determined, the number of adults, juveniles and seedlings was assessed and the level and possible cause of any damage to individuals noted. In the case of large or widespread populations where counting of individuals was impractical, an estimate of the population count was conducted by counting the individuals in defined quadrats and extrapolating those values across the entire population (Cropper 1993). A minimum of three quadrats was used for these estimates. Quadrat size varied with the growth form of the study species; 1 x 2 m quadrats were used for ground layer species; 5 x 10 m quadrats for shrub species; and 20 x 50 m quadrats for tree species. If individual plants were not easily distinguishable, the above ground clumps or stems were counted as a representation of population size.

2.4.3 Results of Targeted Surveys

Targeted field surveys for rare or threatened plant species were carried out over a period of 49 days, covering a distance of 9 660 km throughout the BBS. A total of 182 targeted searches were conducted, including 44 existing rare or threatened plant localities as well as 138 opportunistic searches (Figure 16). A summary of the data collected for each of these species is listed is Table 39. A detailed map of each of the validated species locations is provided in the results of targeted rare plant surveys (Appendix 6).

Validation of Existing Records

Field surveys validated five locality records of *Cadellia pentastylis*, two records of *Philotheca ericifolia*, two records of *Bertya opponens,* and one record of *Rulingia procumbens*. One locality record for a non-target species, *Persoonia cuspedifera* (ROTAP), was validated in Trinkey State Forest.

There are numerous possible reasons why the remaining 32 records could not be relocated. These include season of survey, lack of necessary botanical material for identification, inaccurate locality data, vegetation change and presence of the target species in the form of seed rather than above ground vegetative material. In summary, target surveys can readily confirm the presence of a species at a specific site, but not its absence. Results of targeted searches of existing records are detailed in Table 40, which also summarises the likely reasons why records could not be relocated.

Opportunistic Searches

Opportunistic searches resulted in 7 new priority species locations in the BBS, including 3 new populations of *Cadellia pentastylis* in Deriah State Forest, 1 new record of *Philotheca ericifolia* in Lincoln State Forest, and 2 new records of *Persoonia cuspedifera* in the Pilliga Nature Reserve (Table 41, Figure 17). The fact that 7 records were found in 138 searches reflects, to some extent, the sparsity with which many rare species are distributed within what can be readily identifiable as their likely habitat. The factors listed above, which affect success in validation of existing records, apply equally to searches for new populations.

Population Mapping and Counts

Populations were mapped and counted for *Philotheca ericifolia*, *Cadellia pentastylis*, and *Bertya opponens*. Due to time constraints, not all populations were mapped. Nonetheless, targeted survey and mapping resulted in a total of 5 population maps for priority taxa: 1 population of *C. pentastylis* in Deriah State Forest; 2 populations of *P. ericifolia* in Lincoln State Forest; and 2 populations of *B. opponens* in Jacks Creek State Forest (Appendix 6).

2.4.4 Field Survey Limitations and Constraints

Major constraints were imposed on the survey effort for targeted flora surveys by the limited funding and time available and the vast distances to be travelled in reaching target survey sites. In addition, the season in which surveys were conducted, exacerbated by low rainfall, meant that botanical material with which to confirm identifications was often poor. Consequently, future additional surveys are required to adequately assess the threatened flora of the BBS. In planning such searches, the following points should be considered:

- Additional target surveys should be undertaken for all significant taxa throughout different seasons, but in particular, during Spring, in order to obtain an adequate dataset and ensure sufficient botanical material for accurate identifications
- Additional surveys should be undertaken across all tenures and an appropriate landholder liaison strategy implemented prior to the survey effort
- The liaison strategy should be adequately resourced to incorporate a comprehensive consultative process whereby local experts can contribute critical data on priority species locations.

TABLE 39: BBS SUMMARY OF DATA OBTAINED FOR VALIDATED PRIORITY RECORDS, NEW RECORDS AND SPECIES OF NOTE

Species	Conservation Status			Populations	Data collected		
	EPBC	TSC	ROTAP		Count	Mapped	Autoecology
Philotheca ericifolia	V	V	3RC	2 existing, 1 new	1	1	1
Cadellia pentastylis	V	V	3RCa	5 existing, 3 new	1	1	1
Bertya opponens	V	V	2V	2 existing	1	2	1
Rulingia procumbens	V	V	3V	1 existing	—	1	—
Persoonia cuspedifera	—	—	3K	1 existing, 2 new	—	—	—

* AMG coordinates were obtained for each site using a handheld Global Positioning System.

Figure 16: Survey Site Locations

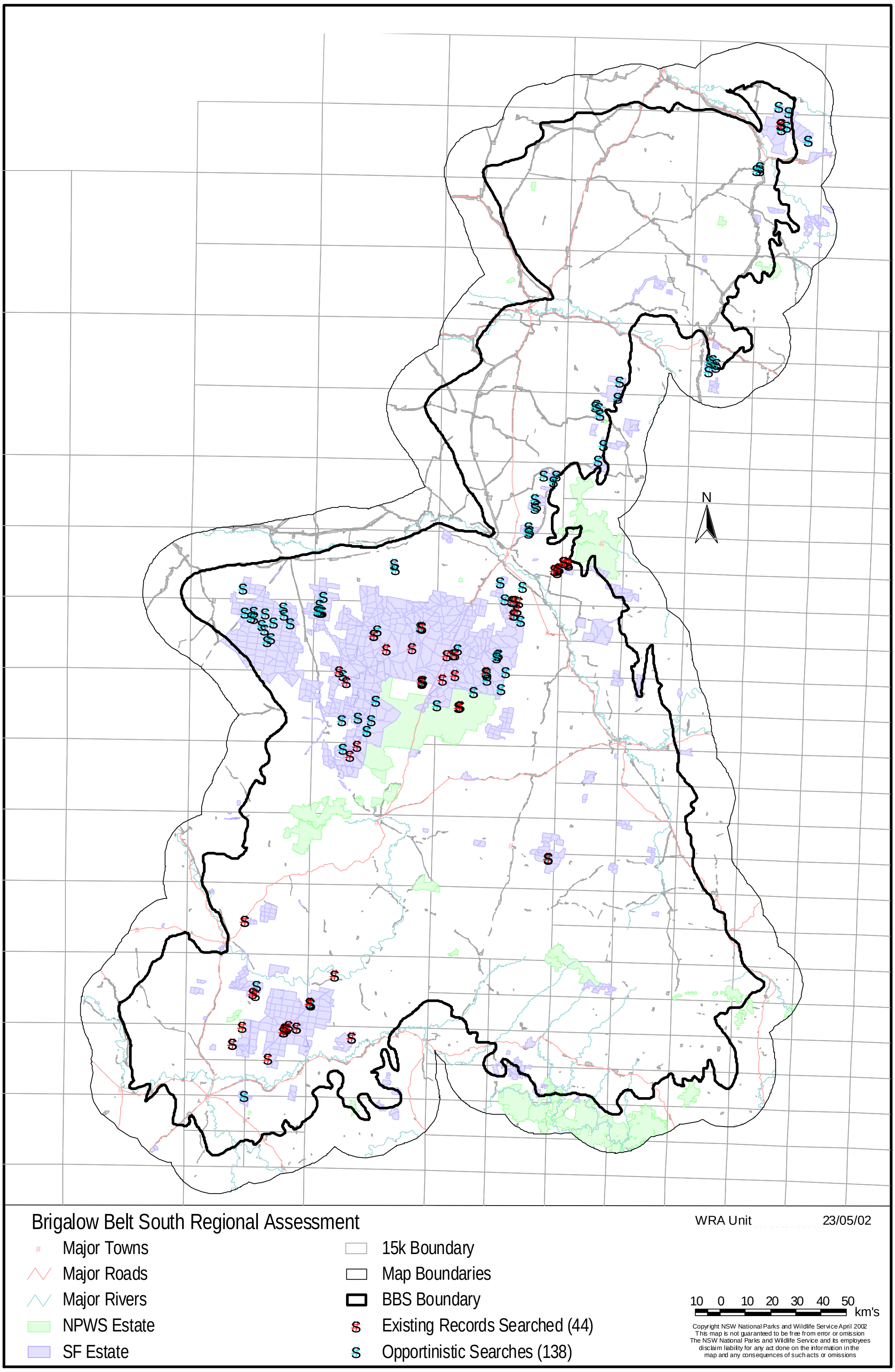


TABLE 40: RESULTS OF TARGETED SURVEYS FOR EXISTING SITES

Site_code	Target Species	Status	Location	Outcome / Notes
BOP1	*Bertya opponens*	Located	Jacks Creek SF	Population counted, mapped and habitat information recorded (Appendix 6)
BOP2	*Bertya opponens*	Not located	Pilliga East SF	
CPE23	*Cadellia pentastylis*	Located	Deriah SF	Population located and record validated.
CPE27	*Cadellia pentastylis*	Located	Deriah SF	Population located and record validated.
CPE28	*Cadellia pentastylis*	Located	Deriah SF	Population located and record validated.
CPE28	*Cadellia pentastylis*	Located	Deriah SF	Population counted, mapped and habitat information recorded (Appendix 6)
CPE29	*Cadellia pentastylis*	Located	Deriah SF	Population located and record validated.
EER12	*Philotheca ericifolia*	Not located	Pilliga East SF	Possible misidentification of *P. ericifolia* as *Pholtheca salsolifolia* and *Philotheca cilliata* have been confirmed at this site.
EER16	*Philotheca ericifolia*	Not located	Pilliga East SF	Possible misidentification. *Pholtheca salsolifolia* and *Philotheca cilliata* have been confirmed at this site.
EER21	*Philotheca ericifolia*	Not located	Goonoo SF	
EER22	*Philotheca ericifolia*	Not located	Goonoo SF	
EER23	*Philotheca ericifolia*	Located	Lincoln SF	Population counted, mapped and habitat information recorded (Appendix 6)
EER27	*Philotheca ericifolia*	Not located	Goonoo SF	Possible misidentification. *Pholtheca salsolifolia* was confirmed at this site.
GMA14	*Goodenia macbarronii*	Not located	Cobbora SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.
GMA17	*Goodenia macbarronii*	Not located	Pilliga East SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.
GMA18	*Goodenia macbarronii*	Not located	Pilliga East SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.
GMA19	*Goodenia macbarronii*	Not located	Cumbil SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.
GMA2	*Goodenia macbarronii*	Not located	Pilliga East SF	Annual flowering herb. Prefers spring to early Autumn, therefore may may have been dormant during survey period.
GMA21	*Goodenia macbarronii*	Not located	Wittenbra SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.
GMA22	*Goodenia macbarronii*	Not located	Wittenbra SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.

Site_code	Species	Status	Location	Outcome / Notes
GMA41	*Goodenia macbarronii*	Not located	Goonoo SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.
GMA9	*Goodenia macbarronii*	Not located	Pilliga East SF	Annual flowering herb. Prefers spring to early Autumn, therefore may have been dormant during survey period.
HDA11	*Homoranthus darwinioides*	Not located	Goonoo SF	
HDA14	*Homoranthus darwinioides*	Not located	Goonoo SF	
IEF5	*Indigofera efoliata*	Not located	Goonoo SF	
PLI2	*Polygala linariifolia*	Not located	Pilliga East SF	
PLI3	*Polygala linariifolia*	Not located	Pilliga East SF	
PLI4	*Polygala linariifolia*	Not located	Coomore Creek SF	
PLI5	*Polygala linariifolia*	Not located	Pilliga East SF	
RPR16	*Rulingia procumbens*	Not located	Pilliga East SF	
RPR34	*Rulingia procumbens*	Not located	Trinkey SF	Site recently burnt.
RPR35	*Rulingia procumbens*	Not located	Pilliga East SF	
RPR7	*Rulingia procumbens*	Not located	Goonoo SF	
TLI1	*Tylophora linearis*	Not located	Commons	
ZIN1	*Zieria ingramii*	Not located	Goonoo SF	
ZIN7	*Zieria ingramii*	Not located	Goonoo SF	
ZIN8	*Zieria ingramii*	Not located	Goonoo SF	
EER30	*Philotheca ericifolia*	Present	Lincoln SF	Population mapped
RPR18	*Rulingia procumbens*	Not located	Yalcogrin SF	Possibly misidentified, the similar species *Melhania oblongifolia* was located near the site.
CPE10	*Cadellia pentastylis*	Not located	Deriah SF	The species is present within a few hundred metres of this location. Possibly inaccurate AMG coordinates.
AJU1	*Acacia jucunda*	Not located	Bebo SF	Site recently burnt.
RPR29	*Rulingia procumbens*	Located	Pilliga Nature Reserve	Population located and record validated.
RPR29	*Rulingia procumbens*	Located	Pilliga Nature Reserve	Population located and record validated.

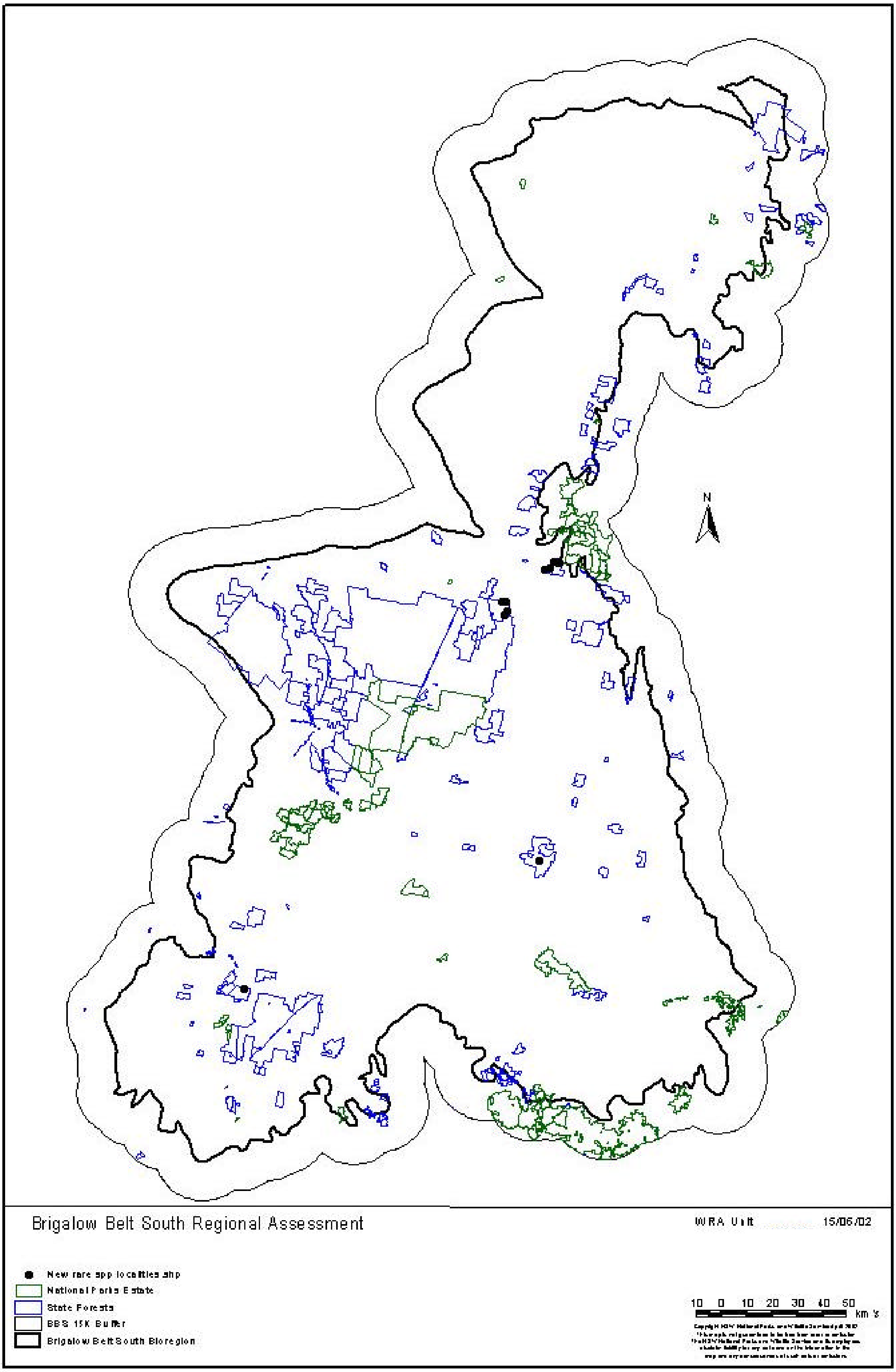
TABLE 41: RESULTS OF OPPORTUNISTIC SITES

Site ID	Result	Target Species	Type of Survey	Location
CPE004	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
CPE005	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
CPE006	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
CPE007	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
OB49	Not found	Various in region	Search area	Warialda State Forest
OB20	Not found	Acacia jacunda	Search area	Bebo State Forest
OB23	Not found	Acacia jacunda	Search area	Bebo State Forest
ST12	Not found	Various in region	Search and structure	Deriah State Forest
ST16	Not found	Various in region	Search and structure	Bebo State Forest
ST17	Not found	Various in region	Search and structure	Bebo State Forest
ST18	Not found	Various in region	Search and structure	Bebo State Forest
ST19	Not found	Various in region	Search and structure	Bebo State Forest
ST21	Not found	Various in region	Search and structure	Yetman State Forest
ST20	Not found	Various in region	Search and structure	Yetman State Forest
ST22	Not found	Various in region	Search and structure	Yetman State Forest
ST23	Not found	Various in region	Search and structure	Warialda State Forest
ST24	Not found	Various in region	Search and structure	Warialda State Forest
ST25	Not found	Various in region	Search and structure	Warialda State Forest
ST26	Not found	Various in region	Search and structure	Warialda State Forest
ST27	Not found	Various in region	Search and structure	Terry Hie Hie State Forest
ST28	Not found	Various in region	Search and structure	Terry Hie Hie State Forest
ST29	Not found	Various in region	Search and structure	Mission State Forest
ST30	Not found	Various in region	Search and structure	Private Property
ST31	Not found	Various in region	Search and structure	Mission State Forest
ST32	Not found	Various in region	Search and structure	Mission State Forest
ST33	Not found	Various in region	Search and structure	Campbell State Forest
ST34	Not found	Various in region	Search and structure	Berrygill State Forest
OB10	Found	*Bertya* species A	Search area	Jacks Creek State Forest
OB13	Not Found	Various in region	Search area	Pilliga West State Forest
OB09	Found	*Persoonia cuspedifera*	Search area	Trinkey State Forest
OB14	Found	*Bertya* species A	Search area	Pilliga East State Forest
OB15	Found	*Bertya* species A	Search area	Pilliga East State Forest
OB25	Not found	*Bertya* species A	Search area	Pilliga East State Forest
OB16	Not found	*Bertya* species A	Search area	Pilliga East State Forest
OB17	Found	*Bertya* species A	Search area	Jacks Creek State Forest
OB18	Not found	Various in region	Search area	Private Property
OB56	Not found	Various in region	Search area	Jacks Creek State Forest
OB57	Not found	Various in region	Search area	Jacks Creek State Forest
OB22	Found	*Bertya* species A	Search area	Jacks Creek State Forest
OB43	Not found	Various in region	Search area	Beni State Forest
OB58	Not found	*Desmodium campylocaulon*	Search area	Timmallallie State Forest
OB64	Not found	*Goodenia macbarronii*	Search area	Pilliga Nature Reserve
OB26	Not found	*Goodenia macbarronii*	Search area	Goonoo State Forest
OB27	Not found	*Goodenia macbarronii*	Search area	Goonoo State Forest
OB28	Not found	*Homoranthus darwinioides*	Search area	Goonoo State Forest
OB29	Not found	*Homoranthus darwinioides*	Search area	Goonoo State Forest
OB30	Not found	*Homoranthus darwinioides*	Search area	Goonoo State Forest
OB31	Not found	*Goodenia macbarronii*	Search area	Pilliga East State Forest
OB32	Not found	*Philotheca ericifolia*	Search area	Pilliga East State Forest
OB33	Not found	*Philotheca ericifolia*	Search area	Pilliga East State Forest

Site ID	Result	Target Species	Type of Survey	Location
OB34	Not found	*Philotheca ericifolia*	Search area	Pilliga East State Forest
OB35	Not found	*Polygala linarilifolia*	Search area	Pilliga East State Forest
OB36	Not found	*Polygala linarilifolia*	Search area	Pilliga East State Forest
OB37	Not found	*Polygala linarilifolia*	Search area	Pilliga East State Forest
OB38	Not found	*Polygala linarilifolia*	Search area	Pilliga East State Forest
OB39	Not found	*Polygala linarilifolia*	Search area	Pilliga East State Forest
OB40	Not found	*Rulingia procumbens*	Search area	Pilliga East State Forest
OB41	Not found	*Rulingia procumbens*	Search area	Pilliga East State Forest
OB42	Not found	*Rulingia procumbens*	Search area	Pilliga East State Forest
OB67	Not found	*Tylophora linearis*	Search area	Private Property
OB44	Not found	*Zieria ingramii*	Search area	Goonoo State Forest
OB45	Not found	*Zieria ingramii*	Search area	Goonoo State Forest
OB46	Not found	*Zieria ingramii*	Search area	Goonoo State Forest
OB47	Not found	*Zieria ingramii*	Search area	Private Property
OB48	Not found	Various in region	Search area	Pilliga West State Forest
OB01	Not found	Bertya species A	Search area	Euligal State Forest
OB50	Not found	Various in region	Search area	Pilliga West State Forest
OB51	Not found	Various in region	Search area	Pilliga West State Forest
OB52	Not found	Various in region	Search area	Pilliga West State Forest
OB53	Not found	Various in region	Search area	Orr State Forest
OB54	Not found	Various in region	Search area	Pilliga East State Forest
ST09	Not found	Various in region	Search and structure	Pilliga East State Forest
OB02	Found	*Bertya* species A	Search area	Jacks Creek State Forest
CPE001	Found	*Cadellia pentastylis*	Search area	Private Property
CPE002	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
OB59	Not found	Various in region	Search area	Pilliga East State Forest
OB60	Not found	*Desmodium campylocaulon*	Search area	Pilliga East State Forest
OB61	Not found	*Goodenia macbarronii*	Search area	Cobbora State Forest
OB62	Not found	Various in region	Search area	Pilliga West State Forest
OB63	Not found	Various in region	Search area	Pilliga West State Forest
OB11	Found	*Philotheca ericifolia*	Search area	Lincoln State Forest
OB66	Not found	Various in region	Search area	Yalcogrin State Forest
OB12	Not Found	Various in region	Search area	Pilliga West State Forest
OB68	Not found	Various in region	Search area	Etoo State Forest
OB69	Not found	Various in region	Search area	Killarney State Forest
OB70	Not found	Various in region	Search area	Pilliga West State Forest
OB71	Not found	Various in region	Search area	Pilliga West State Forest
OB72	Not found	Various in region	Search area	Pilliga West State Forest
OB73	Not found	Various in region	Search area	Pilliga West State Forest
OB74	Not found	Various in region	Search area	Pilliga West State Forest
OB75	Not found	Various in region	Search area	Pilliga West State Forest
OB76	Not found	Various in region	Search area	Quegobla State Forest
OB65	Not found	Various in region	Search area	Quegobla State Forest
OB55	Not found	Various in region	Search area	Quegobla State Forest
OB24	Not found	Various in region	Search area	Quegobla State Forest
OB21	Not found	Various in region	Search area	Quegobla State Forest
OB19	Not found	Various in region	Search area	Etoo State Forest
ST01	Not found	Various in region	Search and structure	Baradine State Forest
ST02	Not found	Various in region	Search and structure	Timmallallie State Forest
ST03	Not found	Various in region	Search and structure	Timmallallie State Forest
ST04	Not found	Various in region	Search and structure	Timmallallie State Forest
ST05	Not found	Various in region	Search and structure	Wittenbra State Forest
ST06	Not found	Various in region	Search and structure	Pilliga East State Forest
ST07	Not found	Various in region	Search and structure	Pilliga East State Forest

Site ID	Result	Target Species	Type of Survey	Location
ST08	Not found	Various in region	Search and structure	Pilliga East State Forest
ST10	Not found	Various in region	Search and structure	Janewindi State Forest
ST11	Not found	Various in region	Search and structure	Janewindi State Forest
ST15	Not found	Various in region	Search and structure	Trinkey State Forest
ST14	Not found	Various in region	Search and structure	Pilliga East State Forest
ST13	Not found	Various in region	Search and structure	Pilliga East State Forest
ST35	Not found	Various in region	Search and structure	Moema State Forest
ST36	Not found	Various in region	Search and structure	Moema State Forest
ST37	Not found	Various in region	Search and structure	Moema State Forest
ST38	Not found	Various in region	Search and structure	Bobbiwaa State Forest
ST39	Not found	Various in region	Search and structure	Bobbiwaa State Forest
ST40	Not found	Various in region	Search and structure	Bobbiwaa State Forest
ST41	Not found	Various in region	Search and structure	Killarney State Forest
ST42	Not found	Various in region	Search and structure	Killarney State Forest
ST43	Not found	*Rulingia procumbens*	Search area	Yalcogrin State Forest
CPE001	Found	*Cadellia pentastylis*	Search area	Private Property
CPE002	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
BOP1	Found	*Bertya* species A	Search area	Jacks Creek State Forest
RPR34	Found	*Persoonia cuspedifera*	Search area	Trinkey State Forest
BOP1	Found	*Bertya* species A	Search area	Jacks Creek State Forest
CPE004	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
CPE005	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
CPE006	Found	*Cadellia pentastylis*	Search area	Deriah State Forest
CPE007	Found	*Cadellia pentastylis*	Search area	Deriah State Forest

Figure 17: New Site Locations for Significant Plant Species



2.5 HABITAT MODELLING FOR RARE OR THREATENED SPECIES

2.5.1 Survey Objectives and Constraints

Habitat modelling techniques create maps of the predicted occurrence of a species across a study area. For rare or threatened species, such maps can be used to guide search efforts for populations, to improve understanding of their ecology and, most importantly, to aid in the assessment of conservation values for specific areas in terms of their importance for conserving biodiversity. Since such maps cover all of a study area for which environmental layers exist, they can be used not only as predictions of current occurrence, but also as a reconstruction of species or community distribution over cleared areas.

The aim of species habitat modelling for the TFP was to produce GIS layers of the predicted distribution, current and reconstructed, for all priority vascular plant species in the BBS which have sufficient records with which to undertake statistical modelling.

2.5.2 Generalised Linear and Additive Modelling

The fundamental aim of our modelling process is to spatially interpolate known occurrences of taxa or communities from field surveys over a study area by finding statistical relationships between the biota and environmental variables. In other words, our spatial modelling makes predictions about the distribution of entities based on their environmental relationships.

A module running under S-PLUS statistical software (StatSci, 1995) produced by Watson (1996) was used with ArcView Spatial Analyst (ESRI, 1996) and the Species Predict ArcView extension developed by NPWS (GIS Research and Development Unit, Armidale) to conduct the modelling. For a given species, the values of the environmental variables at each survey site were determined and then related to recorded presences and absences. The relationship was quantified with a statistical model, which was then used to predict the probability that the species was present in each grid cell across the Bioregion. Figure 18 shows the general analysis and modelling pathway used.

The predictive species modelling package provides the user with a choice between two regression procedures, *generalised linear modelling* (referred to as GLM) and *generalised additive modelling* (referred to as GAM). GLM is essentially an extension of ordinary linear regression. Linear regression fits linear (straight line) functions relating a response (dependent) variable to one or more predictor (independent) variables. Two of the basic assumptions of linear regression are that the relationship between response and predictor variables can be approximated by a straight line and that the variance associated with the response is homogenous throughout the full range of the response variables. GLMs overcome these assumptions by allowing a class of models that provide non-linearity and heterogeneous variance in response functions (NPWS, 1994a). This allows non-continuous responses to be modelled (such as presence-absence and count data) and realistic (non-linear) biological relationships to be specified.

GAMs are essentially an extension of GLMs, the major difference is that GAMs use a nonparametric smooth function relating the response to the predictor. The functions are smooth curves estimated from the data using techniques originally developed for smoothing scatter plots. The GAMs derived by this software use cubic splines to fit smooth functions.

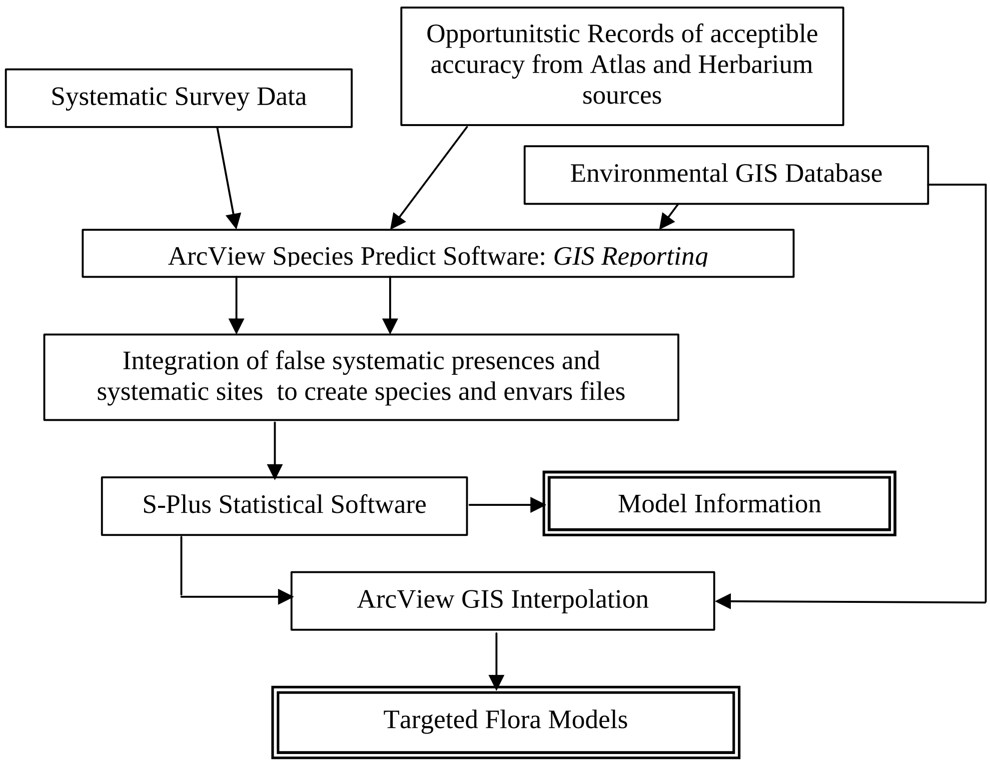
Hence the principal difference between the two modelling techniques is that GAMs allow the survey data to determine the shape of the response curves, whereas GLMs are constrained by parametric forms such as cubic and quadratic polynomial response curves (NPWS, 1994a; Watson, 1996). The outputs from our implementation of both modelling techniques (GLM and GAM) are in two forms:

1. A map of the Bioregion with values indicating the probability of occurrence of the modelled entity (in the case of presence-only modelling this is a relative scale).

2. A postscript file containing information about the model (for example, deviance, model type and degrees of freedom), as well as a graphical plot of each variable found to be significant in indicating the probability of occurrence of the species for the range of values of the variable (Figure 21).

A detailed discussion of the theory and mathematical detail of these modelling techniques is beyond the scope of this report. Key references for GLMs and GAMs are McCullagh and Nelder (1989), Hastie and Tibshirani (1990) and Hastie (1992). Austin and Meyers (1996) and Yee and Mitchell (1991) provide examples of ecological applications. Watson (1996) documents the modelling software used for this study. The following section includes additional explanation of the model outputs.

Figure 18: Spatial Modelling of Targeted Flora Species



2.5.3 Modelling Methods

Abiotic Layers

A total of 45 abiotic layers were used in GAM and GLM modelling (Table 43). Layers relating to temperature, precipitation and radiation were derived by NPWS (GIS Unit) using the Anuclim climatic modelling software (Houlder *et al.*, 1999). Soil property layers were derived from the DLWC BBS Soil Landscapes layer and included fertility, rooting depth, plant available water capacity and drainage. A wetness index and digital elevation model (DEM) was supplied by NPWS (GIS Unit). The DEM was used by the NPWS WRA Unit to derive layers for elevation and topography using the Spatial Analyst ArcView extension. The WRA Unit also derived layers for latitude and longitude, proximity to water sources, plant stress and climatic zones.

Two types of environmenal variables were used in predictive modelling, namely continuous and categorical. Continuous variables contain values on a continuum (eg. temperature) as compared to categorical variables where each value represents discrete categories (eg. soil types). In some cases these variables will be referred to here as "covariates".

Categorical variables used with this modelling process must have a relatively low number of categories to ensure that a sufficient number of presence or absence sites are situated within each category. This requirement precluded the use of the DLWC Soil Landscapes layer which has 47 categories, many of which do not contain a sufficient number of floristic sites with which to establish a meaningful statistical relationship. Environmental layers must also have complete coverage of the study area to ensure that sites have data for all variables. If sites with no data are used, they will be automatically discarded by the modelling software, thereby further reducing the modelling dataset. These requirements prevented the use of vegetation mapping datasets, which typically have a large number of map categories and only partially cover the BBS.

Environmental layers often act as potential surrogates for the factors which influence plant species distribution patterns. The modelling process identifies variables which help to explain the distribution of the presence and absence records across the region. A particular variable may be correlated with the spatial occurrence of a plant species and therefore serve as a useful predictor of its distribution without necessarily being the cause of that distribution. The predictive power of a spatial model is maximised by utilising environmental layers which closely reflect aspects of a plant's niche.

Latitude and longitude do not directly effect distribution, but are required at a number of stages by Species Predict and the modelling software. As modelling predictors, they can be seen as a representation of geographical space. The inclusion of latitude and longitude would be undesirable if they were treated the same way as other variables because they may act as surrogates for environmental relationships which could otherwise be described by environmental variables (Watson 1996). In consideration of this, the software is designed such that latitude and longitude can only be added to a model once all other variables have been tested for their relationship with the species' distribution. Maximum ecological meaning is therefore obtained from existing environmental variables. Longitude and latitude do still frequently emerge as predictors (eg. NPWS 1994) but under the above design can be considered to be acting as surrogates for an environmental response *unrepresented* by existing variables, for historic disturbance events which have shaped its distribution, or for spatial autocorrelation in the species records.

Datasets

For each of the GLM and GAM modelling processes, two sources of data were available:

1. Systematic records, which have been collected from a full floristic plot. Systematic data allow *presence/absence modelling*, which produces models based on recorded presences of a species in relation to recorded absences. Unlike presence-only models, these models produce upper and lower standard error maps and the graphical outputs contain three additional plots portraying model discrimination, calibration and refinement (Murphy and Winkler, 1992), as will be discussed.

2. Opportunistic records, from sources such as herbaria and the Atlas Database. An opportunistic locality does not inform as to the presence or absence on any other species, and such records are only suitable for *presence-only modelling*. Presence-only data are modelled here in relation to 1000 'pseudo-absences' which are randomly chosen within the study area. Unlike presence/absence modelling, this is only a relative index and not an estimation of the probability of occurrence.

Data processing

The GAM/GLM modelling package used for the TFP requires a minimum of 10 systematic sites to function. This requirement limited the number of species which could be modelled to only 8. Opportunistic records were therefore considered an important dataset which should be incorporated into the modelling process. Rather than choosing presence only modelling, which results in a loss of statistical and predictive power, opportunistic records were treated as systematic records to supplement the available dataset for each priority species. Opportunistic records were not, however, used as absences in the modelling of any other species.

Atlas and herbarium opportunistic records were processed based on their rating in the ‘accuracy’ field. This field either contained a distance in metres or an index between 1 and 6 relating to a scale of distances. Only those opportunistic records with an accuracy of 100m or better were included in modelling. Examination of variables relating to topography, wetness and water proximity revealed that within the bioregion many of these values can vary between opposite extremes in less than 1000m (for example, from a valley to a ridge top). Spatial accuracy of 1000m (the next most accurate category in the 'accuracy' field) was therefore considered too coarse to report meaningful relationships with variables. Once opportunistic records were included in the modelling dataset, the number of species which could be modelled increased to 18. These species, and the source of records for modelling are detailed in Table 42.

The spatial modelling process uses two key files as inputs: the ‘envars’ file and the ‘species’ file. The envars file contains all of the covariate (columns) values for each site (rows). Linked to this file is the species file which lists the same sites, and in the same order, as the envars file, with presence or absence of species (columns) at each site in the form of 0's (absence) and 1's (presence). One envars and one species file can usually be used to model multiple species, but in this project separate envars and species files were used for each species in order to accommodate opportunistic records.

A file containing all systematic sites was extracted directly from an MS Access database and further processed using S-plus version 6. A second file containing all opportunistic records was extracted from an ArcView shapefile and then manipulated using MS Access and MS Excel. These files were imported into ARCVIEW Spatial Analyst where they were intersected with all environmental variables (Table 43) using the Species Predict extension. This step produced corresponding envars files for the systematic and oportunistic record files.

Separate species and envars files were created for each species by combining the relevant opportunistic records with the files of systematic sites using MS Excel. Figures 19 and 20 illustrate the format of the species and envars files.

Other files produced by the Species Predict extension include 'varfiles', which contains the range of each variable across the study area, and 'outlines', an ASCII file of the coordinates of the study area. The above files combined with 'sitfiles', a file identifying the covariates being used, and a species index file 'spcseen', were imported into S-PLUS for analysis.

Figure 19: Example of species file (for *Philotheca ericifolia*).

Sitecode	Longitude	Latitude	Method	Effort	3	99	
Phileric14	690700	6467000	10	1	1	1	
Phileric15	718500	6605600	10	1	1	1	
01TWR12	854355	6471205	10	1	0	1	
02TWR12	854744	6470983	10	1	0	1	
03TWR12	854111	6470417	10	1	0	1	
04TWR12	853828	6468929	10	1	0	1	
05TWR12	853628	6468940	10	1	0	1	
06TWR12	854067	6469617	10	1	0	1	

Figure 20: Example of envars file (for *Philotheca ericifolia*).

Longitude	Latitude	Waterprox	Topind5	Topind10	Tempseas	Tempanrg	Slospect
690700	6467000	3	-1	-2	201	293	11
718500	6605600	5	0	0	206	307	11
854355	6471205	0	11	17	183	271	54
854744	6470983	0	1	-7	184	272	54
854111	6470417	5	-1	-12	185	281	44
853828	6468929	3	-3	-11	185	282	43
853628	6468940	3	-10	-25	185	282	41
854067	6469617	5	0	-3	185	281	42
853767	6469634	0	-5	-9	185	278	52

The Modelling Process

For this modelling package the first task within S-PLUS is to establish the variable classes data frame. This comprises a matrix with 100 rows and a column for each variable, with the values in each cell determined by the data ranges file (‘varfiles’). The next major task is to test for collinearity between variables. The procedure employed for this task tests for collinearity in three ways: between continuous variables; between continuous and categorical variables; and between categorical variables (Watson, 1996). Once the modelling software has decided which variables are collinear, the variables are placed into groups such that:

- a group of collinear variables can contain more than two variables but if it does, then all the variables within the group are correlated each other more strongly than the designated threshold.
- a variable may have membership of more than one group
- any single variable that is not correlated with any other variable (i.e., any correlation is less than the designated threshold) is put into a group of its own.

Once the variables have been grouped, the software moves to the stepwise variable selection procedure. The initial test involves the evaluation of all univariate models. Any variable which does not significantly ($p < 0.15$) reduce the deviance is discarded permanently. Groups of collinear variables are dealth with by selecting the variable that reduces the deviance most significantly, and permanently discarding all others. If no univariate model significantly ($p < 0.15$) improves the null fit, then a null model results. Species with fewer than 10 positive observations also result in a null model. After this stage, the forward-backward stepwise selection procedure begins with a pool of non-correlated variables each represented by one term expression. The starting model is the univariate model which achieved the most significant reduction in null deviance (Watson, 1996).

Each of the other variables is added to the starting model. The bivariate model which affords the most significant ($p < 0.15$) reduction in deviance becomes the new interim model. A similar process produces the best trivariate model. Backwards-stepwise selection is then invoked to determine if a bivariate model comprised of the most recently added variable and either of the two already included variables significantly ($p < 0.20$) reduces the deviance of the trivariate model. If so, the bivariate model becomes the new interim model, otherwise the trivariate model enters a new cycle where a fourth variable is tested for inclusion on the same basis as the previous cycles. After each addition, backward selection is performed to explore whether it is possible to revert to a simpler model. When six variables are chosen or when no variable significantly reduces the deviance of the interim model, further selection ceases (Watson, 1996).

Once the model for a species or community has been created, the predicted occurrence of that entity across the study area is calculated. The values in the variable classes dataframe are assigned prediction values on the logit scale (Watson, 1996). These values are imported into ARCVIEW Spatial Analyst and re-scaled and spatially interpolated using the Species Predict extension into a map of predicted species distribution. At this point the values are converted from a probability scale of 0 - 1 into a percentage value (for data storage and manipulation purposes). The output for presence-absence modelling comprises three maps with values ranging from 0–100: (1) a predicted map; (2) an upper standard error map; and (3) a lower standard error map.

The other output from S-PLUS is a postscript file which contains a graphical display of each variable in the final model and the functional form of the relationship between the probability of occurrence of the species and the value of the variable. It also produces various figures and plots for use in model evaluation. These will be discussed in more detail below.

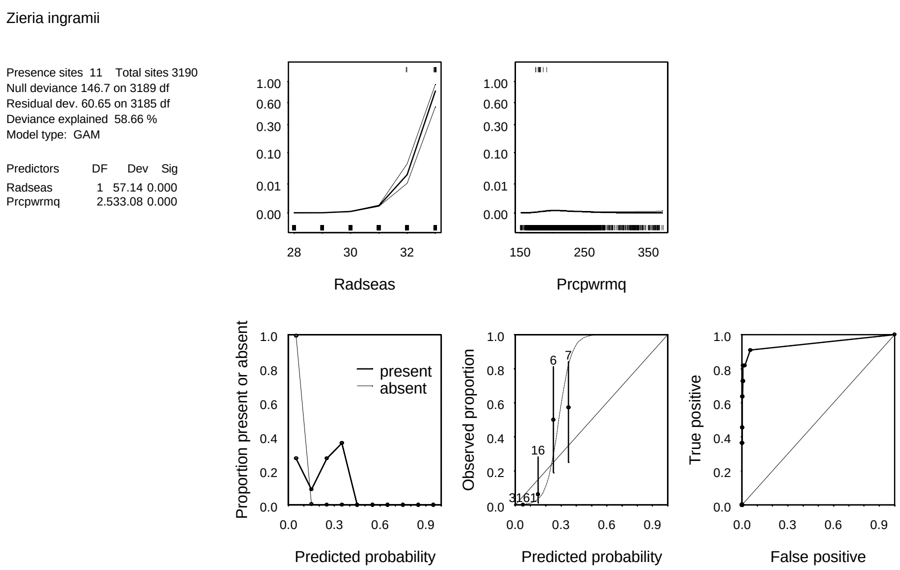
2.5.4 Targeted Flora Models

Explanation of Key Outputs

There are two key outputs from the modelling process. The first is a map of the study area with values corresponding to a probability of occurrence of the particular species expressed as a percentage (or relative probability for presence-only data). The second is a postscript file with data relating to the chosen model (Figure 21). Both of these outputs are presented in Appendix 7 for the 18 targeted flora models.

There are three components to the postscript file: the table at the top left; a graphical display of the variables used in the model; and, three additional graphs describing the performance of the model.

Figure 21: Sample Modelling Output: The Postscript File



The Table

The table provides a mathematical summary of the model. The name of the species is displayed, followed by the number of presence sites for that species and the total number of sites used in the analysis.

The null, residual and explained deviance of the model follows. Deviance is a measure of the closeness of the fit of a model to the data used to derive that model. It measures the variance between the site data (presence or absence of a species) and the probability of presence as predicted by the model (NPWS, 1994). Null deviance is a measure of the deviance of the null model before any environmental variables are used as predictors. In this way a measure of the inherent variation or noise in the data is provided.

Residual deviance is the amount of deviance remaining after a model has been fitted (NPWS, 1994). Deviance explained is the percentage of the null deviance explained by the model.

Deviance explained is calculated using the following equation:

$$\frac{100 \times (\text{null deviance - residual deviance})}{\text{null deviance}}$$

A perfectly fitted model would explain 100% of the deviance. Such a model would not necessarily be desireable for making predictions on species distribution. Actual values are usually much lower and over all modelling for this project averaged 27.73%. This indicates that much of the variation within the data could not be accounted for by the model, and is consistent with the results of similar studies (NPWS, 2000a; NPWS, 1994). Many factors may limit how much deviance is explaned. Most survey data have a degree of sampling error resulting from samplers overlooking or incorrectly identifying species and from incorrect or inaccurate site location information. Further noise is introduced by the limitations of existing data layers, most of which which are usually derived themselves by modelling processes and carry their own degree of error. Perhaps most significant of all is that the complex combination of factors that determine the presence or absence of a species at a particular site cannot be perfectly represented by any combination of GIS layers. Factors such as seasonal effects, microhabitat requirements, a species' ability (or inability) to disperse, interactions with other biota, disturbance effects and pure chance are particularly difficult to represent.

In the evaluation plots the environmental predictors and covariates used in the model are presented in order of decreasing importance. The degrees of freedom for each variable are displayed followed by two columns, deviance and significance, which provide an indication of the importance of each variable to the model. Deviance is measured by calculating the difference between the end model with all environmental variables and a model containing all variables except the variable of interest (NPWS, 1994). This provides a measure of the contribution of each variable to the final model. An approximate significance level for this contribution (i.e. change in deviance) is also provided. This significance level is not always less than 0.05 which is the cut off for inclusion of any one variable during the stepwise selection procedure. This is because a variable selected early in the forward stepwise procedure may cease to make a significant contribution once further variables are added to, and controlled for, in the model (NPWS, 1994).

The Graphs

The second component of the postscript file is a graphical output of the environmental variables and covariates used in the model. Each variable chosen in the model appears as a graph, the most important variable being displayed first. Each graph depicts the modelled relationship between the variable (environmental or covariate) and the probability of occurrence for the range of values for each variable. This is plotted on a cube root scale to highlight the variation at the lower end of the probability range, allowing interpretation of environmental relationships of rarer species that would be indiscernible on an untransformed scale (NPWS 1994).

Each graph plots the modelled effect of a single variable while controlling for (i.e. holding constant) the effects of all other variables in the model. The effect of each of the other environmental variables is always held at a mean value calculated across all surveyed sites. The tick marks across the top of each graph indicate the locations at which the species was recorded as present in relation to the environmental variable or covariate. Each tick represents a single site. The ticks across the bottom of each graph represent those sites at which the species was recorded as absent. The fitted function relating the occurrence of a species to an environmental variable or covariate is plotted as a solid curve. This curve represents a 'best estimate' of the relationship. For presence/absence modelling upper and lower 95% confidence limits for the fitted function are presented as dashed curves. If an environmental variable or covariate is treated as a factor rather than a continuous variable then the fitted value for each factor level is plotted as a short horizontal line and the 95% confidence limits are indicated by a vertical line.

Qualifications

The graphs should be interpreted with care. In particular the reader should be aware of the following considerations:

1. Each graph depicts the effect of only one variable within a multivariate model. This effect is produced by mathematically controlling for the effects of all other variables (i.e. holding each of the other effects at their mean value). This means that the graphs cannot be interpreted in isolation from one another. The effect of a variable in a multivariate model can be very different to the univariate effect of that variable if analysed on its own in the absence of the other variables. The plotted functions depict multivariate, not univariate, effects. It should be noted however that the tickmarks at the top and bottom of each graph reflect the univariate distribution of sites in relation to the environmental variable, *without* controlling for other variables. This may account for any obvious discrepancy between a fitted function and the distribution of presence versus absence tickmarks; one is controlling for effects of other variables while the other is not.

2. The 95% confidence limits need to be considered when assessing the certainty of a fitted function. The fitted function is only a best estimate and therefore has associated error. The magnitude of this error varies both within and between functions, depending partly on the density of sampling within different environments and partly on the strength of the species-environment relationships being modelled. The plotted confidence limits provide an indication of the error associated with a fitted function.

> The confidence limits can be interpreted as follows: at a given value of the environmental variable we are 95% confident that the true value of the function (a probability in the case of presence versus absence models) lies between the upper and lower confidence limits. The importance of a fitted function should be assessed by observing not only the magnitude of change in the fitted function with changing values of the environmental variable, but also the magnitude of the error associated with this change. If error bands are narrow the function is relatively certain.

Below the variable plots three additional graphs (the "validation plots") are produced, based on the modelling data, which describe the performance of the model in terms of model *discrimination*, *calibration* and *refinement* respectively.

“Discrimination measures the extent to which the proportion of all the positive observations falling in separate classes of predicted probabilities, differs from the proportion of all negative observations falling in those same classes of predicted probabilities. In other words, it is the extent to which the model predicts higher probabilities for the positive observations than it does for the negative observations. Good discrimination is illustrated in the plot by separation of the lines joining the respective proportions of positive observations and negative observations across the defined classes of predicted probabilities.” (Watson, 1996).

“Model calibration is a measure of the extent to which the model is either over-predicting or under-predicting. The plot shows, for the survey points occurring in each class of predicted probabilities, the proportion that returned positive observations. The 95% confidence intervals around these proportions is also provided. In a perfectly calibrated model the proportions would lie along the dotted line. A curve fitted to the proportions is displayed to highlight the regions of the predicted probability range which are not well calibrated. In those parts of the range where the fitted curve rises above the line of the ideal model, the model is overpredicting and in those parts of the range where the fitted curve falls below that line, the model is underpredicting.” (Watson, 1996).

The receiver operating curve (ROC) (Cox, 1958) also provides information on the discrimination of the model. "The ROC provides a measure of the extent to which the model is correctly predicting the likelihood of a true positive (presence) and a false positive (absence) across the range of the probability scale. It does this by portraying the heterogeneity of prediction, that is, that the model is predicting outcomes which are spreading across the range of the probability scale. The points on the curve are calculated by plotting, for 100 predicted probability thresholds, the proportion of absence records falling below each threshold against the proportion of presence records falling below those thresholds. A well refined model produces a curve which is distant from the dotted 45 degree line. A curve close to the dotted line indicates that the model has little or no predictive reliability.” (Watson, 1996).

Model Evaluation

GAM and GLM models were produced for all species. Models were then evaluated based on deviance explained and evaluation plots and the best method (GAM or GLM) chosen to interpolate. Plot evaluation information was summarised for each model in a table displaying deviance explained, a rating out of six relating to the level at which the model is overpredicting, and an overall rating between Very Poor and Very Good based on deviance explained, overpredict rating and on the other evaluation plots.

Clipping of models

Probability maps were clipped to a woody vegetation layer to allow comparison of predicted current distribution and reconstructed distribution. The woody vegetation layer was derived by DLWC using Landsat Thematic Mapper (TM) imagery to identify vegetated areas with greater than 15% canopy cover.

Table 42: Targeted flora species modelled and source of records

Species	Systematic Records	Opportunistic Records Used	Opportunistic Records Excluded	Total Records Used
Astrotricha rodii	14	5	3	19
Bothrochloa biloba	35	107	42	142
Cadellia pentastylis	9	34	41	43
Derwentaria arenaria	9	2	0	11
Desmodium campylocaulon	20	1	1	21
Digitaria porrecta	3	10	34	13
Eucalyptus nandewarica	8	6	4	14
Goodenia macbarronii	37	6	7	43
Hibbertia kaputarensis	11	2	6	13
Homopholis belsonii	24	30	6	54
Homoranthus darwinioides	0	11	13	11
Olearia gravis	8	2	0	10
Persoonia cuspidifera	149	7	1	156
Persoonia terminalis ssp. recurva	9	2	5	11
Philotheca ericifolia	9	2	11	11
Polygalia linearifolia	10	0	1	10
Rulingia procumbens	9	20	14	29
Zieria ingramii	1	10	8	11

TABLE 43: ENVIRONMENTAL LAYERS USED IN HABITAT MODELLING

Layer	Max	Min	Description	Units	Variable type	Resolution
Temperature						
avantemp	106	195	Annual mean temperature	°C (×10)	cont	25m
mndiunrg	121	161	Mean Diurnal range (mean period max-min)	°C (×10)	cont	25m
tempseas	174	211	Temperature Seasonality	CoV	cont	25m
maxtwp	242	344	Max Temperature of Warmest Period	°C (×10)	cont	25m
mintcq	-17	41	Min Temperature of Coldest quarter	°C (×10)	cont	25m
tempanrg	256	315	Temperature Annual Range	°C (×10)	cont	25m
mntempwq	170	265	Mean Temperature of wettest quarter	°C (×10)	cont	25m
mntempdq	45	167	Mean Temperature of driest quarter	°C (×10)	cont	25m
mntempcq	35	120	Mean temperature of the coldest quarter	°C (×10)	cont	25m
Precipitation						
avrain	457	1247	Annual Precipitation	mm	cont	25m
prcpdryp	26	80	Precipitation of driest period	mm	cont	25m
prcpseas	10	37	Precipitation seasonality	CoV	cont	25m
prcpwetq	149	374	Precipitation of wettest quarter	mm	cont	25m
prcpdryq	86	268	Precipitation of driest quarter	mm	cont	25m
prcpwrmq	149	374	Precipitation of warmest quarter	mm	cont	25m
prcpcldq	90	297	Precipitation of coldest quarter	mm	cont	25m
Radiation						
anavrad	171	193	Annual mean Radiation	$Mj/m^2/day$	cont	25m
highprad	237	265	Highest period Radiation	$Mj/m^2/day$	cont	25m
lowprad	91	113	Lowest period radiation	$Mj/m^2/day$	cont	25m
radseas	28	34	Radiation of seasonality	CoV	cont	25m
radwetq	222	252	Radiation of wettest quarter	$Mj/m^2/day$	cont	25m
raddryq	103	170	Radiation of driest quarter	$Mj/m^2/day$	cont	25m
radwarm	228	252	Radiation of warmest quarter	$Mj/m^2/day$	cont	25m
radcold	106	128	Radiation of coldest quarter	$Mj/m^2/day$	cont	25m
Wetness						
nibwet25	3	27	Wetness gradient, provided by NPWS Head Office. Original 100m grid with data gaps was resampled to 25m and gaps were filled using "Nibble" command in Arcview.		cont	100m, resampled to 25m
Elevation/Topography						
topind5	-91	103	Simple topographic index. Calculated for each grid cell from a 25m D.E.M using the formula T=e-mean(e), where e=the elevation and mean(e)is the mean elevation within a 5 grid cell radius.	m	cont	25m
topind10	-195	204	Simple topographic index. Calculated for each grid cell from a 25m D.E.M using the formula T=e-mean(e), where e=the elevation and mean(e)is the mean elevation within a 10 grid cell radius.	m	cont	25m
rough5	0	85	Topographic roughness. Calculated from a 25m D.E.M. over a 5 cell radius window around each grid cell using the formula R=Stdev(e), where e=elevation.	m	cont	25m
rough3	0	69	Topographic roughness. Calculated from a 25m D.E.M. over a 3 cell radius window around each grid cell using the formula R=Stdev(e), where e=elevation.	m	cont	25m
rough10	0	118	Topographic roughness. Calculated from a 25m D.E.M. over a 10 cell radius window around each grid cell using the formula R=Stdev(e), where e=elevation.	m	cont	25m
slope	0	71	Derived from a 25m D.E.M. using Arcview and Spatial Analyst.	° angle from horizontal	cont	25m

Layer	Max	Min	Description	Units	Variable type	Resolution
slopecat	1	5	Slope derived from a 25m D.E.M. using Arcview and Spatial Analyst. Reclassified into 5 categories: 1 = 0-1° 2 = 2-5° 3 = 6-10° 4 = 11-20° 5 = >21°		cat	25m
aspctnth	0	5	Aspect derived from a 25m D.E.M. using Arcview and Spatial Analyst. Reclassified into 6 categories relating to "northness": 0 = areas between 0-1 deg slope (aspect deemed "null") 1 = the most northerly 72° 2 = the next most northerly 36° deg (NW and NE) 3 = the next most northerly 36° deg (E and W) 4 = the next most northerly 36° deg (SW and SE) 5 = the southernmost 72° deg.		cat	25m
aspct4ct	0	4	Aspect derived from a 25m D.E.M. using Arcview and Spatial Analyst. Reclassified into 6 categories. Five categories. 0 = areas between 0-1 deg slope (aspect deemed "null") 1 = North (90° of arc) 2 = East (90° of arc) 3 = West (90° of arc) 4 = South (90° of arc)		cat	25m
aspct8ct	0	8	Aspect derived from a 25m D.E.M. using Arcview and Spatial Analyst. Reclassified into 6 categories. Nine categories. 0 = areas between 0-1° slope (aspect deemed "null") 1 = North (45° of arc) 2 = NE (45° of arc) 3 = E (45° of arc) 4 = SE (45° of arc) 5 = S (45° of arc) 6 = SW (45° of arc) 7 = W (45° of arc) 8 = NW (45° of arc)		cat	25m
Soils						
dlwcwhc	1	1312	Estimated plant available water capacity. Unmodified values from DWLC Soil Landscapes Layer. Gaps in derived grid filled with nearest values using "Nibble" command in Arcview.	mm	cont	25m
dlwcrootd	0	200	Estimated rooting depth. From DWLC Soil Landscapes Layer. Gaps in derived grid filled with nearest values using "Nibble" command in Arcview.	m (×10)	cont	25m
dlwcfert	1	5	Estimated soil fertility. Categories range between 1 (very low fertility) and 5 (high fertility). Unmodified values from DWLC Soil Landscapes Layer. Gaps in derived grid filled with nearest values using "Nibble" command in Arcview.		cont	25m
dlwcdrain	1	6	Estimated drainage. Categories range between 1 (very poorly drained) and 5 (well drained). Unmodified values from DWLC Soil Landscapes Layer. Gaps in derived grid filled with nearest values using "Nibble" command in Arcview.		cat	25m

Layer	Max	Min	Description	Units	Variable type	Resolution
Miscellaneous						
waterprox	0	5	Proximity to water. 0 = No proximity 1 = Subject to occasional inundation 2 = Swamp 3 = Within 100m of a minor stream 4 = Within 250m of a lake 5 = Within 250m of a major river		cat	25m
pstress	0	4	Plant stress index. A layer created by intersecting regions where the following values occur in climatic layers: Mintcp - Lowest 20% Maxtwp - Highest 20% Prcpdryp - Lowest 20% Mntempdq - Highest 20% Mnduinrg - Highest 20% Tempseas - Highest 20% Values indicate the number of the above regions which co-occur at each grid cell.		cat	25m
longitude	565800	930250	Created by Heidi Henry using ArcGrid		cont	25m
latitude	6357400	6876550	Created by Heidi Henry using ArcGrid		cont	25m
climzone	1	7	Climatic zones based on average temperature and average rainfall: 1 = Low rainfall/Moderate temperature 2 = Low rainfall/High temperature 3 = Moderate rainfall/Low Temperature 4 = Moderate rainfall/Moderate Temperature 5 = Moderate rainfall/High Temperature 6 = High rainfall/Low temperature 7 = High rainfall/Moderate temperature		cat	25m
elevation	1	1499	25m D.E.M.		cont	25m

Note: Maps for the abiotic GIS dataset are contained in Appendix 10.

2.5.5 Results of Plant Species Modelling

Targeted flora models are summarised in Table 44 and presented in Appendix 7. Each model derived from the GAM / GLM process illustrates the predicted probability of occurrence of the subject plant species with values which range from 0-100, represented by gradational scaling from white (zero) to black (maximum values). A zero grid cell value means that the species would have no probability of occurrence, whereas a value of 100 would indicate a 100% probability of occurrence. In addition to the probability maps are the validation plots for each species and the predicted distribution clipped to woody vegetation.

Models should be interpreted as predictions of potential distribution based on recorded occurrence of the species in environmental and geographical space. The actual occurrence of the species within this predicted area has in all probability been determined over history by disturbance, interactions with other biota and stochastic events.

Evaluation of the Plant Species Models

Overall, the standard of model fit for Targeted flora species was high, despite low sample size for many species (Table 44). The model for *Persoonia cuspidifera* was rated Very Good, having high deviance explained, low overpredict rating and acceptible performance in other evaluation plots. No models were rated as Very Poor or Poor, with models for *Philotheca* *ericifolia* and *Digitaria porrecta* rating as Fair - Poor, mainly due to high levels of oveprediction.

Abiotic predictors

Twenty-seven of the 45 layers used in modelling emerged as a predictor at least once. The most common predictors include longitude, latitude, estimated soil fertility, temperature seasonality, and mean temperature of the driest quarter (Table 45).

Table 44: Model output summary for targeted flora species

Species	Model Chosen	Presence Sites	Devience Explained	Overpredict Rating[1]	Overall Rating[2]	Probability Range	Predictors
Astrotricha rodii	GAM	19	59.08	4	G	0-33	Tempseas, Dlwcdrain, Mntempdq, Longitude
Bothrochloa biloba	GAM	142	35.31	2	G	0-77	Radseas, Dlwcfert, Prcpdryp, Tempseas, Topind10, Pstress
Cadellia pentastylis	GLM	43	45.2	3	G	0-60	Aspct4ct, Mndiunrg, Tempseas, Dlwcwhc, Longitude, Latitude
Derwentaria arenaria	GAM	11	40.55	4-5	G	0-53	Mntempdq, Aspct8ct, Mndiunrg, Latitude
Desmodium campylocaulon	GAM	21	45.5	4-5	G	0-35	Mntempcq, Dlwcfert, Dlwcrootd, Longitude
Digitaria porrecta	GAM	13	29.96	6	F-P	0-19	Dlwcrootd, Nibwet25, Longitude, Latitude
Eucalyptus nandewarica	GAM	14	43.72	5	F-G	0-28	Prcpwrmq, Tempseas, Latitude
Goodenia macbarronii	GAM	43	32.66	5	F	0-39	Mntempdq, Topind10, Prcpdryq, Nibwet25, Radwetq, Longitude
Hibbertia kaputarensis	GLM	13	38.36	3-4	G	0-36	Climzone, Aspct4ct
Homopholis belsonii	GAM	54	40.57	4-5	G	0-59	Radseas, Dlwcfert, Dlwcwhc, Tempseas, Raddryq, Latitude
Homoranthus darwinioides	GAM	11	77.04	5-6	G	0-99	Raddryq, Anavrad, Latitude
Olearia gravis	GAM	10	54.35	5-6	G	0-43	Prcpseas, Dlwcdrain, Longitude
Persoonia cuspidifera	GAM	156	53.74	1	VG	0-85	Radseas, Prcpwrmq, Tempanrg, Mntempdq, Dlwcwhc, Longitude
Persoonia terminalis ssp. recurva	GLM	11	60	3-4	G	0-68	Mndiunrg, Pstress, Slopecat, Latitude
Philotheca ericifolia	GLM	11	37.06	6++	P-F	0-40	Pstress, Prcpwrmq, Longitude
Polygalia linearifolia	GAM	10	28.16	5-6	F	0-23	Prcpdryp, Mndiunrg, Dlwcfert
Rulingia procumbens	GAM	29	30.12	5-6	F	0-92	Radwarm, Dlwcfert, Raddryq, Prcpwrmq
Zieria ingramii	GLM	11	62.23	4	G	0-99	Radseas, Pstress, Mntempdq

[1] Based on validation plots (Appendix 11). Values range between 0 (Negligible over-prediction) and 6 (Extreme over-prediction)

[2] Based on validation plots and devience explained. Values range between VP (Very Poor) and VG (Very Good).

Table 45: Importance of Environmental Variables in Targeted Flora Modelling

Layer	Description	No. of Models Where Significant
Temperature		
Avantemp	Annual mean temperature	0
Mndiunrg	Mean Diurnal range (mean period max-min)	4
Tempseas	Temperature Seasonality	5
Maxtwp	Max Temperature of Warmest Period	0
Mintcq	Min Temperature of Coldest Quarter	0
Tempanrg	Temperature Annual Range	1
Mntempwq	Mean Temperature of wettest quarter	0
Mntempdq	Mean Temperature of driest quarter	5
Mntempcq	Mean temperature of the coldest quarter	1
Precipitation		
Avrain	Annual Precipitation	0
Prcpdryp	Precipitation of driest period	2
Prcpseas	Precipitation seasonality	1
Prcpwetq	Precipitation of wettest quarter	0
Prcpdryq	Precipitation of driest quarter	1
Prcpwrmq	Precipitation of warmest quarter	4
Prcpcldq	Precipitation of coldest quarter	0
Radiation		
Anavrad	Annual mean Radiation	2
Highprad	Highest period Radiation	0
Lowprad	Lowest period radiation	0
Radseas	Radiation of seasonality	4
Radwetq	Radiation of wettest quarter	1
Raddryq	Radiation of driest quarter	3
Radwarm	Radiation of warmest quarter	1
radcold	Radiation of coldest quarter	0
Wetness		
nibwet25	Wetness gradient	3
Elevation/Topography		
Topind5	Simple topographic index, 5 grid cell radius	0
Topind10	Simple topographic index, 10 grid cell radius	2
Rough5	Topographic roughness, 5 grid cell radius	0
Rough3	Topographic roughness, 3 grid cell radius	0
Rough10	Topographic roughness, 10 grid cell radius	0
Slope	Slope	0
slopecat	Slope, reclassified into 5 categories	1
aspctnth	Aspect, reclassified into 6 categories relating to "northness"	0
Aspct4ct	Aspect, reclassified into 4 categories	2
Aspct8ct	Aspect, reclassified into 8 categories	1
Soils		
dlwcwhc	Estimated plant available water capacity	4
dlwcrootd	Estimated rooting depth	2
dlwcfert	Estimated soil fertility	6
dlwcdrain	Estimated soil drainage	2
Miscellaneous		
waterprox	Proximity to water	0
pstress	Plant stress index	4
longitude	Longitude	8
latitude	Latitude	7
Climzone	Climatic zones based on average temperature and average rainfall	1
Elevation	Elevation	0

Limitations of Modelling and Future Work

A large proportion of models had high deviance explained values but many of these overpredicted to a high degree. Overprediction occurs most often where a cluster of presences occurs near, but not necessarily at, the upper limit of a variable's range. This causes the fitted curve to rise sharply towards the variable's upper limit. An overpredicting model can lead to very high probability values being interpolated over areas in which the species was recorded as absent, or at least was not present frequently enough to justify such high values. Where a model is overpredicting, the complexity of the interactions makes effective adjustment for this effect difficult. There is some justification, however, for approaches such as discarding or adjusting to a more moderate value probability values above a certain threshold, determined by the point where 'observed proportion' approaches 1.00 in the 'Model Calibration' plot. Such an approach is advocated by Watson (1996). Any improved predictive power afforded by such measures can only be assessed by field validation, which is beyond the scope of this project. Further work should be carried out to validate and refine targeted flora species and community group models.

Longitude and latitude were the most frequent predictors but were not necessarily the most important, as they are only included by the modelling software as final additions to the best model able to be produced using other variables. Latitude and longitude can also be used by the modelling software as a combined predictor (geographical space). The use of geographical space as a predictor is advocated by Watson (1996) as an advantage for species absent in areas which otherwise appear to be environmentally suitable. The distribution of such species may have been reduced or limited by long term species sifting processes or by a more recent event such as land clearing after European settlement. The inclusion of geographical space restricts the area in which a species can be predicted based on where it is already recorded to occur (Watson 1996). The use of geographical space may be desirable in the case of species whose distribution has been limited by long term processes, such as climatic change. However, in the case of more recent land use change, the use of this variable may not be desirable in estimating pre-European distributions. As it is difficult to determine which case applies to individual species, the decision was made to exclude geographical space as a primary predictor.

Latitude and longitude can have a smilar effect to geographical space, especially if they both emerge as predictors in the same model. Preliminary modelling found a consistant error where the degrees of freedom were not recalculated and the modelling software frequently crashed. It was discovered that inclusion of latitude and longitude as input variables (with geographical space still disabled) rectified the problem. The exclusion of latitude and longitude was therefore not an option available during modelling for this project. As a result, it should be noted that predicted distribution is likely to be an under-representation of predicted pre-clearing distribution for species which have experienced a large reduction in areal extent due to recent clearing.

Uncertainty about the historical factors affecting species or populations should also be considered in interpretation of the effects of predictors other than latitude and longitude. The disturbance history of a species, both recent and long term, can reduce its distribution in both environmental and geographical space. For example, records for a species which, prior to recent clearing might have occurred equally on fertile floodplains and rocky slopes, may now be heavily biased towards rocky slopes due to the high rate of clearing in floodplain areas. Models based on these records are likely to find a positive correlation with sloping or topographically rough areas, or with low soil depth. Model outputs could therefore represent underpredictions of the actual and historic species distribution. Further refinement of models based on the history and autecology of species is therefore recommended as part of future work.

3. PLANT COMMUNITIES

3.1 OVERVIEW

3.1.1 Project Requirements

A key component of the TFP brief was to conduct analyses in order to establish environmental patterns within the BBS and to identify communities of conservation priority (sections 2, 3 and 4). This chapter reviews the occurrence and conservation significance of plant communities within the BBS, including inventory of existing vegetation mapping and plant communities, analysis of systematic floristic data, predictive habitat modelling of plant communities, and assessment of conservation status of plant communities.

3.1.2 Data Requirements

Whilst there are over 30 individual vegetation mapping datasets with some coverage of the BBS, these datasets differ in their floristic classification, have inconsistent levels of map resolution and accuracy, were produced at different times over a 20 year period, and collectively provide only partial coverage of the study area. In order to meet the TFP project objectives, it was necessary to firstly identify, characterise and map the vascular plant communities of the bioregion, and secondly, to undertake research in order to ascertain whether any of these plant communities are of conservation priority, such as communities listed on the EPBC Act or the TSC Act or otherwise considered to be of conservation priority by Specht *et al.* (1995) or other botanical experts.

3.1.3 Format of this Chapter

This chapter is divided into four sections:
(1) an inventory of plant communities based on existing data;
(2) an analysis of floristic data to identify the plant communities in the BBS;
(3) an analysis of spatial data to produce plant community distribution models with complete coverage of the Bioregion;
(4) an assessment of the conservation status of plant communities in the BBS.

3.2 INVENTORY OF PLANT COMMUNITIES

3.2.1 Data Audit and Review

API vegetation maps

A total of 36 API-based vegetation mapping datasets were reviewed for geographic extent, currency, data type and format (Table 46). An inventory of the 2 695 vegetation map codes from these datasets was compiled along with their reservation status (where available), occurrence in a formal reserve, and botanical nomenclature (Appendix 8).

BBS Stage 1 Assessment

The BBS Stage 1 Vegetation Survey and Mapping Project identified 60 broad overstorey types based on API within target map areas (Table 47). The Stage 1 mapping dataset also identified a total of 492 unique vegetation types and 18 special feature types (RACD, 2000).

Conservation Atlas Plant Communities

As noted in the introductory chapter (section 1.4.8), Specht *et al.* (1995) present the results of a continent-wide assessment of Australian plant communities in the *Conservation Atlas of Plant Communities in Australia*. The Conservation Atlas presents each identified floristic group according to the following standard format:

- a map number
- a letter and number code for each plant community
- the key diagnostic species
- the structural formation (eg. Open Forest)
- a distribution map for the plant community based on a 30 x 30 minute grid
- codes for the occurrence of the plant community within particular phytogeographic regions
- a more detailed description of the plant community in terms of structural and floristic variation
- a checklist of the conservation reserves within which the floristic group occurs
- an assessment of the conservation staus of each plant community.

The conservation status of each Atlas plant community was evaluated by Specht *et al.* (1995) using the general criteria set out below in Table 48.

A comprehensive search of the Conservation Atlas was undertaken for the purposes of floristic data collation and for the assessment of the conservation status of plant communities within the Greater BBS. All communities recorded within the 30 x 30 minute grid cells which cover the bioregion were identified using the NSW 1:100,000 mapsheet grid (Figure 22). The 50 communities identified are listed in Table 49, along with their reference code and national conservation status.

TABLE 46: API VEGETATION MAP DATASETS

Dataset Title	Custodian	Currency & Lineage	Description of Data
M305 floristic & Structure (m305FandS_in_bbs.shp)	Paul McDonald / MDBC	½//00 ,27/01/00, 08/05/01 landsat imagery/ground survey	Woody and Non-woody vegetation across the entire Murray Darling Basin. Structural vegetation data including type, density, growth form.
M305 in Buffer (m305_in_buffer)	MDBC (Murray Darling Basin Commission)	27/01/00, 20/01/00, 24/01/00	Woody and Non-woody vegetation across the entire Murray Darling Basin. Structural vegetation data including type, density, growth form.
Sivertson Wheatbelt Vegetation Mapping (sivertsen Clip.shp)	NPWS (Dominic Sivertson- Biodiversity division HO)	original data 1985,latest change 1999-2000	Woody and Non-woody vegetation communities across the Murray Darling Basin (eg Western Poplar Box Woodland) or Non woody Vegetation). Series Number, map code.
Coonabarbran Shire (Coona_shire-veg.shp)	John Whitehead	01/12/1999 aerial photos Fiels surveym based on RN17 r(research note no 17 revised 1989) and M305 mapping classifications .API and ground truthed.	Vegetation Community name (eg White Cypress Ironbark) associations (eg Bloodwood, Stringybark, Red Gum, Oak) and Locations (eg sandy and Rocky Ridges).
Manobalai NR (monobalai_bbs.shp)	NPWS	Aerial photos,	Vegetation Community name (egNarrabeen sheltered dry Forest) with label (eg Q6) and fire regime
Arakoola Nature Reserve (Arakoola_z55)	NPWS		vegetation community groups eg White box basalt woodland and a corresponding Veg type code, eg C3.
Warrumbungles NP (bungles_veg.shp)	NPWS	19/05/00	Community type eg E.blakelyi-A.floribunda open woodland and community type attribute Number eg 14.
Towarri NP(towarri_z55.shp)	NPWS	07/01/00, 24/01/00 Aerial photos,limited ground truthing	Vegetation labels (eg OF1 = Open Forest 1).
High Conservation grasslands (High conservation grasslands 55.shp)	NPWS	15/09/1999..original data 1984 from UNE : "The natural grasslands of Liverpool plains"	Label and area ID for high conservation grasslands within the BBS.
Binnaway NR (BinnawayNR.shp)	NPWS	Field survey,Aerial photos.Data collected continually since 1985.	Label/vegetation community (eg E.sideroxylon, with an attribute label of 5)
Goobang NP (Goobang NP.shp)	NPWS	Field survey,Aerial photos.Data collected continually since 1985.	Vegetation Community (eg E.fibrosa with an attribute of 6/3b).
Weetalibah NR (weetalibah.shp)	NPWS	21/01/2000 field survey,aerial photos.Data collected continually since 1985	Label/Vegetation community (eg Red stringybark with Narrow-leaved Ironbark and Black Cypress, with an attribute of 3)

Dataset Title	Custodian	Currency & Lineage	Description of Data
Mount Kaputar (mt_kaputar_veg.shp)	NPWS	21/01/2000 field survey,aerial pjotos.Data collected continually since 1985	Label/Vegetation community (eg. Narrow-leaved Ironbark. Cypress & Accac with an attribute label of 9.
Kirramingly Nature Reserve (Kirramingly_nr.shp)	NPWS	21/01/2000 field survey,aerial photos.Data collected continually since 1985	Broad classification of vegetation types (eg Astrebla Mixed grassland with an attribute label of 44). Also cultivation and land use classifications.
Eastern Bushlands Data Base (ebd_north.shp & ebd_central.shp)	NPWS	02/12/1999 landsat imagery	Broad vegetation systems for the eastern coast, ranges and tablelands.
WRA stage 1 (wra_api1.shp)	NPWS / RACAD	04/05/00	Overstorey Species Groupings with rainforest or special features mapped as appropriate. Reliability assigned to each polygon. Coverage of Pilliga State Forest and Goonoo State Forest.
Coolah Tops NP (Coolahforest_z55.shp)	NPWS	06/01/00, 24/01/00	Forest typing (eg swamp, mountain/manna gum).
CRA veg mapping-CRAFTI	NPWS	28/08/2001 Aerial photography interpretation	Floristic and structural codes (eg E8E212) incorporating data on understory, disturbance and senescence
NPWS_veg.shp (this is the same as Pilliga Veg mapping but has Binnaway NR included)	NPWS	02/12/99	Community Type (eg Ironbark complex) and corresponding community type code(eg 1)
Goonoo veg mapping (goonoo_api_grouped_v1.shp)	NPWS	18/02/2000	Type (eg: Be;Belah)Vegetation League(eg Western Box-ironbark league) Description(Bimble box-white cypress Pine)This is stage 1 WRA mapping that has been re-grouped by Doug Beckers.
Kwiamblen Vegetation mapping (Kwiamblenp.shp)	NPWS	09/07/01	Broad community typing (eg Limestone woodlands) with corresponding attribute number (eg 2)
Coona shire ironbarks (Coona_shire_ironbarks.shp)	NPWS	06/12/99	Value: numerical character given to grid cells. If a community containing ironbark falls on SFNSW tenure, that cell is given a value of 1. If a community containing ironbark falls on neither SFNSW nor NPWS tenure, that cell is given a value of 99. All other cells are classified as No Data. Count is a count of the grid cells that match the value in the value column for that record. Label is a text string, which can be used as a display name in a map legend.
Goulburn River NP vegetation mapping (vegcomgrnpmung_z55.shp) (clip_Goulburn_bbs.shp)	NPWS	21/01/2000 aerial photos and ground survey	Vegetation community name (eg Box Woodland on Basalt) with code (eg WL2), fire community name (eg Basalt Woodland and Herbfield) and fire regime.

Dataset Title	Custodian	Currency & Lineage	Description of Data
Hunter Veg Mapping(hunter_dlwc_z_z55.shp)	DLWC (Hunter region)	12/01/2000 Reprojected to z55 and merged into Hunter DLWC z-z55.shp(multi attribute)	Categorised for landuse, Vegetation communities,regrowth,canopy cover,growth form,crown seperation and soil erosion,rock outcrop and understory.
Moree Vegetation Mapping (dlwc moree complete with changes .shp)	DLWC	01/10/1999 Satellite TM and SPOT imagery interpretations and interpretation of both recent and historical aerial photography.	Vegetation Communities with species associations (eg Narrow-leaved Ironbark with an associated code).
Gwabegar Vegetation Mapping (gwabvega_z55.shp)	DLWC	Aerial Photos, satellite Imagery,Ground survey 1998-1999	North west Vegetation Communities with species associations (eg Narrow- leaved Ironbark with a code of E37 & the botanical name E. crebra.). Also associated landcover and landuse descriptors.
State forest Lindsay Typing (Lindsay_grouped_types.shp)	State forest NSW (later regrouped by NPWS)	18/02/00,17/02/00,07/02/00,14/01/99 Aerial photos,Lindsay types(report compiled in 1961 by A.D.Lindsay) RN17 (research notes No.17 revised 1989) estimated completion 1986	very broad vegetation community Typing(eg Pine – Red Gum)
State Forest type 55 (typ55.shp)	State forest NSW	10/01/00	Vegetation communities according to Lindsay typing (eg. White cypress Pine League and code: Pmf)
Bingara 1:100,000 topographic map sheet	RACD	27/06/02	Floristics and structure for vegetation with ccp >10%; minimum polygon size 10ha, special features to 2ha,
Yallaroi 1:100,000 topographic map sheet	RACD	27/06/02	Floristics and structure for vegetation with ccp >10%; minimum polygon size 10ha, special features to 2ha,
Yetman 1:100,000 topographic map sheet	RACD	27/06/02	Floristics and structure for vegetation with ccp >10%; minimum polygon size 10ha, special features to 2ha,
Blackville 1:100,000 topographic map sheet	RACD	27/06/02	Floristics and structure for vegetation with ccp >10%; minimum polygon size 10ha, special features to 2ha,
Murrurundi 1:100,000 topographic map sheet	RACD	27/06/02	Floristics and structure for vegetation with ccp >10%; minimum polygon size 10ha, special features to 2ha,
Cobbora 1:100,000 topographic map sheet	RACD	27/06/02	Floristics and structure for vegetation with ccp >10%; minimum polygon size 10ha, special features to 2ha,
Gulgong 1:100,000 topographic map sheet	RACD	27/06/02	Floristics and structure for vegetation with ccp >10%; minimum polygon size 10ha, special features to 2ha,

Table 47: Broad Overstorey Vegetation Types identified during the Stage 1 Assessment

Botanical Name
A. leiocarpa
Acacia harpophylla
C. endlicheri – E. chloroclada
C. endlicheri – E. fibrosa – E. trachyphloia
C. endlicheri – E. nubila – C. glaucophylla
C. endlicheri – E. nubila – E. crebra
C. endlicheri – E. nubila – E. dwyeri
C. endlicheri – E. nubila and E. beyeriana
C. endlicheri – E. nubila
C. endlicheri
C. glaucophylla – C. trachyphloia
C. glaucophylla – E. albens
C. glaucophylla – E. blakelyi / E. chloroclada
C. glaucophylla – E. crebra – C. trachyphloia
C. glaucophylla – E. crebra
C. glaucophylla – E. melanophloia
C. glaucophylla – E. melliodora
C. glaucophylla – E. microcarpa
C. glaucophylla – E. pilligaensis
C. glaucophylla – E. populnea
C. glaucophylla
C. maculata
C. preissii – E. blakelyi / E. chloroclada – A. floribunda
C. trachyphloia – E. chloroclada
C. trachyphloia – E. fibrosa
C. trachyphloia
Casuarina cristata
E. albens
E. beyeriana – E. dwyeri
E. blakelyi / E. chloroclada – A. floribunda
E. blakelyi / E. chloroclada – C. trachyphloia
E. blakelyi / E. chloroclada – E. crebra
E. blakelyi / E. chloroclada – E. macrorhyncha
E. blakelyi / E. chloroclada
E. camaldulensis
E. chloroclada – E. fibrosa
E. conica
E. crebra – C. endlicheri
E. crebra – C. trachyphloia
E. crebra – E. pilligaensis
E. crebra
E. dealbata
E. dumosa
E. dwyeri
E. fibrosa – C. glaucophylla
E. fibrosa – C. trachyphloia
E. fibrosa
E. globoidea
E. macrorhyncha
E. melanophloia
E. melliodora – E. blakelyi
E. microcarpa
E. nubila
E. pilligaensis
E. populnea
E. punctata
E. rossii
E. sideroxylon
E. viridis
Heath and shrubland

Figure 22: BBS Within a 100,000 Scale Mapsheet Grid

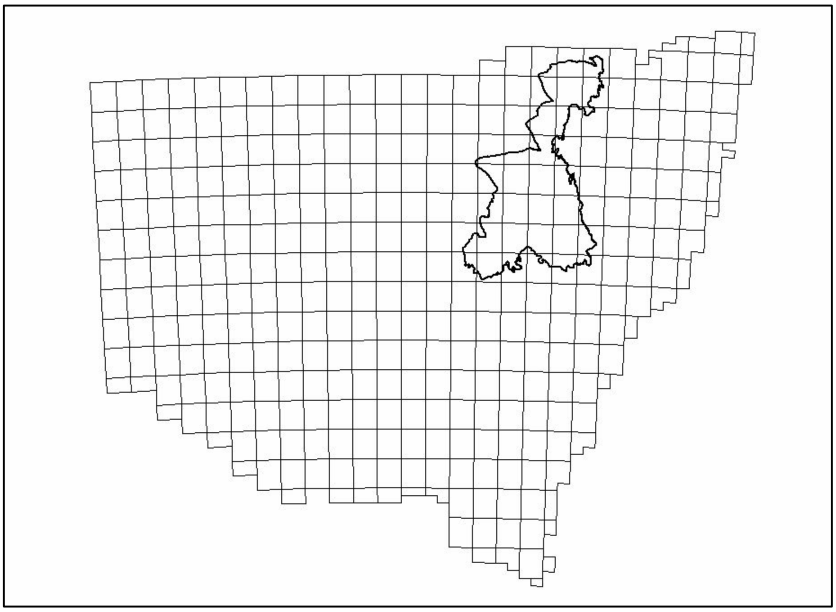


TABLE 48: THE CONSERVATION STATUS CRITERIA FOR AUSTRALIAN PLANT COMMUNITIES (AFTER SPECHT *ET AL.*,1995)

Rating	Criteria
Adequate	The plant community is well conserved in several large reserves which represent the range of biogeographic regions in which the community occurs, each reserve exhibiting ecological diversity.
Reasonable	The plant community is conserved in a large reserve or a number of small reserves which represent a large part of the range of biogeographic regions in which the community occurs; ecological diversity is usually present in the reserves.
Poor	The plant community is conserved in only one or two small reserves probably subject to human pressure. The range of biogeographic regions in which the community occurs is not represented and ecological diversity is not usually present in the reserves.
Very poor	The plant community is conserved in only a few small reserves probably subject to human activities, which represent only a small component of the range of biogeographic regions in which the community occurs and ecological diversity is not present in the reserves; its conservation status is precarious.
Nil	The plant community is not conserved in any conservation reserve.

TABLE 49: COMMUNITY INVENTORY FOR THE BBS AND NATIONAL CONSERVATION STATUS (AFTER SPECHT ET AL., 1995)

Map Code	Community Description	Reservation Status	Conservation Reserves in NSW
T363e	*Eucalyptus microcarpa - E. albens*	Not Conserved	Not reserved in NSW
T716e	*Eucalyptus moluccana - E. siderophloia* woodland	Not Conserved	Not reserved in NSW
M4	*Eucalyptus socialis - E. dumosa* open scrub	Not Conserved	Not reserved in NSW
DA40	*Acacia pendula - Atriplex nummularia* low woodland	Not Conserved	Not reserved in NSW
SAV33	*Bursaria spiinosa - Chrysocephalum apiculatum - Vittadinia sp. - Stipa eremophila* savanna understorey to grassland *(Lomandra)*	Not Conserved	Not reserved in NSW
SAV37	*Arundinella nepalensis - Themeda triandra - Elymus scabrus - Aristida jerichoensis* savanna understorey	Not Conserved	Not reserved in NSW
Callist	*Callistemon spp.* mid height shrubland	Very Poor	Not reserved in NSW
SAV36	*Themeda triandra - Elymus scabrus - Aristida jerichoensis* savanna understorey	Very Poor	Goulburn River NP
SAV38	*Alectryon oleifolius - Convolvulus erubescens - Erodium cygnorum* savanna understorey to grassland	Poorly - Very Poorly	Sturt NP, Mootwingee NP
Atalhem	*Atalaya hemiglauca (+/- Eucalyptus terminalis)* low woodland	Poor	Nocoleche NR
Eucinte	*Eucalyptus intertexta (+/- E. populnea +/- Callitris glaucophylla)* low woodland	Poor	Yathong NR, Nombinnie NR, Round Hill NR, Woggoon NR, Tollingo NR, Mount Grenfell Historic Site, Loughnan NR
A46	*Eleocharis acuta - Potamogeton crispus - Typha spp*. Wetland	Poor	Macquarie Marshes NR
Bracpop	*Brachychiton populneus* scattered trees	Poor - Reasonable	Goulburn River NP, Egans Peak NR
T339c	*Eucalyptus sideroxylon* woodland	Poor - Reasonable	Blue Mountains NP, Pilliga NR, Nangar NP
Calend	*Callitris endlicheri* low woodland / open forest	Poor - Reasonable	Razorback NR, Dananbilla NR
T366b	*Allocasuarina luehumannii* low woodland	Poor - Reasonable	Not reserved in NSW
Daspar	*Acacia sparsiflora - A. burrowii* low open forest	Poor - Reasonable	Not reserved in NSW
T361	*Eucalyptus chloroclada (syn. E. dealbata) - E. sideroxylon* open forest / woodland	Reasonable	Weddin Mountains NP, Conimbla NP, Nangar NP, Kings Plains NP, Tollingo NR, Ironbark NR
T363d	*Eucalyptus pilligaensis (+/- Callitris glaucophylla)* woodland / open forest	Reasonable	Brigalow Park NR
T342b	*Eucalyptus bridgesiana* open forest	Reasonable	Tinderry NR, Nungatta NP, Bald Rock NP, Razorback NR, Wee Jasper NR
T666b	*Eucalyptus bicostata* open forest	Reasonable	Kanangra-Boyd NP, Burrinjuck NR
T188	*Eucalyptus coolabah, E. microtheca, etc*. low open woodland	Reasonable	Nocoleche NR, Macquarie Marshes NR, Narran Lake NR

Map Code	Community Description	Reservation Status	Conservation Reserves in NSW
T190	*Eucalyptus camaldulensis* woodland	Reasonable	Kosciusko NP, Sturt NP, Mootwingee NP, Kinchega NP, Warrumbungle NP, Pindera Downs Aboriginal Area, Coturaundee NR, Narran Lake NR, Kemendok NR, Morrisons Lake NR, Hattons Corner NR
T366a	*Eucalyptus largiflorens* woodland	Reasonable	Sturt NP, Nocoleche NR, Kinchega Np, Willandra NP, Macquarie Marshes NR, Kajuligah NR, Narran Lake NR, Nearie Lake NR, Yanga NR, Kemendok NR, Morrisons Lake NR
G100	*Astrebla pectinata - A.* lappacea open tussock grassland	Reasonable	Sturt NP, Pindera Downs Aboriginal Area
C23a	*Atriplex vesicaria - A. nummularia (+/- Acacia pendula)* low shrubland	Reasonable	Mungo NP, Narran Lake NR, Nearie Lake NR, Yanga NR, Kemendok NR
A42	*Eleocharis acuta - E. sphacelata - Typha spp.* Wetland	Reasonable	Nadgee NR, Wallaga Lake NP, Thirlmere Lakes NP
SCLER185	*Monotoca scoparia - Pteridium esculentum* sclerophyll understorey	Reasonable	Myall Lakes NP, Yuraygir NP, Bundjalung NP, Banyabba NR, Limeburners Creek NR, Warrabah NP
SAV35	*Chloris truncata - Bothriochloa macra* savanna understorey to grassland	Reasonable	Kosciusko NP, Oxley Wild Rivers NP, Werrikimbe Np, Border Ranges NP
HW10	*Acacia stenophylla - Muehlenbeckia florulenta* understorey of T366a	Reasonable	Sturt NP, Nocoleche NR, Mootwingee NP, Pindera Downs Aboriginal Area, Narran Lake NR, Kemendok NR, Morrison's Lake NR
T360	*Eucalyptus chloroclada (syn. E. dealbata) - Angophora costata subsp.* Leiocarpa open forest / woodland	Reasonable - Adequate	Not reserved in NSW
T363c	*Eucalyptus populnea (+/- E. terminalis +/- Callitris glaucophylla)* woodland	Reasonable - Adequate	Nocoleche NR, Nombinnie NR, Kajuligah NR, Cocoparra NP, Narran Lake NR, Mount Grenfell Historic Site, Brigalow Park NR.
Calcolu	*Callitris glaucophylla (syn. C. columellaris)* low woodland / open forest	Reasonable - Adequate	Kosciusko NP, Yathong NR, Pilliga NR, Nombinnie NR, Mootwingee NP, Mungo NP, Warrumbungle NP, Kajuligah NR, Round Hill NR, Coturaundee NR, Woggoon NR
T365a	*Eucalyptus melanophloia (+/- E. crebra)* woodland / open forest	Reasonable - Adequate	Narran Lake NR, Warrabah NP
NT	*Eucalyptus radiata - E. acaciiformis - E. nova-anglica* Northern Tablelands Complex	Reasonable - Adequate	Werrikimbe NP, Gibraltar Range NP, Cathedral Rock NP, Serpentine NR
T338b	*Eucalyptus melliodora - E. blakelyi* open forest / woodland	Reasonable - Adequate	Kosciusko NP, Namadgi NP (ACT), Oxley Wild Rivers NP, Pilliga NR, Border Ranges NP, Warrumbungle NP, Tidbinbilla NR (ACT), Ulandra NR, Pantoneys Crown NR, Queanbeyan NR

Map Code	Community Description	Reservation Status	Conservation Reserves in NSW
T341c	*Eucalyptus macrorhyncha - E. rossii*	Reasonable - Adequate	Kosciusko NP, Namadgi NP (ACT), Warrumbungle NP, Tinderry NR, Weddin Mountains NP, Tarlo River NP, Conimbla NP, Bimberi NR, Tidbinbilla NR (ACT), Nangar NP, Razorback NR, Burrinjuck NR, Linton NR, Wee Jasper NR, Black Mountain Reserve (ACT), Pucawan NR, Big Bush NR
T347e	*Eucalyptus fastigata - E. viminalis (+/- obliqua +/- E. cypellocarpa)* open forest	Reasonable - Adequate	Kosciusko NP, Morton NP, Deua NP, Wadbilliga NP, Kanangra-Boyd NP, Barrington Tops NP, Werrikimbe NP, New England NP, Murramarang NP, Macquarie Pass NP, Badja Swamps NR
T352b	*Casuarina cunninghamiana* humid wetland open forest	Reasonable - Adequate	Wollemi NP, Oxley Wild Rivers NP, Nattai NP and SRA, Deua NP, Border Ranges NP, Warrumbungle NP, Tarlo River NP, Dorrigo NP, Mann River NR
HW11	*Acacia harpophylla - Casuarina* cristata open forest / woodland	Reasonable - Adequate	Brigalow Park NR
T168	*Eucalyptus andrewsii - E. youmanii - E. cameroni* open forest	Adequate	Oxley Wild Rivers NP, Werrikimbe NP, Washpool NP, Cathedral Rock NP, Mann River NR, Kings Plains NP, Boonoo Boonoo NP, The Basin NR, Mount Seaview NR, Watsons Creek NR
T361c	*Eucalyptus fibrosa subsp. Nubila (+/- E. dealbata)* open forest / woodland	Adequate	Nattai NP & SRA, Pilliga NR
Euclaev	*Eucalyptus laevopinea* open forest	Adequate	Wollemi NP, Oxley Wild Rivers NP, Barrington Tops NP, Nymboidea NP, Mount Seaview NR, Mount Hyland NR
T717b	*Eucalyptus crebra (+/- Callitris glaucophylla)* open forest / woodland	Adequate	Warrumbungle NP, Kings Plains NP
T338c	*Eucalyptus albens (+/- Callitris spp.*) open forest / woodland	Adequate	Kosciusko NP, Wollemi NP, Oxley Wild Rivers NP, goulburn River NP, Warrumbungle NP, Weddin Mountains NP, Nangar Np, Ulandra NR, Pantoneys Crown NR, Razorback NR, Dananbilla NR
T347f	*Eucalyptus fastiga - E. sieberi (+/- E. obliqua +/- E. cypellocarpa)* open forest	Adequate	Blue Mountains NP, Wadbilliga NP, Budawang NP, Nungatta NP, Budderoo Np, Nalbaugh NP, Egans Peak NR, Badja Swamps NR
T350i	*Eucalyptus agglomerata* open forest	Adequate	Wollemi NP, Blue Mountains NP, Yengo NP, Nattai NP & SRA, Nadgee NR, Brisbane Water NP, Bournda NR & NP, Tarlo River NP, Hat Head NP, Nungatta NP, Nalbaugh NP, Mount Imlay NP, Egans Peak NR
Gstip	*Stipa aristiglumis (or S. scabra - S. bigeniculata) semi-arid (or montane*) grassland / forbland	Adequate	Kosciusko Np, Nombinnie NR, Goulburn River NP, Mallee Cliffs NP, Kinchega NP, Mount Kaputar NP, Mungo NP

Map Code	Community Description	Reservation Status	Conservation Reserves in NSW
SCLER368	*Banksia serrata - B. spinulosa - Pteridium esculentum* sclerophyll understorey	Adequate	Wadbilliga NP, Myall Lakes NP, New England NP, Yuraygir NP, Bundjalung NP, Gibraltar Range NP, Budawang NP, Brisbane Water NP, Limeburners Creek NR, Dorrigo NP, Cathedral Rock NP, Murramarang NP, Botti Botti NP
SCLER367	*Brachyloma* daphnoides sclerophyll understorey	Adequate	Namadgi NP (ACT), Oxley Wild Rivers NP, Goulburn River NP, Mount Kaputar NP, Werrikimbe NP, Warrumbungle NP, Cocoparra Np, Bald Rock NP

3.3 PLANT COMMUNITY ANALYSIS

3.3.1 Analysis Dataset

The NPWS has been engaged in concurrent bioregional assessments involving floristic analyses across three contiguous bioregions in western NSW, namely Brigalow Belt South, Darling Riverine Plains and Nandewar. The data from each of these bioregions were assembled into a single large analysis dataset for the floristic analyses in order to provide a more comprehensive sample of the environmental heterogeneity of the study area, increase the ability to discern linkages between species in the landscape, and minimise the impact of imposed artificial bioregional boundaries. This larger ‘analysis area dataset’ includes 5,221 full floristic sites, and was converted into a presence / absence site-by-species matrix for the purposes of analysis. Due to inconsistencies in the cover / abundance data (Cavallaro, 2002), these values were not utilised in the floristic analysis, as discussed in detail below.

3.3.2 Exploratory Analyses

A suite of exploratory analyses were conducted using the PATN analysis package (Belbin, 1991; 1995a; 1995b) and the S-Plus statistical software package, in combination with the ArcView GIS. These analyses included dendrogram-based site group and species group classifications using the Bray-Curtis association measure and flexible UPGMA. NMDS ordinations were performed on both sites and species. The dataset was subdivided into woody and herbaceous species subsets and all of the preceding analyses repeated. Ordination plots were displayed within the ArcView GIS to visually interrogate relationships between individual sites and between individual species. Ordination plots were displayed within the ArcView GIS relative to a suite of abiotic variables in order to examine potential controls on the structure of the various data clouds. Group statistics were reported against the same variables to gauge the role of individual environmental variables in influencing plant species composition across the analysis area. The main purpose of the various exploratory analyses was to become familiar with the dataset and to decide upon the most appropriate analytical approach to identify and diagnose floristic communities.

3.3.3 Analytical Approach

General Considerations

The final decision on a suitable analytical approach took into account the following:
- ecological theory;
- the large size of the dataset (5,221 systematic sites);
- the heterogeneity present in the data;
- the 'noise' in the data due to survey season (ie. the impact of drought on the ground cover stratum);
- project constraints in terms of available time and human resources.

This approach was required to:
- allow easy diagnosis of plant communities;
- be robustness to minor flaws in either the underlying dataset or pre-analysis data management procedures;
- produce outputs that have utility for a range of expert and non-expert users and planning or assessment processes.

Community Classification

After due consideration of these issues and the results of exploratory analyses, it was resolved to base the community classification on species groups in preference to the traditional site groups. This analysis of systematic floristic data and subsequent classification as 'communities', is based on the fundamental premise of the definition of a community as "any naturally occurring group of different organisms inhabiting a common environment, interacting with each other and relatively independent of other groups"…the term community is however, "frequently used incorrectly as an alternative for an association, alliance or structural formation" (Cropper, 1993).

In the seminal work of R. H. Whittaker (1982:117), "Ordination of Plant Communities", the meaning and ecological importance of species groups is clearly explained:

> "One may wish to know, not whether particular pairs of species are correlated but whether a whole group of species tend to occur together. For instance, correlations among groups of species provide an objective basis for the recognition of "ecological groups" or " sociological groups". This concept, originated by Duvigneaud (1946, 1953) and developed further by Ellenberg (1950) and Gounot (1961) among others…, has affinities with the "characteristic species" of associations recognosied by the Zurich-Montpellier School…a group of species with similar environmental requirements tend to occur together, and a given vegetation type is identifiable from the presence of one or more such ecological groups. A numerical method for recognising correlated groups of species may accordingly be useful in vegetation classification."

Species groups are fundamental ecological entities, whereas vegetation types are composite descriptive entities based on those groups. Species groups most closely reflect actual plant communities, which are typically understood as groups of co-occuring and interacting species, rather than as groups of floristically similar sites (eg. Cropper, 1993; Whittaker, 1982). Species groups can be readily diagnosed and evaluated with reference to the scientific literature (even by non-experts) whilst site groups must first be diagnosed by their often variable floristic composition before their ecological meaning can be evaluated. In the latter case, this less direct process is typically laborious and often imprecise, even for small datasets. Consequently, this type of classification was not considered practical for a dataset containing over 5,000 sites. Species groups also appear to be less sensitive to variations in the number of species per quadrat and have been demonstrated to be better surrogates for biological diversity in conservation planning (Ferrier *et al.*, in press.). McKenzie et al. (1989) provide examples of such species group community analysis for both flora and fauna.

Presence / Absence Data

Species occurrence within survey plots may be expressed as simple presence/absence data (i.e. a species is present or absent), or in terms of the cover and/or abundance of the species in the plot (e.g. 30 individuals with a combined cover of 60%). In floristic datasets containing the results of many individual surveys, presence/absence is usually the minimum compatible dataset (Austin *et al.*, 2000). This is because cover/abundance data is not always collected during floristic surveys and / or the cover / abundance scheme has varied between surveys. In this latter case, cover/abundance scores may not be amenable to simple standardisation (Cavallaro, 2002).

In NSW, cover/abundance values are typically expressed as projective foliage cover class estimates (e.g. <5% 5-<25%, 25-<50%, 50-75%, >75%), irrespective of plant life form. This means that ground cover ferns (e.g. *Pteridium esculentum*) can potentially achieve values greater than a dominant canopy eucalypt. Furthermore, the measurement of cover/abundance is based on visual estimates which may show significant variation between observers.

Where site or species groups are to be derived using an association measure that accommodates cover/abundance data (e.g. Bray-Curtis), the relative abundance of species plays as much a role in the determination of association values as species presence. For example, in the following site by species matrix where species composition between two sites is identical but cover abundance values vary markedly, the level of dissimilarity would be relatively high.

	Sp1	**Sp2**	**Sp3**	**Sp4**	**Sp5**	**Association Value**
Site1	1	1	1	1	1	**0.67**
Site2	5	5	5	5	5	0=similar; 1=dissimilar

It is entirely plausible that values similar to these could be measured before and after a fire event at a single site, illustrating that ecological perturbations or other ‘disturbance’ events/processes can profoundly affect association values. In the context of dynamic vegetation change, especially in relation to fire-prone and ‘fire-adapted’ vegetation, various levels of association may be as much a function of ‘time since last perturbation’ as true ecological dissimilarity. This ‘disturbance effect’ is likely to be stronger in cover/abundance data than presence/absence data.

In contrast, association measures used for presence/absence data (e.g Czekanowski, Jaccard) treat the presence of all species equally, meaning that the presence or absence of a number of relatively rare species could lead to otherwise compositionally similar sites being treated as more or less dissimilar. In full floristic analyses, this effect could exaggerate dissimilarity where some surveys have been conducted during drought or outside of the flowering periods of many of the species. This ‘rare species effect’ is likely to be stronger in presence/absence data than cover/abundance data.

The use of cover abundance does provide extra information on the level of dominance of various species when the site grouping method is utilised. For conservation planning, where groups are to be chosen for use as surrogates for biodiversity and relative dominance has little value, this effect is undesirable as a factor determining groupings. From the perspective of species groupings, species which generally occur at low cover/abundance would tend to group with other species that have similarly low cover/abundance and abundant species would group with abundant species. In the following example, differences in cover/abundance cause a species (Sp1) to be more closely associated with a species with which it co-occurs in only two sites (Sp3) than a species with which it co-occurs in five sites (Sp2).

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site6**	**Site7**
Sp1	1	1	1	1	1	1	1
Sp2	5	5	5	5	5	0	0
Sp3	0	0	0	0	0	1	1

Association value between sp1 and sp2 = 0.69
Association value between sp1 and sp3 = 0.56
(0 = similar, 1 = dissimilar)

Regardless of whether presence/absence or cover/abundance data is used in a floristic analyses, it is important to understand the essential character of the data type, the ultimate purpose of analysis outputs, and how the relevant measure of association simplifies the data into association values. It is also important to keep in mind potential controls on association values that are not strictly a function of ecological distance. This knowledge should inform the interpretation of analysis outputs and may justify the pre-processing of raw species by site data to control for these undesirable effects.

Woody and Herbaceous Datasets

In addition to adoption of the species group approach, it was decided to subdivide the dataset into woody (trees, shrubs, vines and epiphytes) and herbaceous (grasses, sedges, forbs and herbs) species subsets . This was to reduce the level of heterogeneity which would otherwise be present in a full floristic dataset due to potential fundamental differences in the scale of plant-environment relationships. Herbaceous taxa may be responding to micro-habitat variation and short-term seasonal or other ecological perturbation (disturbance) events or cycles to which the woody components of the vegetation may be largely unaffected. Subdivision of the dataset also facilitated the rapid diagnosis of plant communities because of the reality of the two quite distinct 'ecological scales'. A further benefit flows from the identification of woody plant communities (rather than full floristic species groups or site groups) due to the familiarity of many people with woody rather than herbaceous taxa and the probable greater congruence of these groups with existing classifications, including those used in API mapping. Whilst no analytical method is utopian and each must of necessity compress, simplify and, to a greater or lesser extent, distort the underlying relationships in the data, the woody and herbaceous species grouping approach was considered the best given the project objectives, the likely use of analytical outputs and the nature of the floristic dataset.

3.3.4 Classification and Diagnosis

Once attributed, the analysis dataset was subdivided into woody and herbaceous subsets. Each subset was then subject to PATN analysis using the Bray-Curtis association measure and flexible UPGMA. The analysis generated species association dendrograms for each subset which were then subject to visual interpretation to generate preliminary groups. Each group was then investigated in relation to the ecology and habitat preferences of its constituent species with reference to the scientific literature. Where the autecology of species within a group was disparate the group was either split into ecologically meaningfull subgroups (using the dendrogram to determine species allocation) or subject to more detailed research. In virtually all cases, the woody species groups encompassed discrete geoecological envelopes, such as sandy soils on sandstone or granite. Time constraints and the large number of species precluded a thorough diagnosis of the herbaceous species groups but a preliminary diagnosis has been included in this report.

Group Presence

There are at least three possible measures of ‘presence’ for a particular plant species group at any given site: absolute presence (AP); proportional presence (PP); and relative presence (RP). Each measure generates values which range from zero (none of the species in the group are present at the site) to one (all species in the group are present at the site). The various measures are calculated as follows:

AP = g/G
PP = g/S
RP = (g/G+gS)/2

where:
G is the number of species in the group;
g is the number of species in the group that occur at the site; and
S is the number of species at the site.

The results of simulation work indicate that none of the measures is satisfactory in all circumstances given the variable size of quadrats and groups, the variable density of plants *per se*, and the variable number of species likely to occur within any given site. Where group presence is to be reported for a group in isolation, or where the distribution of the group is to be modelled mathematically, absolute presence is the preferred measure. However, where group presence is to be reported for many groups across a large geographic area, or where the presence of a group is to be considered relative to the presence of other groups, relative presence is a more reliable measure.

For the purposes of this study (inventory), a relative presence value of at least 0.15 was chosen as a threshold to identify the simple occurrence of a particular group within the BBS. In practice, this threshold eliminated groups with only a small number of typically widespread species present at survey sites.

3.3.5 Plant Communities of the BBS

A total of 75 woody and 108 herbaceous plant communities were reported to occur within the Greater BBS (Tables 50 and 51). These communities are described in the following section according to a standard format which includes indicator species, geoecology, life form composition and species composition.

Table 50: Woody Plant communities in the BBS

No.	Name
1	Proteaceae-dominated heath on sandy soils
2	Black Plum rainforest
3	Sassafras Warm Temperate rainforest
4	Muttonwood wet sclerophyll forest on high nutrient soils
5	Baradine Gum dry sclerophyll forest on sandy soil
6	Showy Parrot-pea heath on sandy or rocky ridges
7	Black Cypress Pine forest on stony hillsides
8	Red Ironbark-White Bloodwood forest on infertile sandy soils
9	Red Stringybark dry sclerophyll forest on sandy or rocky soils
10	Red Gum–Orange Gum woodland on skeletal soils
11	Yellow Box–Red Gum woodland on fertile alluvial soils
12	White Box-Kurrajong woodland on rocky hillsides
13	Red Olive Plum dry vine forest
14	River Red Gum-Coolibah forest
15	Poplar Box - Belah semi-arid woodland on clays
16	Ironbark-Cypress forest on sands or red earths
17	Mulga-Brigalow plains woodlands on red earths
18	Green and White Mallee on sandy red earths
19	Mallee Red Gum on rocky ridges
20	Cheese Tree gully rainforest
21	Rusty Fig rocky gully rainforest
22	Black Sally subalpine forest on fertile soils
23a	Coolah Box forest on rocky mountain slopes
23ba	Snow Gum – Mountain Gum Forest at high altitudes
24	Blackbutt dry sclerophyll forest on poor sandy soils
25	Mint Bush shrubs on warm temperate rainforest margins
26	Saltbush-Nitre Bush shrubs on over-grazed plains
28	Weeping Bottlebrush sclerophyll shrubs on sandstone or granite
29	Dry Sclerophyll Forest to Woodland on Granite
30	Currawang and Ruby Urn Heath
31	Broombush mallee on sandy red earths
32	Mugga Ironbark Rocky Sandstone Community
33	Black Sheoak woodland on sandy soils
34	Narrow-leaved Stringybark Forest Complex
35	Bluebush shrubs on calcareous soils
36	Hillside Sandy Heath Community
37	Native Cascarilla shrubs on red earths
38	Silver Croton Woodland on Rainforest Margins
39	High Altitude Small Fruited Hakea Woodland on Rainforest Margins
40	Brush Kurrajong Moist Eucalypt Forest
41	Currawang Rocky Hill Community
42	Dolly Bush Rocky Dry Sclerophyll Woodland or Forest
43x	Grey Box forest on granitic soils (Groups 43, 44, 45)
47	Dwarf Cherry open forest shrubs on sandy soils
48	Inland White Mahogany Rocky Woodland Community
49	Weeping Boree Forest
50x	Stringybark Sheoak forest shrubs on sandy soils (50, 51, 52)
53	Cycad Woodland or Forest on Sandy and Stony Soils
54	Bent Leaf Wattle Dry Sclerophyll Woodland or Forest on Sandstone
55	Wyalong Wattle shrubland on sandy red earths
57	Apple Box – Brittle Gum woodland on shallow sandy soil
58	Round-leaved Mint Bush Rocky Sandstone Woodland
59	Beefwood-Waxflower woodland shrubs on rocky hills
60	Sugarwood shrubs on saline, solonized brown soils
61	Hovea heath on sandy soils
62	Boomerang Wattle Woodland or Forest Community
64	Beyer’s Ironbark on sandy infertile soils
65	Bursaria woodland shrubs in rocky areas
66	Forest Red Gum on alluvial soils

No.	Name
67	Sandplain Wattle shrubs near watercourses in open forest
68	Yellow Rattlepod shrubs on poor sandy soils
69	Heath on sandy soils
70	Rice-flower shrubs on sandy or rocky hillsides
71	Sweet Quandong forest on sandy soils
72	Orange Mistletoe
73a	Fuzzy Box forest on river banks or floodplain
75	Velvet-bush sandy Red Earth association
76	Gum-topped Box Woodland on Loamy Clay Soils
77x	Native Currant shrubland on rocky slopes (77&78)
79	Black Box floodplain woodland on heavy clays
80	Rare shrub species on clay soils
81	Colonising shrubs on heavy soils
82	Sandalwood shrubland on rocky hillsides
83	Bloodwood sandplain woodland
84	Unreliable group – DELETED FROM INVENTORY
85	Hibiscus skeletal soil association

TABLE 51: HERBACEOUS PLANT COMMUNITIES IN THE GREATER BBS

No.	Name (Indicator Species)
1	*Bracteantha viscosa - Austrodanthonia eriantha*
2	*Calotis cuneifolia - Commelina cyanea*
3	*Eragrostis sororia - Monachather paradox*
4	*Dianella revoluta - Lepidosperma laterale*
5	*Aristida jerichoensis -Gahnia aspera*
6	*Actinotus helianthi -Lomandra leucocephala*
7	*Aristida ramosa - Cymbopogon refractus*
8	*Asperula conferta - Austrodanthonia racemosa*
9	*Aristida vagans - Echinopogon caespitosus*
10	*Ajuga australis - Themeda australis*
11	*Acaena novae-zelandiae - Austrodanthonia laevis*
13	*Blechnum nudum - Polystichum proliferum*
14	*Carex gaudichaudiana - Asplenium aethiopicum*
15	*Pterostylis obtusa - Pterostylis revoluta*
16	*Austrocynoglossum latifolium - Libertia paniculata*
17	*Calochlaena dubia - Doodia caudata*
18	*Aneilema acuminata - Entolasia marginata*
19	*Ammobium alatum - Ripogonum album*
20	*Isolepis australiensis - Isolepis hookeriana*
21	*Eriocaulon scariosum - Juncus fockei*
22	*Goodenia paniculata - Juncus ochrocoleus*
23	*Drosera auriculata - Drosera burmannii*
24	*Caesia parviflora - Juncus psammophilus*
25	*Centipeda racemosa - Drosera Indica*
26	*Cyperus sanguinolentus - Cyperus sphaeroideus*
27	*Asplenium trichomanes* and *Juncus sandwithii*
28	*Blechnum minus - Ranunculus inundatus*
29	*Agrostis venusta - Juncus alexandri*
31	*Eriachne mucronata - Maireana villosa*
32	*Eragrostis microcarpa - Sporobolus contiguus*
33	*Enneapogon avenaecus - Triraphis mollis*
35	*Cyperus alterniflorus - Pseudoraphis spinescens*
36	*Bolboschoenus fluviatilis - Juncus firmus*
37	*Amphibromus nervosus - Paspalidium gausum*
38	*Alternanthera nana - Eragrostis setifolia*
39	*Azolla filiculoides - Eleocharis sphacelata*
40	*Atriplex leptocarpa - Eleocharis plana*
41	*Astrebla elymoides - Eragrostis molybdea*
42	*Atriplex muelleri* and *Iseilema vaginiflorum*
43	*Homopholis belsonii - Leptochloa divaricatissima*
44	*Ixiolaena tomentosa - Aristida leptopoda*
45	*Einadia nutans - Chloris truncata*
46	*Enneapogon gracilis - Eragrostis leptostachya*
47	*Chenopodium ambrosioides - Panicum maximum*
48	*Chenopodium truncatum - Vetiveria filipes*
49	*Chenopodium cristatum - Perotis rara*
50	*Hyalosperma semisterile - Scleranthus pungens*
51	*Helichrysum semifertile - Eragrostis australasica*
52	*Crassula colorata -Maireana triptera*
53	*Harmsiodoxa puberula - Scleroblitum atriplicinum*
55	*Juncus dolicanthus - Sclerolaena parallelicuspis*
57	*Wahlenbergia fluminalis - Dichelachne crinita*
59	*Ptilotus erubescens - Aristida obscura*
61	*Blechnum cartilagineum - Hibbertia dentata*
62	*Carex appressa - Carex incomitata*
64	*Gonocarpus humilis - Pterostylis decurva*
66	*Gonocarpus tetragynus - Dianella caerulea*
67	*Hypoxis exilis - Juncus pauciflorus*
70	*Swainsona cadellii - Bromus molliformis*
71	*Sisyrinchium species A - Heteropogon contortus*

No.	Name (Indicator Species)
72	*Pelargonium australe - Aristida muricata*
73	*Plantago varia - Pterostylis daintreana*
74	*Paspalidium albovillosum - Urochloa foliosa*
75	*Sclerolaena anisacanthoides - Minuria denticulata*
76	*Sida species B - Brachyscome melanocarpa*
77	Widespread Perennial Community *Sclerolaena longicuspis - Lepidium fasciculatum*
78	Perennials in Heavy Soil *Swainsona murrayana - Aristida latifolia*
80	*Lepidium hyssopifolium - Capsella bursa-pastoris*
81	*Austrodanthonia duttoniana - Notodanthonia semiannularis*
82	*Rumex tenax - Atriplex suberecta*
83	*Swainsona luteola - Glycine latifolia*
84	*Sida filiformis - Chenopodium carinatum*
85	*Vittadinia gracilis - Austrodanthonia caespitosa*
87	*Rhodanthe corymbiflora - Digitaria porrecta*
88	*Glycine tomentella - Echinopogon cheelii*
89	*Stackhousia monogyna - Wurmbea biglandulosa*.
91	Damp Perennial Herb Community *Utricularia dichotoma - Goodenia gracilis*
93	*Patersonia glabrata - Haemodorum planifolium*
95	*Podolepis neglecta - Solanum cinereum*
96	*Parsonsia lanceolata - Sisymbrium irio*
97	*Stellaria multiflora - Ranunculus sessiliflorus*
98	*Swainsona queenslandica - Arthropodium minus*
100	*Lepidosperma gunnii - Ptilotus indivisus*
101	*Swainsona microphylla - Aristida behriana*
103	*Senna clavigera - Eragrostis megalosperma*
106	*Rumex stenoglottis - Hypoxis hygrometrica*
107	*Tolpis umbellata - Dichopogon strictus*
108	*Leucochrysum albicans - Dichanthium setosum*
109	*Juncus filicaulis - Eragrostis benthamii*
110	*Juncus australis - Brachyscome diversifolia*
111	*Linum marginale - Tetrarrhena juncea*
112	*Luzula densiflora - Aristida calycina*
113	*Eragrostis falcata - Thellungia advena*
114	*Velleia paradoxa - Medicago sativa*
119	*Stellaria species D - Scaevola humilis*
120	*Danthonia linkii - Austrodanthonia induta*
121	*Teucrium species A - Rorippa nasturtium-aquaticum*
123	*Podolepis arachnoidea - Austrodanthonia richardsonii*
124	*Scaevola ramosissima - Lomandra patens*
126	*Thysanotus tuberosus - Pterostylis setifera*
128	*Tricoryne elatior - Juncus subsecundus*
130	*Swainsona phacoides - Podolepis canescens*
132	*Rhodanthe troedelii - Eleocharis cylindrostachys*
135	*Thysanotus patersonii*
138	*Persicaria prostrata*
140	*Swainsona bracteata*
144	*Panicum simile*
149	*Tragus australianus*
150	*Menkea australis*

3.3.6 Woody Plant Community Diagnosis

Each of the woody species groups are diagnosed in a summary format as follows:

Group number	The group reference number identifies the group relative to the larger floristic analysis of western NSW and is included simply for the purposes of concise identification.
Title	A title for the group using the common names of selected indicator species (e.g. “Poplar Box”), the associated vegetation formation (e.g. “woodland”) and a summary note on the geoecology of the group (e.g. “on clays”).
Indicator species	A concise list of the species which most aptly illustrate the geoecology of the group. They include
Geoecology	A summary statement characterising the geoecology of the group based on a more detailed consideration of the autecology of each constituent species (not presented here).
Life form composition	The plant life forms included in the group (e.g. trees and shrubs).
Species composition	A list of the plant species that define the group, along with their site frequency in the analysis dataset (species are listed in order of decreasing site frequency).

Community Profiles

Group No. 1 – Proteaceae-dominated heath on sandy soils
Indicator species: *Lomatia silaifolia* (Crinkle Bush) and *Grevillea linearifolia*.
Geoecology: Typically heath, dry sclerophyll forest or woodland on sandy soils, usually over sandstone or granite.
Life form composition: Shrubs.
Species composition: (N=5) *Grevillea linearifolia* (Grevline); *Leptospermum arachnoides* (Leptarac); *Lomatia silaifolia* (Lomasila); *Mirbelia speciosa* (Mirbspec); *Petrophile canescens* (Petrcane).

Group No. 2 – Black Plum rainforest
Indicator species: *Alectryon subcinereus* (Wild Quince) and *Diospyros australis* (Black Plum).
Geoecology: Typically warmer rainforest types.
Life form composition: Trees and vines.
Species composition: (N=7) *Alectryon subcinereus* (Alecsubc); *Cissus antarctica* (Cissanta); *Clerodendrum tomentosum* (Clertome); *Daphnandra micrantha* (Daphmicr); *Diospyros australis* (Diosaust); *Hibbertia scandens* (Hibbscan); *Rubus moluccanus* (Rubumolu).

Group No. 3 – Sassafras Warm Temperate rainforest
Indicator species: *Doryphora sassafras* (Sassafras) and *Hymenosporum flavum* (Native Frangipani).
Geoecology: Warm temperate rainforest at moderate elevations.
Life form composition: Trees, shrubs and a vine.
Species composition: (N=8) *Acacia maidenii* (Acacmaid); *Celastrus australis* (Celaaust); *Claoxylon australe* (Claoaust); *Doryphora sassafras* (Dorysass); *Ficus coronata* (Ficucoro); *Hedycarya angustifolia* (Hedyangu); *Hymenosporum flavum* (Hymeflav); *Solanum aviculare* (Solaavic).

Group No. 4 – Muttonwood wet sclerophyll forest on high nutrient soils
Indicator species: *Allocasuarina torulosa* (Forest Oak) and *Rapanea variabilis* (Muttonwood).
Geoecology: Typically wet sclerophyll forest on high nutrient soils.
Life form composition: Trees and shrubs.
Species composition: (N=4) *Acacia longifolia* (Acaclonf); *Allocasuarina torulosa* (Allotoru); *Prostanthera incisa* (Prosinci); *Rapanea variabilis* (Rapavari).

Group No. 5 – Baradine Gum dry sclerophyll forest on sandy soil
Indicator species: *Eucalyptus chloroclada* (Baradine Gum) and *Acacia spectabilis* (Mudgee Wattle).
Geoecology: Typically dry sclerophyll forest on sands; associated with Bimble Box and White Cypres Pine communities.
Life form composition: Shrubs and a tree.
Species composition: (N=11) *Leptospermum polygalifolium* (Leptpoly); *Acacia polybotrya* (Acacpoly); *Acacia spectabilis* (Acacspec); *Acacia tindaleae* (Acactind); *Aotus mollis* (Aotumoll); *Babingtonia cunninghamii* (Babicunn); *Dodonaea peduncularis* (Dodopedu); *Eucalyptus chloroclada* (Eucachlo); *Lissanthe strigosa* (Lissstri); *Melaleuca thymifolia* (Melathym); *Pultenaea foliolosa* (Pultfoli).

Group No. 6 – Showy Parrot-pea heath on sandy or rocky ridges
Indicator species: *Dillwynia sericea* (Showy Parrot-pea) and *Dampiera adpressa* (Bushy Dampiera).
Geoecology: Typically heath or dry sclerophyll forest on sandy or rocky ridges, often associated with Mugga Ironbark communities.
Life form composition: Shrubs and a tree.
Species composition: (N=15) *Cryptandra amara* (Crypamar), *Acacia caroleae* (Acaccaro), *Babingtonia densifolia* (Babidens), *Boronia bipinnata* (Borobipi), *Dampiera adpressa* (Dampadpr), *Dillwynia sericea* (Dillseri), *Dodonaea falcata* (Dodofalc), *Hibbertia covenyana* (Hibbcove), *Hibbertia riparia* (Hibbripa), *Leptospermum parvifolium* (Leptparv), *Leucopogon biflorus* (Leucbifl), *Mirbelia pungens* (Mirbpung), *Ozothamnus diosmifolius* (Ozotdios), *Platysace* sp. aff. *linearifolia* (Platsali), *Prostanthera howelliae* (Proshowe)

Group No. 7 – Black Cypress Pine forest on stony hillsides
Indicator species: *Callitris endlicheri* (Black Cypress Pine, Black Pine).
Geoecology: Typically gravelly or stony soils on hillsides and low ridges associated with dry sclerophyll forest.
Life form composition: Shrubs and a tree.
Species composition: (N=6) *Brachyloma daphnoides* (Bracdaph), *Callitris endlicheri* (Callendl), *Calytrix tetragona* (Calytetr), *Hibbertia obtusifolia* (Hibbobtu), *Leucopogon muticus* (Leucmuti), *Melichrus urceolatus* (Meliurce).

Group No. 8 – Red Ironbark-White Bloodwood forest on infertile sandy soils
Indicator species: *Eucalyptus fibrosa* (Red Ironbark), *Eucalyptus dwyeri* (Dwyer's Red Gum) and *Allocasuarina diminuta* and *Corymbia trachyphloia* (White Bloodwood).
Geoecology: Typically infertile sandy or rocky soils associated with dry sclerophyll forest and heath.
Life form composition: Trees, shrubs, a cycad and a grass tree.
Species composition: (N=20) *Allocasuarina diminuta* (allodimt), *Acacia gladiiformis* (Acacglad), *Acacia penninervis* (Acacpenn), *Acacia pilligaensis* (Acacpill), *Boronia glabra* (Boroglab), *Cassinia arcuata* (Cassarcu), *Chloanthes parviflora* (Chloparv), *Corymbia trachyphloia* (Corytrac), *Eucalyptus dwyeri* (Eucadwye), *Eucalyptus fibrosa* (Eucafibr), *Homoranthus flavescens* (Homoflav), *Macrozamia heteromera* (Macrhete), *Persoonia cuspidifera* (Perscusp), *Persoonia sericea* (Persseri), *Pimelea linifolia* (Pimelini), *Platysace ericoides* (Plateric), *Pultenaea cinerascens* (Pultcine), *Ricinocarpos bowmanii* (Ricibowm), *Styphelia triflora* (Styptrif), *Xanthorrhoea acaulis* (Xantacau).

Group No. 9 – Red Stringybark dry sclerophyll forest on sandy or rocky soils
Indicator species: *Eucalyptus macrorhyncha* (A Red Stringybark) and *Acacia uncinata* (Gold-dust Wattle)
Geoecology: Typically, sandy or rocky soils; associated with dry sclerophyll forest.
Life form composition: Shrubs, a tree and a grass tree.
Species composition: (N=8) *Aotus subglauca* (Aotusubg), *Bossiaea rhombifolia* (Bossrhom), *Xanthorrhoea glauca* (Xantglau), *Acacia buxifolia* (Acacbuxi), *Acacia uncinata* (Acacunci), *Eucalyptus macrorhyncha* (Eucamacr), *Grevillea triternata* (Grevtrit), *Isopogon petiolaris* (Isoppeti).

Group No. 10 – Red Gum–Orange Gum woodland on skeletal soils
Indicator species: *Eucalyptus dealbata* (Tumbledown Red Gum) and *Eucalyptus prava* (Orange Gum).
Geoecology: Typically woodland on poor, skeletal, sandy or rocky soils on granite or sandstone.
Life form composition: Trees, shrubs and a grass tree.
Species composition: (N=7) *Eucalyptus caleyi* (Eucacale); *Acacia neriifolia* (Acacneri); *Cassinia laevis* (Casslaev); *Eucalyptus dealbata* (Eucadeal); *Eucalyptus prava* (Eucaprav); *Leptospermum brevipes* (Leptbrev); *Xanthorrhoea johnsonii* (Xantjohn).

Group No. 11 – Yellow Box–Red Gum woodland on fertile alluvial soils
Indicator species: *Eucalyptus melliodora* (Yellow Box) and *Eucalyptus blakelyi* (Blakey's Red Gum).
Geoecology: Typically, at least moderately fertile sandy or alluvial soils.
Life form composition: Trees, shrbus and vines.
Species composition: (N=13) *Acacia implexa* (Acacimpl); *Angophora floribunda* (Angoflor); *Bursaria spinosa* (Bursspin); *Clematis glycinoides* (Clemglyc); *Correa reflexa* (Corrrefl); *Eucalyptus blakelyi* (Eucablak); *Eucalyptus laevopinea* (Eucalaev); *Eucalyptus melliodora* (Eucamell); *Exocarpos cupressiformis* (Exoccupr); *Hardenbergia violacea* (Hardviol); *Indigofera adesmiifolia* (Indiades); *Olearia viscidula* (Oleavisc); *Pultenaea* species G (Pultspeg).

Group No. 12 – White Box-Kurrajong woodland on rocky hillsides
Indicator species: *Eucalyptus albens* (White Box) and *Brachychiton populneus* (Kurrajong).
Geoecology: Typically, open forest or woodland on rocky hillsides and ridges.
Life form composition: Trees and shrubs.
Species composition: (N=9) *Dodonaea sinuolata* (Dodosinu), *Dodonaea viscosa* (Dodovisc), *Pimelea neo-anglica* (Pimeneo), *Acacia decora* (Acacdeco), *Brachychiton populneus* (Bracpopu), *Cassinia quinquefaria* (Cassquin), *Eucalyptus albens* (Eucaalbe), *Notelaea microcarpa* (Notemicr), *Olearia elliptica* (Oleaelli).

Group No. 13 – Red Olive Plum dry vine forest
Indicator species: ***Cassine australis*** (Red Olive Plum) and ***Eucalyptus melanophloia*** (Silver-leaved Ironbark).
Geoecology: Dry rainforest (vine thicket) on sandy, rocky or red earths soils.
Life form composition: Trees, shrubs and vines.
Species composition: (N=16) *Cassine australis* (Cassaust); *Acacia cheelii* (Acacchee); *Alphitonia excelsa* (Alphexce); *Alstonia constricta* (Alstcons); *Beyeria viscosa* (Beyevisc); *Breynia oblongifolia* (Breyoblo); *Canthium odoratum* (Cantodor); *Carissa ovata* (Cariovat); *Clematis microphylla* (Clemmicr); *Einadia hastata* (Einahast); *Eucalyptus melanophloia* (Eucamela); *Jasminum lineare* (Jasmline); *Pandorea pandorana* (Pandpand); *Parsonsia eucalyptophylla* (Parseuca); *Solanum parvifolium* (Solaparv); *Spartothamnella juncea* (Sparjunc).

Group No. 14 – River Red Gum forest
Indicator species: *Eucalyptus camaldulensis* (River Gum, River Red Gum) and *Eucalyptus coolabah* (Coolibah).
Geoecology: Riverine areas and other areas subject to periodic or seasonal inundation, mostly on heavy clay soils on floodplains or along drainage lines.
Life form composition: Trees and a shrub.
Species composition: (N=5) *Acacia stenophylla* (Acacsten); *Eremophila bignoniiflora* (Erembign); *Eucalyptus camaldulensis* (Eucacama); *Eucalyptus coolabah* (Eucacool); *Muehlenbeckia florulenta* (Muehflor).

Group No. 15 – Poplar Box-Belah semi-arid woodland on clays
Indicator species: *Eucalyptus populnea* subsp. *bimbil* (Bimble Box, Poplar Box), *Casuarina cristata* (Belah) and *Alectryon oleifolius* (Western Rosewood, Bonaree).
Geoecology: Semi-arid areas on a variety of soil types but most commonly on clays. Associated with Bimble Box communities.
Life form composition: Trees and shrubs.
Species composition: (N=12) *Eucalyptus populnea* subsp. *bimbil* (Eucapopb), *Alectryon oleifolius* (Alecolei); *Apophyllum anomalum* (Apopanom); *Atalaya hemiglauca* (Atalhemi); *Capparis lasiantha* (Capplasi); *Capparis mitchellii* (Cappmitc); *Casuarina cristata* (Casucris); *Enchylaena tomentosa* (Enchtome); *Eremophila mitchellii* (Eremmitc); *Geijera parviflora* (Geijparv); *Rhagodia spinescens* (Rhagspin); *Sclerolaena birchii* (Sclebirc).

Group No. 16 – Ironbark-Cypress forest on sands or red earths

Indicator species: *Allocasuarina luehmannii* (Bulloak), *Eucalyptus pilligaensis* (Narrow-leaved Grey Box), *Eucalyptus crebra* (Narrow-leaved Ironbark), *Callitris glaucophylla* (White Cypress Pine).

Geoecology: Typically forest or woodland on sands or red earths.

Life form composition: Trees, shrubs, a mistletoe and a twiner.

Species composition: (N=19) *Hibiscus sturtii* var. *sturtii* (Hibistur); *Senna artemisioides* subsp. *zygophylla* (Sennarte); *Acacia deanei* (Acacdean); *Acacia hakeoides* (Acachake); *Acacia ixiophylla* (Acacixio); *Allocasuarina luehmannii* (Allolueh); *Amyema miquelii* (Amyemiqu); *Callitris glaucophylla* (Callglau); *Canthium oleifolium* (Cantolei); *Eremophila longifolia* (Eremlong); *Eucalyptus crebra* (Eucacreb); *Eucalyptus pilligaensis* (Eucapill); *Maytenus cunninghamii* (Maytcunn); *Myoporum montanum* (Myopmont); *Olearia decurrens* (Oleadecu); *Olearia pimeleoides* (Oleapime); *Rhyncharrhena linearis* (Rhynline); *Solanum ferocissimum* (Solafero); *Solanum tetrathecum* (Solatetr).

Group No. 17 – Mulga-Brigalow plains woodlands on red earths

Indicator species: *Acacia harpophylla* (Brigalow), *Acacia cambagei* (Gidgee) and *Acacia aneura* (Mulga).

Geoecology: Typically on open plains on a variety of soil types but often clay loams or red earths in association with mallee and Bimble Box communities.

Life form composition: Trees, shrubs, a subshrub, a mistletoe and a twiner.

Species composition: (N=12) *Amyema maidenii* (Amyemaid); *Acacia aneura* (Acacaneu); *Acacia cambagei* (Acaccamb); *Acacia colletioides* (Acaccoll); *Acacia excelsa* (Acacexce); *Acacia harpophylla* (Acacharp); *Eremophila deserti* (Eremdese); *Eremophila glabra* (Eremglab); *Eremophila sturtii* (Eremstur); *Flindersia maculosa* (Flinmacu); *Marsdenia australis* (Marsaust); *Sclerolaena articulata* (Sclearti).

Group No. 18 – Green and White Mallee on sandy red earths

Indicator species: ***Eucalyptus viridis*** (Green Mallee) and ***Eucalyptus dumosa*** (White Mallee).

Geoecology: Typically, calcareous sandy or sandy loam red earths on sandplains or dunes or gravelly loam soils on low ridges.

Life form composition: Mallee, shrubs and a climber.

Species composition: (N=14) *Pultenaea laxiflora* (Pultlaxi); *Acacia calamifolia* (Acaccala); *Acacia montana* (Acacmont); *Acacia rigens* (Acacrige); *Bertya cunninghamii* (Bertcunn); *Eucalyptus dumosa* (Eucadumo); *Eucalyptus viridis* (Eucaviri); *Halgania cyanea* (Halgcyan); *Marsdenia suaveolens* (Marssuav); *Melaleuca lanceolata* (Melalanc); *Olearia floribunda* (Oleaflor); *Phebalium glandulosum* (Phebglan); *Styphelia laeta* (Styplaet); *Westringia eremicola* (Westerem).

Group No. 19 – Mallee Red Gum on rocky ridges

Indicator species: ***Eucalyptus nandewarica*** (Mallee Red Gum) and ***Olearia ramulosa*** (Twiggy Daisy-Bush, Oily Bush, Water Cypress).

Geoecology: Typically, shallow sandy or rocky soils on ridges, associated with dry sclerophyll forest and heath communities, especially Mugga Ironbark and Green Mallee.

Life form composition: Shrub and a mallee.

Species composition: (N=12) *Leucopogon neo-anglicus* (Leucneo), *Prostanthera nivea* (Prosnive), *Acacia viscidula* (Acacvisc), *Cassinia uncata* (Cassunca), *Eucalyptus nandewarica* (Eucanand), *Goodenia ovata* (Goodovat), *Kunzea* species D (Kunzsp.d), *Leionema viridiflorum* (Leioviri), *Olearia ramulosa* (Olearamu), *Ozothamnus obcordatus* (Ozotobco), *Prostanthera cruciflora* (Proscruc), *Senna aciphylla* (Sennacip).

Group No. 20 – Cheese Tree gully rainforest
Indicator species: *Glochidion ferdinandi* (Cheese Tree) and *Omalanthus populifolius* (Bleeding Heart, Native Poplar).
Geoecology: Gully rainforest or rainforest margins at lower elevations.
Life form composition: Trees, a shrub and a vine.
Species composition: (N=4) *Glochidion ferdinandi* (Glocferd); *Morinda jasminoides* (Morijasm); *Omalanthus populifolius* (Omalpopu); *Zieria cytisoides* (Ziercyti).

Group No. 21 – Rusty Fig rocky gully rainforest
Indicator species: *Acmena smithii* (Lilly Pilly), *Alectryon forsythii* and *Ficus rubiginosa* (Port Jackson Fig, Rusty Fig).
Geoecology: Typically, rainforest and rainforest margins in warm sheltered rocky gullies.
Life form composition: Trees, shrubs, climbers and a tree fern.
Species composition: (N=18) *Stephania japonica* (Stepjapo); *Acmena smithii* (Acmesmit); *Adriana tomentosa* (Adritomt); *Alectryon forsythii* (Alecfors); *Breynia cernua* (Breycern); *Cassinia leptocephala* (Casslept); *Celastrus subspicata* (Celasubs); *Clematis aristata* (Clemaris); *Coprosma quadrifida* (Coprquad); *Cyathea australis* (Cyataust); *Discaria pubescens* (Discpube); *Eucalyptus cypellocarpa* (Eucacype); *Eucalyptus elliptica* (Eucaelli); *Ficus rubiginosa* (Ficurubi); *Melicope micrococca* (Melimicr); *Pittosporum undulatum* (Pittundu); *Plectranthus parviflorus* (Plecparv); *Sambucus gaudichaudiana* (Sambgaud).

Group No. 22 – Black Sally subalpine forest on fertile soils
Indicator species: *Eucalyptus stellulata* (Black Sally) and *Eucalyptus nobilis* (Forest Ribbon Gum).
Geoecology: Typically forest at high altitudes on fertile soils associated with swampy areas.
Life form composition: Trees and shrubs.
Species composition: (N=7) *Eucalyptus nobilis* (Eucanobi); *Eucalyptus stellulata* (Eucastel); *Leptospermum gregarium* (Leptgreg); *Leucopogon hookeri* (Leuchook); *Leucopogon lanceolatus* (Leuclanc); *Olearia alpicola* (Oleaalpi); *Pimelea ligustrina* (Pimeligu).

Group No. 23a – Coolah Box forest on rocky mountain slopes
Indicator species: *Eucalyptus volcanica* (Coolah Box) and *Mirbelia oxylobioides* (Mountains Mirbelia).
Geoecology: Typically, high altitude and escarpment slopes on shallow volcanic soils; associated with sclerophyll forest.
Life form composition: Shrubs and a tree.
Species composition: (N=8) *Scaevola albida* (Scaealbi), *Bertya mollissima* (Bertmoll), *Cassinia theodori* (Casstheo), *Eucalyptus volcanica* (Eucavolc), *Hakea eriantha* (Hakeeria), *Kunzea opposita* (Kunzoppo), *Mirbelia oxylobioides* (Mirboxyl), *Pultenaea species I* (Pultspei).

Group No. 23ba – Snow Gum-Mountain Gum forest at high altitudes
Indicator species: *Eucalyptus dalrympleana* (Mountain Gum) and *Eucalyptus pauciflora* (White Sally, Snow Gum).
Geoecology: Typically, moist mountain forest or woodland above 700 metres elevation adjacent to cool temperate rainforest.
Life form composition: Trees and shrubs.
Species composition: (N=6) *Acacia dealbata* (Acacdeal), *Acacia melanoxylon* (Acacmela), *Eucalyptus dalrympleana* (Eucadalr), *Eucalyptus pauciflora* (Eucapauc), *Lomatia arborescens* (Lomaarbo), *Rubus parvifolius* (Rubuparv).

Group No. 24 – Blackbutt dry sclerophyll forest on poor sandy soil
Indicator species: *Eucalyptus andrewsii* (New England Blackbutt, Gum-topped Peppermint) and *Boronia microphylla* (Small-leaved Boronia).
Geoecology: Typically, poor sandy soils derived from sandstone or granite; associated with dry sclerophyll forest, woodland and heath.
Life form composition: Trees and shrubs.
Species composition: (N=20) *Acacia brownii* (Acacbrow), *Acacia myrtifolia* (Acacmyrt), *Boronia microphylla* (Boromicr), *Boronia polygalifolia* (Boropoly), *Daviesia latifolia* (Davilati), *Dodonaea filifolia* (Dodofili), *Eucalyptus andrewsii* (Eucaandr), *Eucalyptus malacoxylon* (Eucamala), *Eucalyptus youmanii* (Eucayoum), *Gompholobium huegelii* (Gomphueg), *Hibbertia linearis* (Hibbline), *Hovea heterophylla* (Hovehete), *Leucopogon microphyllus* (Leucmicr), *Olearia myrsinoides* (Oleamyrs), *Opercularia aspera* (Operaspe), *Persoonia cornifolia* (Perscorn), *Persoonia fastigiata* (Persfast), *Pultenaea campbellii* (Pultcamp), *Pultenaea* species C (Pultspez) and *Rhytidosporum diosmoides* (Rhytdios)

Group No. 25 – Mint Bush shrubs on warm temperate rainforest margins
Indicator species: *Prostanthera lasianthos* (Victorian Christmas Bush, Mint Bush) and *Rapanea howittiana* (Muttonwood, Brush Muttonwood).
Geoecology: Typically on the margins of warm temperate rainforest.
Life form composition: Shrubs.
Species composition: (N=4) *Cassinia compacta* (Casscomp); *Prostanthera lasianthos* (Proslasi); *Rapanea howittiana* (Rapahowi); *Senecio linearifolius* (Seneline).

Group No. 26 – Saltbush-Nitre Bush shrubs on over-grazed plains
Indicator species: *Atriplex stipitata* (Mallee Saltbush) and *Nitraria billardierei* (Nitre Bush).
Geoecology: Typically, over-grazed or eroded areas.
Life form composition: Shrubs.
Species composition: (N=3) *Atriplex stipitata* (Atristip); *Nitraria billardierei* (Nitrbill).

Group No. 28 – Weeping Bottlebrush sclerophyll shrubs on sandstone or granite
Indicator species: *Acacia fimbriata* (Fringed Wattle), *Acacia granitica* and *Callistemon viminalis* (Weeping Bottlebrush).
Geoecology: Typically, on sandy soils on sandstone and granite outcrops along watercourses; associated with dry sclerophyll forest and heath.
Life form composition: Shrubs and a tree.
Species composition: (N=12) *Acacia fimbriata* (Acacfimb); *Acacia granitica* (Acacgran); *Acacia torringtonensis* (Acactorr); *Callistemon viminalis* (Callvimi); *Cryptandra propinqua* (Crypprop); *Daviesia umbellulata* (Daviumbe); *Dodonaea triquetra* (Dodotriq); *Grevillea beadleana* (Grevbead); *Hovea longifolia* (Hovelonf); *Leptospermum brachyandrum* (Leptbrac); *Notelaea linearis* (Noteline); *Pomaderris lanigera* (Pomalani).

Group No. 29 – Granite Dry Sclerophyll Forest to Woodland

Indicator species: *Acacia betchei*, *Acacia pruinosa*, *Acacia williamsiana* and *Astrotricha roddii.*

Geoecology: A dry sclerophyll forest to woodland community that occurs on granite and rocky sites mostly in mountainous areas.

Life form composition: Shrubs and/or tree.

Species composition: (N=14) *Acacia betchei* (Acacbetc); *Acacia pruinosa* (Acacprui); *Astrotricha roddii* (Astrrodd); *Bertya oleifolia* (Bertolei); *Calotis dentex* (Calodent); *Hibbertia species B* (Hibbspec); *Leucopogon melaleucoides* (Leucmela); *Logania albiflora* (Logaalbi); *Olearia gravis* (Oleagrav); *Pultenaea flexilis* (Pultflex); *Stylidium laricifolium* (Styllari); *Zieria fraseri* (Zierfras); *Acacia williamsiana* (Acacwili); *Phyllanthus carpentariae* (Phylcarp).

Group No. 30 – Currawang and Ruby Urn Heath

Indicator species: *Acacia doratoxylon* and *Melichrus erubescens*

Geoecology:

Life form composition: Trees and shrubs

Species composition: (N=14) *Daviesia mimosoides* (Davimimo), *Acacia lanigera* (Acaclani), *Allocasuarina verticillata* (Allovert), *Dodonaea truncatiales* (Dodotrun), *Indigofera coronillifolia* (Indicoro), *Phebalium nottii* (Phebnott), *Platysace lanceolata* (Platlanc), *Pseudanthus divaricatissimus* (Pseudiva), *Rhytidosporum procumbens* (Rhytproc), *Acacia doratoxylon* (Acacdora), *Acrotriche rigida* (Acrorigi), *Melichrus erubescens* (Melierub), *Dillwynia sieberi* (Dillsieb), *Leptospermum divaricatum* (Lepsdiva).

Group No. 31 – Broombush mallee on sandy red earths

Indicator species: *Melaleuca uncinata* (Broombush) and *Melaleuca erubescens* (Pink Honey-myrtle).

Geoecology: Typically, sandy red earths (which may be subject to flooding); associated with mallee communities.

Life form composition: Shrubs, including a multi-stemmed shrub.

Species composition: (N=7) *Acacia pravifolia* (Acacpraf), *Dodonaea heteromorpha* (Dodohete), *Hibbertia incana* (Hibbinca), *Melaleuca erubescens* (Melaerub), *Melaleuca uncinata* (Melaunci), *Micromyrtus sessilis* (Micrsess), *Westringia cheelii* (Westchee).

Group No. 32 – Mugga Ironbark Rocky Sandstone Community

Indicator species: *Eucalyptus sideroxylon, Eucalyptus nubila, Allocasuarina gymnanthera* and *Astroloma humifusum.*

Geoecology: A dry sclerophyll woodland, heath to open forest community that predominantly occurs in sandy stony soil on a variety of substrates including sandstone, shale and basalt. This community may also occur on sandy flats, hillsides and ridges. In western NSW *Persoonia curvifolia*, *Eucalyptus sideroxylon* and *Astroloma humifusum* grow in association with *Acacia doratoxylon.*

Life form composition: Shrubs and trees.

Species composition: (N=21) *Acacia caesiella* (Acaccaes); *Acacia triptera* (Acactrip); *Acacia ulicifolia* (Acaculic); *Acacia verniciflua* (Acacvern); *Allocasuarina gymnanthera* (Allogymn); *Astroloma humifusum* (Astrhumi); *Dillwynia juniperina* (Dilljuni); *Eucalyptus camaldulensis<->chloroclada* (Eucacach); *Eucalyptus nubila* (Eucanubi); *Eucalyptus sideroxylon* (Eucasidx); *Grevillea arenaria* (Grevaren); *Hakea decurrens* (Hakedecu); *Hibbertia monogyna* (Hibbmono); *Leucopogon virgatus* (Leucvirg); *Philotheca ericifolia* (Phileric); *Leucopogon attenuatus* (Leucatte); *Micromyrtus striata* (Micrstri); *Persoonia curvifolia* (Perscurv); *Prostanthera saxicola* (Prossaxi); *Pultenaea boormanii* (Pultboor); *Pultenaea cunninghamii* (Pultcunn);

Group No. 33 – Black Sheoak woodland on sandy soils
Indicator species: *Angophora leiocarpa* and *Allocasuarina littoralis* (Black Sheoak)
Geoecology: Typically, infertile sandy soils associated with dry sclerophyll forest or woodland and Buck Spinifex communities.
Life form composition: Trees and shrubs.
Species composition: (N=9) *Acacia conferta* (Acacconf), *Allocasuarina littoralis* (Allolitt), *Angophora leiocarpa* (Angoleio), *Calytrix longiflora* (Calylong), *Dodonaea triangularis* (Dodotria), *Hovea lanceolata* (Hovelanc), *Jacksonia scoparia* (Jackscop), *Petalostigma pubescens* (Petapube), *Xylomelum cunninghamianum* (Xylocunn).

Group No. 34 – Narrow-leaved Stringybark Forest Complex
Indicator species: *Eucalyptus sparsifolia,* E*. dawsonii, E. polyanthemos* and *E. punctata*
Geoecology: A complex group containing a number of sub-groups. Further diagnosis is required.
Life form composition: Trees and shrubs.
Species composition: (N=21) *Acacia echinula* (Acacechi), *Goodenia stephensonii* (Goodstep), *Persoonia chamaepitys* (Perschai), *Acacia ausfeldii* (Acacausf), *Acacia linearifolia* (Acaclinr), *Acacia subulata* (Acacsubu), *Dillwynia phylicoides* (Dillphyl), *Eucalyptus dawsonii* (Eucadaws), *Eucalyptus polyanthemos* (Eucapola), *Eucalyptus punctata* (Eucapunc), *Eucalyptus sparsifolia* (Eucaspar), *Hibbertia circumdans* (Hibbcirc), *Melichrus procumbens* (Meliproc), *Melichrus* sp. aff. *erubescens* (Melisaer), *Persoonia linearis* (Persline), *Podolobium ilicifolium* (Podoilic), *Poranthera corymbosa* (Poracory), *Pultenaea linophylla* (Pultlino), *Pultenaea microphylla* (Pultmicr), *Solanum brownii* (Solabrow), *Solanum campanulatum* (Solacamp).

Group No. 35 – Bluebush shrubs on calcareous soils
Indicator species: ***Maireana pyramidata*** (Black Bluebush, Shrubby Bluebush) and ***Maireana sedifolia*** (Pearl Bluebush)
Geoecology: Typically, calcareous soils.
Life form composition: Shrubs.
Species composition: (N=4) *Acacia victoriae* (Acacvict); *Maireana pyramidata* (Mairpyra); *Maireana sedifolia* (Mairsedi); *Sclerolaena decurrens* (Scledecu).

Group No. 36 – Hillside Sandy Heath Community.
Indicator species: *Allocasuarina distyla* and *Pultenaea petiolaris.*
Geoecology: Heath community that grows on sandstone hillsides and gullies.
Life form composition: Shrubs.
Species composition: (N=3) *Allocasuarina distyla* (Allodist); *Pomaderris angustifolia* (Pomaangu); *Pultenaea petiolaris* (Pultpeti).

Group No. 37 – Native Cascarilla shrubs on red earths
Indicator species: *Croton phebalioides* (Native Cascarilla) *and Lycium australe* (Australian Boxthorn).
Geoecology: Typically, red earths; associated with mallee or Bimble Box communities.
Life form composition: Shrubs.
Species composition: (N=4) *Croton phebalioides* (Crotpheb); *Isotropis foliosa* (Isotfoli); *Lycium australe* (Lyciaust); *Spartothamnella puberula* (Sparpube).

Group No. 38 – Silver Croton Woodland – Rainforest Margins
Indicator species: *Croton insularis* (Silver Croton); *Indigofera brevidens; Sarcostemma australe* and *Correa glabra.*
Geoecology: A woodland – rainforest margin community that predominately occurs on stony or rocky sites on a variety of soils in escarpment ranges.
Life form composition: Trees and shrubs.
Species composition: (N=12) *Correa glabra* (Corrglab); *Acalypha capillipes* (Acalcapi); *Croton insularis* (Crotinsu); *Cryptandra longistaminea* (Cryplong); *Dodonaea tenuifolia* (Dodotenu); *Hovea longipes* (Hovelonp); *Indigofera brevidens* (Indibrev); *Olearia canescens* (Oleacane); *Olearia viscosa* (oleaviso); *Sarcostemma australe* (Sarsaust); *Senna coronilloides* (Senncoro); *Streblus brunonianus* (Strebrun).

Group No. 39 – High Altitude Small Fruited Hakea Woodland – Rainforest Margins
Indicator species: *Astrotricha latifolia* and *Hakea microcarpa.*
Geoecology: A woodland to rainforest margin community that grows in wet situations and occurs on sandy or rocky soils.
Life form composition: Shrubs.
Species composition: (N=3) *Astrotricha latifolia* (Astrlati); *Hakea microcarpa* (Hakemicr*);* *Pultenaea spinosa* (Pultspin).

Group No. 40 – Brush Kurrajong Moist Eucalypt Forest.
Indicator species: *Commersonia fraseri* and *Keraudrenia corollata.*
Geoecology: A forest to rainforest margin community that occurs in rocky sites.
Life form composition: Shrubs and/or tree.
Species composition: *Keraudrenia corollata* (Keracoro); *Bertya sp Cobar-Coolabah* (Bertspea); *Commersonia fraseri* (Commfras).

Group No. 41 – Currawang Rocky Hill Community.
Indicator species: *Acacia burrowii burrowii* (Burrow's Wattle, Yarran, Currawang) and *Phebalium squamulosum.*
Geoecology: Dry sclerophyll forest, woodland or mallee communities in rocky, hilly areas with skeletal soils, including sands and red earths.
Life form composition: Shrubs and/or trees.
Species composition: *Acacia burrowii* (Acacburr); *Phebalium squamulosum* (Phebsquu); *Philotheca ciliata* (Philcili).

Group No. 42 - Dolly Bush Rocky Dry Sclerophyll Woodland-Forest
Indicator species: ***Cassinia aculeata*** (Dolly Bush) and ***Macrozamia secunda***
Geoecology: A dry sclerophyll woodland to forest community that predominately occurs on stony, sandy and skeletal.soils.
Life form composition: Shrubs.
Species composition: (N=6) *Cassinia aculeata* (Cassacul); *Cassinia cunninghamii* (Casscunn); *Grevillea sericea* (Grevseri); *Hibbertia cistoidea* (Hibbciso); *Kunzea parvifolia* (Kunzparv); *Macrozamia secunda* (Macrsecu).

Group No. 43x (43, 44, 45) – Grey Box forest on granitic soils
Indicator species: *Eucalyptus mollucanna* (Grey Box) and *Leionema rotundifolium* (Round-leaf Phebalium).
Geoecology: Typically, granitic soils; associated with dry sclerophyll forest and heath.
Life form composition: Trees and shrubs.
Species composition: (N=11) *Acacia leucoclada* (Acacleuc), *Callistemon linearis* (Calllins), *Acacia burbidgeae* (Acacburb), *Cassinia* species D (Casssp.d), *Eucalyptus caliginosa* (Eucacali), *Eucalyptus moluccana* (Eucamolu), *Eucalyptus stannicola* (Eucastan), *Leionema rotundifolium* (Leiorotu), *Leptospermum trinervium* (Lepttrin), *Kunzea obovata* (Kunzobov), *Leptospermum novae-angliae* (leptnova)

Group No. 47 – Dwarf Cherry open forest shrubs on sandy soils
Indicator species: ***Exocarpos strictus*** (Dwarf Cherry) and *Choretrum* species A.
Geoecology: Typically, sandy soils.
Life form composition: Shrubs.
Species composition: (N=4) *Choretrum* species A (Chorspea), *Acacia ligulata* (Acacligu), *Exocarpos strictus* (Exocstri), *Phyllanthus occidentalis* (Phylocci).

Group No. 48 – Inland White Mahogany Rocky Woodland Community
Indicator species: *Eucalyptus apothalassica, Eucalyptus banksii* and *Acacia amblygona.*
Geoecology: A woodland to forest community that predominately occurs in stony or sandy soils often on ridges or slopes.
Life form composition: Trees and shrubs.
Species composition: (N=8) *Acacia amblygona* (Acacambl); *Acacia sparsiflora* (Acacspas); *Daviesia nova-anglica* (Davinova); *Eucalyptus apothalassica* (Eucaapot); *Eucalyptus banksii* (Eucabank); *Eucalyptus subtilior* (Eucasubt); *Hovea purpurea* (Hovepurp); *Ozothamnus adnatus* (Ozotadna).

Group No. 49 – Weeping Boree forest
Indicator species: *Acacia vestita* and *Leucopogon juniperinus.*
Geoecology: A woodland to forest community that grows on steep slopes and gullies in various soils over shale and sandstone.
Life form composition: Shrubs and a cycad.
Species composition: (N=3) *Acacia vestita* (Acacvest); *Leucopogon juniperinus* (Leucjuni*);* *Macrozamia pauli-guilielmi* (Macrpaul).

Group No. 50x (50, 51, 52) – Stringybark Sheoak forest shrubs on sandy soils
Indicator species: *Allocasuarina inophloia* (Stringybark Sheoak), *Acacia juncifolia* (Rushed-leaved Wattle) and *Persoonia terminalis.*
Geoecology: Typically sandy or rocky soils associated with dry sclerophyll forest.
Life form composition: Shrubs.
Species composition: (N=8) *Persoonia terminalis* (Persterm); *Prostanthera cryptandroides* (Proscryp); *Acacia juncifolia* (Acacjunc); *Allocasuarina inophloia* (Alloinop); *Boronia rosmarinifolia* (Bororosm); *Dillwynia retorta* (Dillreto); *Acacia falciformis* (Acacfali); *Pultenaea polifolia* (Pultpoli).

Group No. 53 – Cycad Woodland- Forest on Sandy/Stony Soils
Indicator species: *Eucalyptus goniocalyx* , *Leptospermum sphaerocarpum*, *Macrozamia polymorpha* and *Macrozamia plurinervia.*
Geoecology: A woodland to forest community where the understorey is dominated by cycads. This community predominately occurs in sandy and stony soils often on slopes.
Life form composition: Trees, shrubs and cycads.
Species composition: (N=15) *Acacia piligera* (Acacpili); *Acacia sertiformis* (Acacsert); *Amyema pendulum* (Amyepend); *Bertya oblonga* (Bertoblo); *Bossiaea obcordata* (Bossobco); *Conospermum taxifolium* (Conotaxi); *Eucalyptus goniocalyx* (Eucagoni); *Eucalyptus rossii* (Eucaross); *Leptospermum sphaerocarpum* (Leptspha); *Macrozamia diplomera* (Macrdipl); *Macrozamia plurinervia* (Macrplur); *Macrozamia polymorpha* (Macrpoly); *Olax stricta* (Olaxstri); *Platysace linearifolia* (Platline); *Pultenaea canescens* (Pultcane).

Group No. 54 – Bent – Leaf Wattle Sandstone Dry Sclerophyll Woodland-Forest
Indicator species: *Acacia cultriformis, Acacia flexifolia, Zieria aspalathoides* and *Acacia gunnii.*
Geoecology: A dry sclerophyll woodland, heath to forest community that occurs on sandy, stony soils.
Life form composition: Shrubs and/or a tree.
Species composition: (N=19) *Gompholobium virgatum* (Gompvirg); *Acacia cultriformis* (Acaccult); *Acacia debilis* (Acacdebi); *Acacia flexifolia* (Acacflex); *Acacia gunnii* (Acacgunn); *Bertya gummifera* (Bertgumm); *Boronia ledifolia* (Boroledi); *Boronia warrumbunglensis* (Borowarr); *Coopernookia barbata* (Coopbarb); *Dampiera purpurea* (Damppurp); *Daviesia acicularis* (Daviacic); *Hemigenia cuneifolia* (Hemicune); *Hibbertia serpyllifolia* (Hibbserp); *Leucopogon parviflorus* (Leucparv); *Micrantheum ericoides* (Micreric); *Olearia microphylla* (Oleamicr); *Philotheca salsolifolia* (Philsals); *Rulingia procumbens* (Ruliproc*); Zieria aspalathoides* (Zieraspa).

Group No. 55 – Wyalong Wattle shrubland on sandy red earths
Indicator species: *Acacia cardiophylla* (Wyalong Wattle) and *Acacia havilandiorum.*
Geoecology: Typically sandy red earths in association with mallee communities.
Life form composition: Shrubs.
Species composition: (N=5) *Acacia cardiophylla* (Acaccard); *Acacia havilandiorum* (Acachavl); *Acacia lineata* (Acaclint); *Melaleuca densispicata* (Meladens); *Micromyrtus ciliata* (Micrcili).

Group No. 57 – Apple Box – Brittle Gum woodland on shallow sandy soil
Indicator species: *Eucalyptus bridgesiana* (Apple Box) and *Eucalyptus praecox* (Brittle Gum).
Geoecology: Typically dry sclerophyll woodland on shallow, usually sandy soil.
Life form composition: Trees, a shrub and a cycad.
Species composition: (N=5) *Acrotriche serrulata* (Acroserr); *Eucalyptus bridgesiana* (Eucabrid); *Eucalyptus nortonii* (Eucanort); *Eucalyptus praecox* (Eucaprae); *Macrozamia concinna* (Macrconc).

Group No. 58–Round-leaved Mint-Bush Rocky Sandstone Woodland
Indicator species: *Acacia venulosa* and *Prostanthera rotundifolia.*
Geoecology: A dry sclerophyll woodland to forest community that grows in sandy and stony soils over sandstone.
Life form composition: Shrubs.
Species composition: (N=5) *Acacia venulosa* (Acacvenu); *Pimelea stricta* (Pimestrc); *Plectranthus graveolens* (Plecgrav); *Prostanthera ovalifolia* (Prosoval); *Prostanthera rotundifolia* (Prosrotu).

Group No. 59 – Beefwood-Waxflower woodland shrubs on rocky hills
Indicator species: *Grevillea striata* (Beefwood) and *Philotheca difformis* (White Waxflower).
Geoecology: Typically, red earths on rocky hills; associated with woodland.
Life form composition: Trees and shrubs.
Species composition: (N=5) *Philotheca difformis* (Phildiff), *Acacia petraea* (Acacpetr), *Grevillea striata* (Grevstri), *Prostanthera ringens* (Prosring), *Sauropus trachyspermus* (Saurtrac).

Group No. 60 – Sugarwood shrubs on saline, solonized brown soils
Indicator species: ***Myoporum platycarpum*** (Sugarwood, False Sandalwood).
Geoecology: Typically, brown solonised soils or brown clay soils which may be saline.
Life form composition: Shrubs.
Species composition: (N=3) *Abutilon malvifolium* (Abutmalv); *Maireana brevifolia* (Mairbrev); *Myoporum platycarpum* (Myopplat).

Group No. 61 – Hovea heath on sandy soils
Indicator species: *Hovea linearis* (Narrow-leaf Hovea) and *Prostanthera granitica.*
Geoecology: Typically heath on sandy soils.
Life form composition: Shrubs.
Species composition: (N=3) *Hovea linearis* (Hoveline); *Pomaderris queenslandica* (Pomaquee); *Prostanthera granitica* (Prosgran).

Group No. 62 – Boomerang Wattle Woodland – Forest Community
Indicator species: *Acacia amoena, Bossiaea buxifolia* and *Hakea dactyloides*
Geoecology: This community occurs within a variety of habitats from dry sclerophyll woodland to forest on stony, sandy to clay soils.
Life form composition: Shrubs and a tree.
Species composition: (N=9) *Acacia amoena* (Acacamoe); *Acacia leptoclada* (Acaclept); *Bossiaea buxifolia* (Bossbuxi); *Bossiaea scortechinii* (Bossscor); *Choretrum candollei* (Chorcand); *Chorizema parviflorum* (Chorparv); *Euphorbia eremophila* (Eupherem); *Hakea dactyloides* (Hakedact); *Maytenus silvestris* (Maytsilv).

Group No. 64 – Beyer's Ironbark on sandy infertile soils
Indicator species: *Eucalyptus beyeriana.*
Geoecology: Typically sandy infertile soils.
Life form composition: Shrubs and a tree.
Species composition: (N=4) *Acacia acinacea* (Acacacin); *Eucalyptus beyeriana* (Eucabeya); *Styphelia angustifolia* (Stypangu); *Westringia rigida* (Westrigi).

Group No. 65 – *Bursaria* woodland shrubs in rocky areas
Indicator species: *Bursaria longisepala* and *Pimelea curviflora* (Curved Rice-flower)
Geoecology: Typically associated with dry sclerophyll forest or woodland in rocky situations.
Life form composition: Shrubs.
Species composition: (N=6) *Acacia salicina* (Acacsaln); *Bursaria longisepala* (Burslong); *Hibbertia acicularis* (Hibbacic); *Jasminum suavissimum* (Jasmsuav); *Phyllanthus subcrenulatus* (Phylsubc); *Pimelea curviflora* (Pimecurv).

Group No. 66 – Forest Red Gum on alluvial soils
Indicator species: *Eucalyptus tereticornis* (Forest Red Gum), *Callistemon sieberi* (River Bottlebrush) and *Pimelea strigosa*.
Geoecology: Typically, along rocky watercourses or on alluvial soils; asssociated with forest or woodland.
Life form composition: Trees and shrubs.
Species composition: (N=7) *Acacia paradoxa* (Acacpara), *Callistemon sieberi* (Callsieb), *Eucalyptus tereticornis* (Eucatere), *Melaleuca bracteata* (Melabrac), *Melia azedarach* (Meliazed), *Pimelea strigosa* (Pimestrg), *Casuarina cunninghamiana* subsp. *cunninghamiana* (River Oak, River Sheoak).

Group No. 67 – Sandplain Wattle shrubs near watercourses in open forest
Indicator species: *Pomaderris andromedifolia* and *Acacia murrayana* (Sandplain Wattle).
Geoecology: Typically; near watercourses; associated with open forest.
Life form composition: Shrubs and mistetoes.
Species composition: (N=4) *Acacia murrayana* (Acacmura); *Muellerina eucalyptoides* (Mueleuca); *Notothixos subaureus* (Notosuba); *Pomaderris andromedifolia* (Pomaandr).

Group No. 68 – Yellow Rattlepod shrubs on poor sandy soils
Indicator species: *Crotalaria mitchellii* (Yellow Rattlepod).
Geoecology: Typically, poor sandy soils
Life form composition: Shrubs.
Species composition: (N=3) *Crotalaria mitchellii* (Crotmitc), *Acacia irrorata* (Acacirro), *Hovea rosmarinifolia* (Hoverosm).

Group No. 69 – Heath on sandy soils
Indicator species: *Boronia anethifolia* and *Dampiera stricta*.
Geoecology: Typically heath on sandy soils.
Life form composition: Shrubs.
Species composition: (N=2) *Boronia anethifolia* (Boroanet); *Dampiera stricta* (Dampstri).

Group No. 70 – Rice-flower shrubs on sandy or rocky hillsides
Indicator species: *Pimelea penicillaris* (Sandhill Rice-flower) and *Indigofera australis* (Hill Indigo).
Geoecology: Typically, in rocky or sandy soil, often on hillsides; associated with dry sclerophyll forest.
Life form composition: Shrubs and a cycad.
Species composition: (N=8) *Canthium buxifolium* (Cantbuxi), *Hibbertia kaputarensis* (Hibbkapu), *Indigofera australis* (Indiaust), *Macrozamia stenomera* (Macrsten), *Olearia ramosissima* (Olearamo), *Phyllanthus gunnii* (Phylgunn), *Pimelea penicillaris* (Pimepeni), *Solanum elegans* (Solaeleg).

Group No. 71 – Sweet Quandong forest on sandy soils
Indicator species: *Dodonaea boroniifolia* (Fern-leaf Hopbush) and *Santalum acuminatum* (Sweet Quandong)
Geoecology: Typically sands, sandy loams or gravelly soil on ridges or hillsides.
Life form composition: Trees and shrubs.
Species composition: (N=7) *Acacia filicifolia* (Acacfili); *Cadellia pentastylis* (Cadepent); *Dodonaea boroniifolia* (Dodoboro); *Geijera paniculata* (Geijpani); *Parsonsia straminea* (Parsstra); *Pimelea pauciflora* (Pimepauc); *Santalum acuminatum* (Santacum).

Group No. 72 – Orange Mistletoe
Indicator species: *Acacia elongata*
Geoecology: Typically sandy soils but diagnosis unclear.
Life form composition: Shrubs and a pendent parasite.
Species composition: (N=5) *Acacia elongata* (Acacelon); *Dendrophthoe glabrescens* (Dendglab); *Muellerina bidwillii* (Muelbidw); *Pimelea glauca* (Pimeglau); *Pimelea micrantha* (Pimemica).

Group No. 73a – Fuzzy Box forest on river banks or floodplains
Indicator species: ***Eucalyptus conica*** (Fuzzy Box) and ***Templetonia stenophylla*** (Leafy Templetonia).
Geoecology: Typically, riverbanks or floodplains; associated with dry sclerophyll forest.
Life form composition: Shrubs and a tree.
Species composition: (N=6) *Acacia falcata* (Acacfala), *Bossiaea foliosa* (Bossfoli), *Daviesia genistifolia* (Davigeni), *Eucalyptus conica* (Eucaconi), *Pycnosorus thompsonianus* (Pycnthom), *Templetonia stenophylla* (Tempsten).

Group No. 75 – Velvet-bush sandy Red Earth association
Indicator species: *Lasiopetalum baueri* (Slender Velvet-bush) and *Owenia acidula* (Gruie, Colane).
Geoecology: Typically semi-arid areas on red sands or sandy red earths associated with mallee or Mulga communities.
Life form composition: Shrubs and a tree.
Species composition: (N=5) *Lasiopetalum baueri* (Lasibaue); *Lysiana linearifolia* (Lysiline); *Lysiana subfalcata* (Lysisubf); *Owenia acidula* (Owenacid); *Scaevola spinescens* (Scaespin).

Group No. 76 – Gum-topped Box woodland on loamy clay soils
Indicator species: *Eucalyptus microcarpa* (Gum-topped Box) and *Senecio cunninghamii* (Bushy Groundsel).
Geoecology: Typically, loamy clay soil of moderate fertility; associated with woodland including species of Casuarinaceae.
Life form composition: Trees, shrubs and mistletoes.
Species composition: (N=7) *Lysiana exocarpi* (Lysiexoc), *Acacia oswaldii* (Acacoswa), *Amyema cambagei* (Amyecamb), *Dodonaea macrossanii* (Dodomacr), *Eucalyptus microcarpa* (Eucamica), *Exocarpos aphyllus* (Exocaphy), *Senecio cunninghamii* (Senecunn).

Group No. 77x (77&78) – Native Currant shrubland on rocky slopes
Indicator species: *Acacia brachystachya* (Umbrella Mulga) and *Canthium latifolium* (Native Currant).
Geoecology: Typically dry rocky slopes, ridges and outcrops with shallow stony soils; associated with mulga-dominated vegetation.
Life form composition: Shrubs.
Species composition: (N=8) Group 77: (N=3) *Abutilon leucopetalum* (Abutleuc); *Canthium latifolium* (Cantlati); *Sida rohlenae* (Sidarohl). Group 78: (N=5) *Ptilotus obovatus* (Ptilobov); *Abutilon fraseri* (Abutfras); *Acacia brachystachya* (Acacbras); *Chenopodium curvispicatum* (Chencurv); *Solanum sturtianum* (Solastur).

Group No. 79 – Black Box floodplain woodland on heavy clays
Indicator species: *Eucalyptus largiflorens* (Black Box), *Atriplex vesicaria* (Bladder Saltbush) and *Sclerolaena divaricata* (Tangled Copperburr.
Geoecology: Typically, on heavy clay soils on the periodically waterlogged floodplains of major rivers; the composition of this community is partly a function of overgrazing.
Life form composition: Trees, shrubs and an epiphytes.
Species composition: (N=12) *Atriplex vesicaria* (Atrivesi); *Acacia pendula* (Acacpend); *Amyema quandang* (Amyequan); *Atriplex nummularia* (Atrinumm); *Chenopodium nitrariaceum* (Chennitr); *Eremophila maculata* (Eremmacu); *Eucalyptus largiflorens* (Eucalari); *Maireana aphylla* (Mairaphy); *Maireana decalvans* (Mairdeca); *Sclerolaena bicornis* (Sclebico); *Sclerolaena diacantha* (Sclediac); *Sclerolaena divaricata* (Sclediva).

Group No. 80 – Rare shrub species on clay soils
Indicator species: *Phyllanthus maderaspatensis.*
Geoecology: Poorly known, although *Phyllanthus maderaspatensis* is associated with heavy soils and soil disturbance.
Life form composition: Shrubs.
Species composition: (N=2) *Atriplex* species B (Atrispec); *Phyllanthus maderaspatensis* (Phylmada).

Group No. 81 – Colonising shrubs on heavy soils
Indicator species: *Sclerolaena muricata* (Black Rolypoly).
Geoecology: Typically disturbed sites on heavy soils; often associated with Bimble Box (*Eucalyptus populnea* subsp. *bimbil*).
Life form composition: Shrubs and a subshrub.
Species composition: (N=6) *Acacia farnesiana* (Acacfarn); *Eremophila debilis* (Eremdebi); *Maireana microphylla* (Mairmicp); *Sclerolaena muricata* (Sclemuri); *Sida spinosa* (Sidaspin); *Sida subspicata* (Sidasubs).

Group No. 82 – Sandalwood shrubland on rocky hillsides
Indicator species: *Santalum lanceolatum* (Northern Sandalwood).
Geoecology: Typically on poor soils in rocky areas, usually associated with eucalypt woodlands; also on sandy and clay soils.
Life form composition: Shrubs and a tree.
Species composition: (N=6) *Ehretia membranifolia* (Ehremem b); *Pittosporum angustifolium* (Pittangu); *Rhagodia parabolica* (Rhagpara); *Santalum lanceolatum* (Santlanc); *Solanum semiarmatum* (Solasemi); *Ventilago viminalis* (Ventvimi).

Group No. 83 – Bloodwood sandplain association
Indicator species: *Corymbia dolichocarpa* and *Corymbia tessellaris.*
Geoecology: Typically sandplains or sandy alluvial flats but also along riverbanks.
Life form composition: Tall trees.
Species composition: (N=2) *Corymbia dolichocarpa* (Basionym: *Eucalyptus dolichocarpa*) (Corydoli); *Corymbia tessellaris* (Corytess).

Group No. 85 – Hibiscus skeletal soil association
Indicator species: *Abutilon cryptopetalum* (Hill Lantern-flower).
Geoecology: Typically skeletal, gravelly soils, often on rocky hillsides.
Life form composition: Shrubs.
Species composition: (N=3). *Abutilon cryptopetalum* (Abutcryp); *Halgania brachyrhyncha* (Halgbrac); *Melhania oblongifolia* (Melhoblo).

3.3.7 Plant Community Modelling

Spatial modelling was carried out on woody and herbaceous species groups identified in PATN analyses with the purpose of producing GIS layers of predicted occurrence of each group across the greater BBS. Such layers provide summaries of floristic patterns across the area which can be used in much the same way as a suite of individual species models (Ferrier et al. in press), but which are much more manageable for conservation planning purposes.

Modelling was undertaken in order to assess the likely distribution of the overstorey communities identified by PATN analysis. As the first step in the modelling process, the sites versus species matrices for woody and herbaceous taxa were transformed using the results of the PATN analysis into site versus community matrices in preparation for statistical modelling using MS Access. Values in the matrix indicated for each group the proportion of the total species in the group present (Absolute Presence as defined in section 3.3.4) at each site (Figure 23).

Figure 23: Example of species file for modelling of community groups

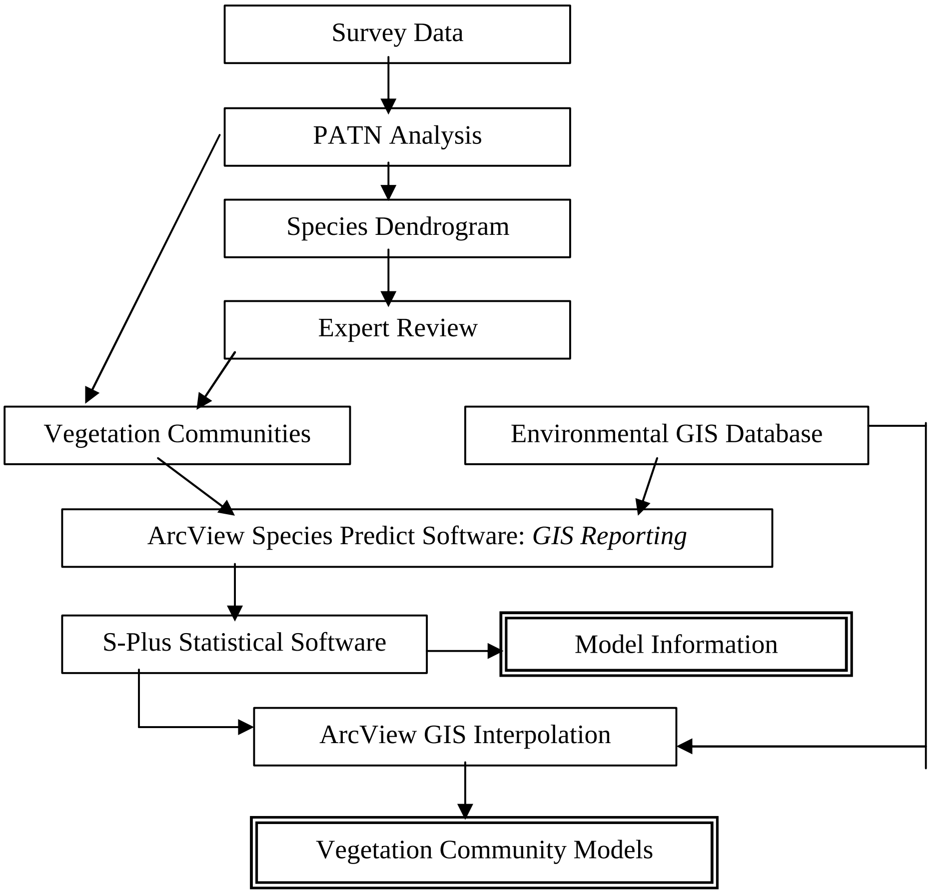
Sitecode	Longitude	Latitude	Method	Effort	1	10	11	12	13	14	15	16	17	18
a1FKLA	886357	6770921	10	1	0	0.57	0	0	0.19	0	0	0	0	0
a1FKLB	886389	6771170	10	1	0	0.57	0	0	0.06	0	0	0	0	0
a1FKLC	887763	6773135	10	1	0	0.43	0	0	0.13	0	0	0.05	0	0
a1FKLD	887700	6773078	10	1	0	0.57	0.08	0	0.13	0	0	0.05	0	0
a1FKLE	887547	6773226	10	1	0	0.43	0.08	0.11	0.06	0	0	0.05	0	0
a1FKLF	887206	6773214	10	1	0	0.43	0	0.11	0.06	0	0	0	0	0
a1FKLG	884881	6770886	10	1	0	0.57	0.08	0.11	0.25	0	0	0.05	0	0
a1OKLA	886391	6770809	10	1	0	0.14	0	0	0.06	0	0	0.05	0	0
a2OKLA	886076	6770915	10	1	0	0.29	0	0	0.06	0	0	0	0	0
a2OKLB	886079	6770975	10	1	0	0.29	0	0	0.13	0	0	0.05	0	0

Generalised Additive Modelling (GAM), Generalised Linear Modelling (GLM) and Generalised Dissimilarity Modelling (GDM) were utilised to assess relationships between proportional community presence and a variety of environmental variables. The use of multiple analytical methods was adopted for the TFP in order to compare the ouputs of alternative methods. The GAM and GLM techniques used for community modelling are identical to plant species modelling (Section 2.5), with the exception that the columns within the species file represent communities and the values in that column represent the proportion of species within each group occurring at each site (Figure 24).

Inputs to Community Modelling

Three sets of species groups were modelled: woody species (86 groups), herbaceous species (150 groups) and a broad classification of herbaceous species (33 groups). This second classification of herbaceous species was carried out because a large proportion of original herbaceous species groups yielded too few presence values to enable them to be modelled.

Figure 24: Spatial modelling (GAM / GLM) of species groups



General Dissimilarity Modelling (GDM)

As described earlier in this report, the main approach used to model distributions of species groups in the BBS involved fitting a separate GLM or GAM to the data for each species group. While this approach has many strengths (Ferrier et al. in press), a potential weakness is that the models are fitted independently of one another – i.e. each model is based on the data for a single species group, and ignores the data for all other species groups. Each model is therefore fitted using a relatively small proportion of the total information contained in the data-set, which may limit the power of such models – especially for species groups occurring at a small number of sites (i.e. with small sample sizes). Greater power might be achieved by modelling all of the species groups simultaneously – i.e. fitting a single multivariate model to the entire data-set. We trialed such an approach to modelling species groups in the BBS through a combination of generalised dissimilarity modelling (GDM) and k-nearest neighbour learning.

GDM is a recently developed statistical technique for modelling the biological dissimilarity (turnover in species composition) between pairs of survey sites as a function of the environmental and geographical separation of these sites (Ferrier et al. 1999b; Ferrier 2002; Ferrier et al. in press). The basic analytical strategy of GDM is derived from that of permutational matrix regression (e.g. Legendre et al. 1994) which uses multiple linear regression to predict the dissimilarities in a sites-by-sites matrix (the response) as a function of distances in one or more independent (explanatory) matrices. In the application of interest here the response matrix contains biological dissimilarities between all pairs of survey sites calculated using the Bray-Curtis measure (Bray and Curtis 1957). A sites-by-sites matrix is also prepared for each of the explanatory variables. For example, if one of these variables is mean annual rainfall, then a matrix is prepared in which each value is the difference in rainfall between a given pair of sites. Significance testing in matrix regression is performed by Monte Carlo permutation to overcome the problem of dependency between pairs of sites. For previous examples of the application of matrix regression to ecological data see Poulin and Morand (1999), Ferrier et al. (1999a) and Duivenvoorden et al. (2002).

GDM extends the technique of matrix regression to address two types of non-linearity commonly encountered in ecological data sets: 1) non-linearity in the relationship between ecological separation and observed biological dissimilarity is accommodated by fitting models using generalised linear modelling (McCullagh and Nelder 1989) instead of ordinary linear regression; 2) variation in the rate of biological turnover along different parts of an environmental gradient is accommodated through automated non-linear transformation of environmental variables, using I-splines (Winsberg and De Soete 1997).

The general strategy by which GDM was used to model distributions of species groups in the BBS is depicted in Figure 25. The derivation of “woody” and “herbaceous” species groups using PATN has already been described earlier in this report. Each of the sites-by-species data matrices used in the PATN analysis (one for woody species and one for herbaceous species) were also used to derive a GDM. The compositional dissimilarity between pairs of survey sites (Bray-Curtis measure based on presence/absence of species) was modelled in relation to: mean annual temperature, mean annual rainfall, Prescott moisture index, relative elevation index, soil fertility, rooting depth, distance to major rivers / water bodies, distance to any stream / river / water body, and geographical separation. Each of these environmental layers was then transformed according to the I-spline function fitted in the GDM, thereby generating a transformed multivariate environmental / geographical space that best fits the observed pattern of floristic dissimilarities within the region (one space for the woody data-set and another for the herbaceous data-set). The transformed layers were derived and stored at 25m grid resolution.

For each grid-cell in the region, the predicted proportion of species in each species group was then estimated using variable-kernel similarity metric (VSM) learning (Lowe 1995), a form of k-nearest neighbour learning. For each species group, *i*, the proportion of species from this group, p_i, occurring at a grid-cell was predicted as a function of the proportions observed at the *J* survey sites nearest to (i.e. most similar to) the cell within the transformed environmental / geographical space:

$$p_i = \frac{\sum_{j=1}^{J} n_j s_{ij}}{\sum_{j=1}^{J} n_j}$$

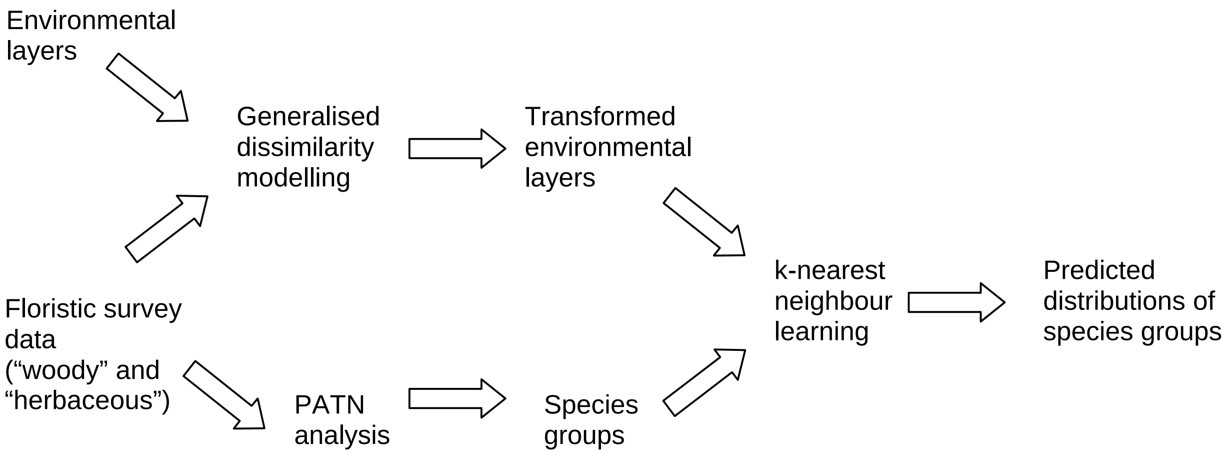
where s_{ij} is the proportion of species in group *i* observed at survey site *j*, and n_j is a distance weighting for site *j*, calculated as:

$$n_j = \exp\left[\frac{-d_j^2}{2r\left(\sum_{m=1}^{J} d_m \Big/ J\right)^2}\right]$$

where d_j is the distance (in transformed environmental / geographical space) between the grid-cell of interest and survey site *j*, and *r* is a constant determining how quickly the weighting of sites declines with increasing distance. The values assigned to *J* and *r* were optimised through cross-validation of the survey data (see Lowe 1995 for details).

This combination of GDM and VSM (Figure 25) was used to generate predicted distribution maps for 86 woody species groups (appendix 13)..

Figure 25: Process of GDM



Results of Plant Community Modelling

Community models for woody and herbaceous species groups are presented in Appendix 11. Each community model is represented by maps depicting the predicted distribution of the community based on the fitted model. The grey scale indicates the likelihood of occurrence of the community, with lighter greys representing lower likelihood and darker greys representing higher likelihood.

The modelling software produces two more maps depicting the lower and upper 95% confidence limits for the predicted distribution. These are derived using the estimated error bands associated with functions of the fitted model. The confidence limit maps can be interpreted as follows: at a given location within the region we are 95% confident that the true probability of recording the species lies between the probability depicted on the lower confidence limit map and the probability on the upper confidence limit map. The lower confidence limit map is useful for identifying an area where we are highly confident a species exists, and the upper confidence limit map is useful for identifying areas where high confidence of the absence of a species is required (NSW NPWS, 1994a). Whilst these maps were generated for each species group they are not presented here.

Model Evaluation

GAM / GLM Woody Groups

Seventy-one of the 86 woody species groups yielded enough presence sites to allow modelling. Of these only 3 (groups 56, 64 and 77) had model outputs rated as 'Very Poor' (Table 52). A further 16 were rated 'Poor' or 'Fair-Poor', mostly due to high overprediction ratings rather than low deviance explained (refer to section 2.5 for discussion on overpredicting models).A further 30 were rated as 'Good.' Models for groups 3, 22 and 23a were rated as 'Very Good', having deviance explained greater than 60 and low-moderate overprediction values.

GAM/ GLM Fine Herbaceous Groups

Only 54 of the 150 fine herbaceous groups had enough presence sites to be modelled. Model fit for these groups was poor compared to targeted flora species and woody species groups, with 5 groups rated as 'Very Poor' and a further 17 rated as Poor' or "Fair-Poor' (Table 53). Models with low (<15) deviance explained were common. 13 models rated as 'Good' but no models achieved a 'Very Good' rating.

GAM/GLM Broad Herbaceous Groups

Reclassifying herbaceous species into fewer, larger groups allowed all but 3 groups to be modelled, but lead to mixed success in producing improved model outputs. Four of the 30 models were rated as 'Very Poor', the highest proportion for any model set (Table 54). A further 7 were rated as '-Poor' or ' Fair Poor'. Only 5 received a 'Good' rating and no models were rated as 'Very-Good'.

Table 52: Model outputs summary for woody species groups

Group	Model Chosen	Presence Sites	Deviance Explained	Overprediction Rating[1]	Overall Rating[2]	Probability Range	Predictors
2	GLM	25	78.88	4	G	0–99	Tempseas, Rough3, Aspct8ct, Topind5, Climzone
3	GAM	23	61.37	3	VG	0–99	Tempseas, Climzone, Topind10, Dlwcfert, Nibwet25
4	GLM	16	59.19	3-4	G	0–78	Tempseas, Dlwcfert, Pstress, Nibwet25, Longitude
5	GAM	706	26.11	2	G	0–63	Radseas, Tempseas, Prcpwrmq, Dlwcwhc, Dlwcfert, Dlwcdrain
6	GAM	509	21.16	1	G	0–56	Tempseas, Mntempwq, Dlwcfert, Dlwcwhc, Dlwcdrain, Longitude
7	GAM	1609	36.01	0	G	0–99	Tempseas, Prcpwrmq, Pstress, Raddryq, Dlwcwhc, Longitude
8	GAM	1169	38.71	1	G	0–99	Tempseas, Prcpwrmq, Pstress, Mntempdq, Raddryq, Longitude
9	GAM	494	27.75	1	G	0–77	Radseas, Prcpwrmq, Tempanrg, Pstress, Mntempdq, Longitude
10	GAM	624	19.23	1	G	0–83	Tempseas, Prcpwrmq, Raddryq, Nibwet25, Dlwcfert, Longitude
11	GAM	1169	26.89	0	G	0–97	Radseas, Tempseas, Prcpwrmq, Waterprox, Dlwcfert, Latitude
12	GAM	1390	24.93	0	G	0–99	Radseas, Prcpwrmq, Topind5, Tempanrg, Slopecat, Longitude
13	GAM	1111	24.03	0	G	0–98	Radseas, Topind5, Slopecat, Mntempdq, Dlwcwhc, Longitude
14	GAM	139	45.68	2	G	0–95	Radseas.PRcpwrmq, Waterprox, Dlwcwhc, Dlwcfert, Tempanrg
15	GAM	742	38.53	1	G	0–91	Radseas, Tempseas, Prcpwrmq, Mntempdq, Dlwcfert, Longitude
16	GAM	1790	18.34	1	G	0–90	Tempseas, Prcpwrmq, Radwetq, Dlwcwhc, Dlwcfert, Longitude
17	GAM	112	31.18	4	G	0–64	Radseas, Prcpwrmq, Mntempdq, Dlwcrootd, Slopecat, Latitude
18	GAM	59	26.29	5	F	0–36	Avantemp, Raddryq, Dlwcrootd, Dlwcfert, Tempseas, Latitude
19	GLM	186	12.66	2	F-P	0–38	Prcpwrmq, Dlwcfert, Pstress, Nibwet25, Dlwcwhc, Longitude
20	GAM	13	56.32	5	G	0–96	Avrain, Topind10, Tempanrg, Latitude
21	GAM	205	39.66	1	G	0–99	Tempseas, Prcpwrmq, Waterprox, Mntempdq, Topind5, Latitude
22	GAM	45	76.34	3	VG	0–99	Tempseas, Raddryq, Topind10, Radwetq, Aspctnth
23a	GAM	71	63.02	3	VG	0–72	Tempseas, Prcpwrmq, Mntempdq
23b	GAM	293	37.11	2	G	0–97	Radseas, Tempseas, Prcpwrmq, Nibwet25, Mntempdq, Latitude
24	GAM	88	31.21	4	G	0–62	Prcpwrmq, Tempanrg, Mntempdq, Dlwcdrain, Prcpseas, Latitude
28	GAM	28	25.45	6	F-P	0–8	Prcpwetq, Raddryq
29	GAM	74	48.53	2	G	0–59	Radseas, Tempseas, Dlwcfert, Raddryq, Longitude
30	GAM	30	15.71	6	P	0–8	Dlwcdrain, Topind10, Dlwcfert, Longitude
31	GAM	456	28.27	1	G	0–79	Radseas, Tempseas, Prcpwrmq, Dlwcfert, Mntempdq, Longitude
32	GAM	423	35.23	2	G	0–81	Radseas, Prcpwrmq, Pstress, Dlwcfert, Mntempd, Dlwcwhc
33	GAM	363	23.01	2	G	0–74	Radseas, Prcpwrmq, Tempseas, Pstress, Dlwcdrain, Longitude
34	GAM	131	29.93	2	G	0–97	Tempseas, Raddryq, Dlwcfert, Dlwcrootd, Latitude, Longitude
36	GAM	10	34.95	6	P-F	0–5	Highprad, Prcpwetq
37	GAM	11	27.45	6	P-F	0–12	Mntempdq, Dlwcrootd
38	GAM	66	29.75	5-4	F	0–66	Mndiunrg, Nibwet25, Avrain, Dlwcwhc, Tempseas
39	GAM	10	40.96	4	G	0–44	Mntempcq, Dlwcdrain

41	GAM	84	23.72	5	F	0–45	Mintcq, Dlwcfert, Dlwcrootd, Radseas, Mntempdq, Longitude
42	GAM	42	32.92	3	G	0–59	Raddryq, Mntempcq, Tempseas, Latitude
44	GLM	11	38.82	5	G-F	0–32	Slope, Waterprox, Dlwcfert, Longitude
45	GAM	25	30.46	4	F-G	0–72	Radwetq, Tempseas, Climzone, Mntempdq, Latitude
48	GAM	28	35.26	5	F	0–40	Prcpwrmq, Lowprad, Pstress, tempseas, Raddryq, Latitude
50	GAM	42	53.07	4-5	F-G	0–74	Radseas, Prcpwrmq, Mntempdq, Dlwcwhc, Topind10, Latitude
51	GAM	11	27.77	6	F-P	0–8	Radwetq, Prcpdryp
53	GAM	172	28.02	3	G	0–79	Radseas, Mntempdq, Prcpwrmq, Dlwcrootd, Dlwcfert, Topind5
54	GAM	242	25.41	3	G	0–51	Radseas, Tempseas, Mntempdq, Dlwcwhc, Prcpwrmq, Dlwcfert
55	GAM	42	26.37	5-6	F	0–22	Prcpwrmq, Highprad, Dlwcwhc, Tempseas
56	GAM	41	8.73	6	VP	0–6	Mntempcq, Raddryq, Dlwcdrain
57	GAM	39	42.34	5	F-G	0–38	Tempseas, Prcpdryp, Slopecat
58	GAM	37	20.06	6-5	F-P	0–56	Prcpwrmq, Raddryq, Dlwcrootd
59	GAM	14	18.94	6	P	0–5	Radseas, Topind10
60	GAM	12	35.42	6	F-P	0–10	Avrain, Radcold, Longitude
61	GAM	15	20.75	6	P	0–4	Avrain, Raddryq
62	GAM	38	15.62	6	P	0–18	Prcpseas, Nibwet25, Prcpwetq, Longitude
63	GAM	10	34.21	6	F-P	0–17	Radwarm, Prcpwetq, Dlwcwhc, Dlwcfert
64	GAM	26	11.56	6	VP	0–11	Dlwcrootd, Tempanrg, Nibwet25, Longitude
65	GAM	283	22.1	1	G	0–87	Tempseas, Prcpwrmq, Prcpseas, Dlwcwhc, Topind5, Raddryq
66	GAM	81	23.28	3	G	0–74	Waterprox, Climzone, Dlwcwhc, Raddryq, Pstress, Latitude
67	GAM	26	18.77	5	F-P	0–25	Prcpseas, Raddryq, Dlwcrootd
68	GAM	18	22.8	6	P	0–11	Prcpdryp, Waterprox, Longitude
69	GAM	16	32.43	6	P	0–10	Raddryq, Prcpwetwq, Latitude
70	GAM	133	12.01	4	F-P	0–24	Prcpwrmq, Prcpseas, Raddryq, Tempseas
71	GAM	98	17.58	5	F-P	0–35	Mndiunrg, Dlwcfert, Aspctnth, tempseas, Latitude, Longitude
72	GAM	76	20.67	4	F	0–37	Prcpwrmq, Mntempdq, Raddryq, Dlwcrootd, Tempanrg, Latitude
73	GAM	135	13.77	4	F-P	0–36	Tempseas, Mintcq, Dlwcwhc, Dlwcfert, Dlwcdrain, Longitude
76	GAM	141	21.07	4	F	0–76	Radseas, Slopecat, Mntempdq, Tempseas, Prcpwrmq, Raddryq
77	GAM	10	13.96	6++	VP	0–1	Mntempcq
79	GAM	165	23.39	3	F-G	0–64	Prcpwrmq, Radwetq, Mntempdq, Dlwcdrain, Latitude, Longitude
80	GAM	15	50	4	G-F	0–38	Mntempcq, Tempseas
81	GAM	658	29.22	0	G	0–87	Radseas, Prcpwrmq, Dlwcfert, Mntempdq, Longitude, Latitude
82	GAM	175	17.71	4	F	0–60	Radseas, Maxtwp, Raddryq, Topind10, Aspct8ct, Longitude
83	GAM	51	31.8	5	F	0–51	Radseas, Raddryq, Dlwcwhc, Mntempcq, Latitude
84	GAM	23	26.97	5-6	F-P	0–93	Tempseas, Mintcq, Dlwcfert, Nibwet25, Latitude

[1] Based on validation plots (Appendix 11). Values range between 0 (Negligible over-prediction) and 6 (Extreme over-prediction)

[2] Based on validation plots and devience explained. Values range between VP (Very Poor) and VG (Very Good).

Table 53: Model outputs summary for fine herbaceous species groups

Group	Model Chosen	Presence Sites	Devience Explained	Overpredict Rating[1]	Overall Rating[2]	Probability Range	Predictors
1	GAM	378	13.43	1-2	F-P	1-89	Radseas, Raddryq, Prcpwrmq, Pstress, Dlwcwhc, Longitude
2	GAM	1407	16.22	2	F	6-79	Tempseas, Radwetq, Prcpdryq, Dlwcfert, Dlwcwhc, Mntempdq
3	GAM	730	12.33	1-2	F-P	1-87	Tempseas, Prcpwrmq, Radwetq, Raddryq, Dlwcdrain, longitude
4	GAM	1676	25.37	0	G	2-95	Radseas, Tempanrg, Mntempdq, Dlwcwhc, Dlwcfert, Longitude
5	GAM	1247	21.98	0	G	1-99	Tempseas, Pstress, Raddryq, Dlwcwhc, Longitude, Latitude
6	GAM	1259	24.68	0	G	1-99	Tempseas, Pstress, Raddryq, Dlwcwhc, Longitude, Latitude
7	GAM	2476	14.72	1	F	3-13	Prcpwrmq, Radwetq, Slopecat, Dlwcfert, Waterprox, Mntempdq
8	GAM	2041	16.31	0	F	2-12	Radseas, Tempseas, Prcpwrmq, Waterprox, Dlwcwhc, Longitude
9	GAM	1934	14.82	0	F	3-99	Radseas, Tempseas, Prcpwrmq, Waterprox, Mntempdq, Latitude
10	GAM	1729	14.31	0	F	3-99	Radseas, Tempseas, Prcpwrmq, Waterprox, Longitude, Latitude
11	GAM	1451	17.33	0	F	3-99	Radseas, Tempseas, Prcpwrmq, Waterprox, Dlwcfert, Raddryq
13	GAM	1177	14.76	0	F	0-98	Radseas, Tempseas, Prcpwrmq, Dlwcfert, Waterprox, Longitude
14	GAM	947	15.38	0	F	0-95	Tempseas, Prcpwrmq, Waterprox, Dlwcfert, Raddryq, Longitude
15	GAM	757	13.84	0	F-P	0-94	Tempseas, Prcpwrmq, Waterprox, Dlwcfert, Raddryq, Longitude
16	GAM	540	13.18	1	F-P	0-89	Tempseas, Waterprox, Dlwcfert, Prcpwrmq, Longitude, Latitude
17	GAM	403	10.55	1	F-P	0-78	Tempseas, Dlwcfert, Waterprox, Prcpwrmq, Topind10, Longitude
18	GAM	253	10.81	2	F-P	0-61	Dlwcfert, Waterprox, Prcpwetq, Highprad, Latitude
19	GAM	144	12.53	3	F-P	0-88	Dlwcfert, Topind10, Waterprox, Climzone, Aspct4ct, Tempseas
20	GAM	90	13.26	3-4	F-P	0-87	Topind10, Dlwcfert, Climzone, Aspct4ct, Waterprox, Dlwcdrain
21	GAM	55	14.08	4	F-P	0-91	Topind10, Climzone, Dlwcdrain, Dlwcfert
22	GAM	29	15.16	5	P	0-80	Highprad, Dlwcrootd, Topind5, Raddryq, Longitude
23	GAM	13	22.88	5	F-P	0-92	Prcpdryp, Topind5, Tempseas
24	GAM	18	10.09	6++	VP	0-4	Raddryq, Maxtwp
36	GAM	62	38.31	3	G	0-67	Waterprox, Mintcq, Dlwcfert, Mndiunrg
38	GAM	119	29.1	2-3	G	0-64	Radwetq, Topind5, Nibwet25, Dlwcdrain, Dlwcfert, Tempseas
39	GAM	22	31.66	3-4	G	0-68	Dlwcwhc, Waterprox, Tempseas, Mintcq, Raddryq, Latitude

40	GAM	241	37.02	2	G	0-91	Radseas, Prcpwrmq, Dlwcwhc, Dlwcfert, Tempanrg, Slopecat
41	GAM	211	38.92	2	G	0-74	Radseas, Prcpwrmq, Dlwcfert, Nibwet25, Dlwcwhc, Longitude
42	GAM	141	37.04	2	G	0-63	Radseas, Prcpwrmq, Dlecfert, Nibwet25, Dlwcdrain, Longitude
43	GAM	170	41.13	3	G	0-64	Radseas, Prcpwrmq, Dlwcfert, Topind5, Dlwcwhc, Slopecat
44	GAM	266	37.45	1	G	0-91	Radseas, Prcpwrmq, Dlwcfert, Slopecat, Waterprox, Longitude
45	GAM	496	32.32	1	G	0-87	Radseas, Prcpwrmq, Dlwcfert, Dlwcwhc, Raddryq, Longitude
46	GAM	422	25.95	1	G	0-72	Radseas, Prcpwrmq, Dlwcfert, Dlwcwhc, Longitude, Latitude
47	GAM	243	24.49	2	F-G	0-78	Radseas, Prcpwrmq, Dlwcfert, Dlwcwhc, Waterprox, Longitude
48	GAM	145	18.79	3	F	0-56	Maxtwp, Dlwcfert, Dlwcrootd, Waterprox, Longitude, Latitude
49	GAM	65	16.62	5	F	0-37	Avantemp, Waterprox, Dlwcfert
50	GAM	29	27.78	5	F-P	0-59	Maxtwp, Waterprox, Raddryq, Aspct4ct, Latitude
51	GAM	19	35.92	4	F	0-97	Mintcq, Dlwcwhc, Dlwcfert, Nibwet25, Waterprox
57	GAM	16	11.75	6++	VP	0-2	Prcpdryp, Nibwet25
62	GAM	15	15.8	5-6	F-P	0-99	Topind5, Nibwet25, Prcpseas
63	GLM	15	2.98	6++	VP	0-3	Prcpwrmq
66	GAM	31	22.86	4	F	0-36	Prcpwrmq, Tempseas, Nibwet25, Aspct4ct, Latitude
73	GAM	37	13.75	6++	VP	0-9	Prcpdryp, Raddryq, Latitude
96	GAM	21	36.5	4-5	F	0-74	Radwetq, Aspct8ct, Dlwcwhc, Tempseas, Longitude
98	GAM	11	30.96	6++	P	0-8	Prcpseas, Dlwcrootd, Latitude
103	GAM	11	44.47	5	F-G	0-45	Mntempwq, Slopecat, Nibwet25, Dlwcwhc
104	GLM	18	14.33	6	P	0-8	Radseas, Aspctnth
120	GAM	61	19.94	5	F-P	0-31	Prcpwetq, Tempanrg, Mntempdq, Dlwcdrain, Longitude, Latitude
123	GAM	11	30.07	5	F	0-37	Radcold, Climzone, Dlwcfert, Rough10
126	GAM	20	22.94	5	F	0-34	Mntempdq, Dlwcrootd, Dlwcfert
128	GAM	48	4.89	6++	VP	0-15	Mntempcq, Dlwcfert, Dlwcrootd
129	GAM	183	9.93	4	P	0-31	Maxtwp, Radseas, Topind10, Dlwcfert, Dlwcwhc, Latitude
140	GAM	24	37.64	5	F	0-30	Radseas, Tempseas, Rough10, Mntempdq, Latitude
144	GAM	10	38.22	6	F	0-78	Radcold, Tempseas

[1] Based on validation plots (Appendix 11). Values range between 0 (Negligible over-prediction) and 6 (Extreme over-prediction)

[2] Based on validation plots and devience explained. Values range between VP (Very Poor) and VG (Very Good).

Table 53: Model outputs summary for broad herbaceous species groups

Group	Model Chosen	Presence Sites	Devience Explained	Overprediction Rating[1]	Overall Rating[2]	Probability Range	Predictors
1	GAM	255	17.59	3	F-G	0-54	Tempseas, Prcpcldq, Mndiunrg, Nibwet25, Longitude, Latitude
2	GAM	2279	24.56	1	G	10-99	Radseas, Prcpwrmq, Dlwcwhc, Dlwcfert, Longitude, Latitude
3	GLM	184	17.47	2	F-G	0-87	Radwarm, Waterprox, Dlwcfert, Slopecat, Raddryq, Longitude
4	GAM	169	32.07	2	G	0-79	Radseas, Tempseas, Prcpwrmq, Dlwcdrain, Dlwcfert, Longitude
5	GAM	2581	17.06	2	F	26-99	Tempseas, Prcpwrmq, Radwetq, Waterprox, Slopecat, Latitude
6	GAM	39	11.77	6++	VP	0-6	Mntempwq, Raddryq, Tempseas, Longitude
7	GAM	289	10.66	3-4	P	0-39	Radwetq, Tempseas, Dlwcwhc, Dlwcdrain, Raddryq, Latitude
8	GAM	52	24.73	3	F	0-57	Avrain, Radwetq, Tempseas
9	GAM	238	35.42	1-2	G	0-99	Tempseas, Prcpwrmq, Topind5, Waterprox, Slopecat, Longitude
10	GAM	643	19.39	1	F-G	0-84	Radseas, Prcpwrmq, Dlwcwhc, Dlwcfert, Slopecat
11	GAM	81	26.78	3	F	0-90	Prcpwrmq, Tempseas, Topind10
12	GAM	261	15.91	4-5	F	0-34	Tempseas, Radwetq, Dlwcwhc, Dlwcfert, Mntempdq, Raddryq
13	GAM	131	26.66	3	F	0-74	Radwetq, Dlwcwhc, Raddryq, Dlwcfert, Slopecat, Latitude
14	GAM	28	5.21	6++	VP	0-1	Radwarm
15	GAM	144	26.33	3	F-G	0-62	Waterprox, Mintcq, Mndiunrg, Slopecat, Dlwcfert
16	GAM	55	18.81	5-6	F-P	0-17	Radseas, Prcpwrmq, Dlwcfert, Topind5, Tempanrg, Longitude
17	GAM	372	10.02	2	P	0-46	Radseas, Tempseas, Dlwcrootd, Prcpdryp, Dlwcfert, Longitude
19	GAM	120	16.12	3	F-P	0-36	Prcpwrmq, Mntempdq, Prcpseas, Raddryq, Tempseas, Longitude
20	GAM	60	13.31	5-6	P	0-23	Pstress, Tempseas, Aspctnth, Rough10
21	GAM	178	30.48	3	G	0-51	Prcpwrmq, Dlwcfert, Tempanrg, Dlwcdrain, Raddryq, Latitude
22	GAM	229	15.26	2-3	F	0-65	Prcpwrmq, Radwetq, Dlwcwhc, Nibwet25
23	GAM	63	7.94	5	VP	0-76	Tempseas, Nibwet25, Radwetq, Longitude
24	GAM	257	23.01	2-3	F-G	0-72	Radseas, Rough5, Pstress, Climzone, Dlwcwhc, Longitude
25	GAM	166	41.14	2	VG	0-98	Prcpwrmq, Mntempdq, Radwetq, Waterprox, Dlwcdrain, Dlwcwhc
26	GAM	80	12.93	4-5	P	0-47	Avantemp, Waterprox, Tempseas, Radseas, Dlwcwhc
27	GAM	753	26.41	0	G	0-90	Radseas, Prcpwrmq, Dlwcfert, Dlwcdrain, Longitude, Latitude
29	GAM	73	16.7	5-6	F-P	0-42	Avantemp, Radseas, Topind5, Tempseas, Dlwcrootd, Longitude
31	GAM	124	7.4	4	VP	0-37	Prcpwetq, Dlwcwhc, Raddryq, Latitude
32	GAM	90	13.85	5	P	0-38	Dlwcfert, Tempseas, Raddryq, Nibwet25, Lowprad, Dlwcwhc
33	GAM	2305	31.14	0	VG	7-99	Radseas, Prcpwrmq, Tempanrg, Dlwcwhc, Dlwcfert, Longitude

[1] Based on validation plots (see appendix 11). Values range between 0 (Negligible over-prediction) and 6 (Extreme over-prediction)

[2] Based on validation plots and devience explained. Values range between VP (Very Poor) and VG (Very Good).

Abiotic predictors for GAMs / GLMs

Woody Groups

Thirty-six of the 45 abiotic variables used emerged as predictors for woody groups (Table 54). Temperature seasonality was the most frequent predictor, and often emerged as the most important predictor in individual models as well. This is unsurprising in a study area which encompasses such a broad range of temperature conditions. Very high temperature seasonality is characteristic of the west of the greater BBS, including West Pilliga. The lowest seasonality occurs in the south-east of the greater BBS. Precipitation in the warmest quarter was the next most frequent predictor. Summer rainfall is lowest in the south west of the bioregion and highest in mountainous areas such as the Warrumbungles, Coolah Tops and Mount Kaputar. As for targeted flora species, latitude, longitude and soil fertility were also frequent predictors.

Fine Herbaceous Groups

Similar predictors were important in predicting distribution of fine herbaceous groups. Soil fertility was the most frequent predictor, followed by longitude and precipitation in the warmest quarter (Table 55). Proximity to water, only rarely important in modelling for woody groups, emerged frequently for fine herbaceous groups. Distinct groups emerged from PATN analyses which prefer stream banks, lake margins and/or areas subject to inundation.

Broad Herbaceous Groups

Water proximity is less important in broad herbaceous group models (Table 56). It seems likely that specialised riparian communities have been lumped together with non-riparian communities in the broad grouping. The important predictors for broad herbaceous groups were similar to woody and fine herbaceous group models, with temperature seasonality emerging most frequently.

Table 54: Importance of environmental variables in modelling of woody species groups

Layer	Description	No. of models where significant
Temperature		
avantemp	Annual mean temperature	1
mndiunrg	Mean Diurnal range (mean period max-min)	2
tempseas	Temperature Seasonality	34
maxtwp	Max Temperature of Warmest Period	1
mintcq	Min Temperature of Coldest Quarter	3
tempanrg	Temperature Annual Range	7
mntempwq	Mean Temperature of wettest quarter	1
mntempdq	Mean Temperature of driest quarter	21
mntempcq	Mean temperature of the coldest quarter	6
Precipitation		
avrain	Annual Precipitation	4
prcpdryp	Precipitation of driest period	3
prcpseas	Precipitation seasonality	5
prcpwetq	Precipitation of wettest quarter	5
prcpdryq	Precipitation of driest quarter	0
prcpwrmq	Precipitation of warmest quarter	31
prcpcldq	Precipitation of coldest quarter	0
Radiation		
anavrad	Annual mean Radiation	0
highprad	Highest period Radiation	2
lowprad	Lowest period radiation	1
radseas	Radiation of seasonality	22
radwetq	Radiation of wettest quarter	5
raddryq	Radiation of driest quarter	22
radwarm	Radiation of warmest quarter	1
radcold	Radiation of coldest quarter	1
Wetness		
nibwet25	Wetness gradient	9
Elevation/Topography		
topind5	Simple topographic index, 5 grid cell radius	6
topind10	Simple topographic index, 10 grid cell radius	7
rough5	Topographic roughness, 5 grid cell radius	0
rough3	Topographic roughness, 3 grid cell radius	1
rough10	Topographic roughness, 10 grid cell radius	0
slope	Slope	1
slopecat	Slope, reclassified into 5 categories	5
aspctnth	Aspect, reclassified into 6 categories relating to "northness"	2
aspct4ct	Aspect, reclassified into 4 categories	0
aspct8ct	Aspect, reclassified into 8 categories	2
Soils		
dlwcwhc	Estimated plant available water capacity	17
dlwcrootd	Estimated rooting depth	10
dlwcfert	Estimated soil fertility	25
dlwcdrain	Estimated soil drainage	9
Miscellaneous		
waterprox	Proximity to water	6
pstress	Plant stress index	9
longitude	Longitude	27
latitude	Latitude	20
climzone	Climatic zones based on average temperature and average rainfall	4
elevation	Elevation	0

Table 55: Importance of environmental variables in modelling of fine herbaceous species groups

Layer	Description	No. of Models Where Significant
Temperature		
avantemp	Annual mean temperature	1
mndiunrg	Mean Diurnal range (mean period max-min)	1
tempseas	Temperature Seasonality	21
maxtwp	Max Temperature of Warmest Period	4
mintcq	Min Temperature of Coldest Quarter	3
tempanrg	Temperature Annual Range	3
mntempwq	Mean Temperature of wettest quarter	1
mntempdq	Mean Temperature of driest quarter	7
mntempcq	Mean temperature of the coldest quarter	1
Precipitation		
avrain	Annual Precipitation	
prcpdryp	Precipitation of driest period	3
prcpseas	Precipitation seasonality	2
prcpwetq	Precipitation of wettest quarter	2
prcpdryq	Precipitation of driest quarter	1
prcpwrmq	Precipitation of warmest quarter	22
prcpcldq	Precipitation of coldest quarter	0
Radiation		
anavrad	Annual mean Radiation	0
highprad	Highest period Radiation	2
lowprad	Lowest period radiation	0
radseas	Radiation of seasonality	18
radwetq	Radiation of wettest quarter	5
raddryq	Radiation of driest quarter	13
radwarm	Radiation of warmest quarter	0
radcold	Radiation of coldest quarter	2
Wetness		
nibwet25	Wetness gradient	8
Elevation/Topography		
topind5	Simple topographic index, 5 grid cell radius	5
topind10	Simple topographic index, 10 grid cell radius	5
rough5	Topographic roughness, 5 grid cell radius	0
rough3	Topographic roughness, 3 grid cell radius	0
rough10	Topographic roughness, 10 grid cell radius	2
slope	Slope	0
slopecat	Slope, reclassified into 5 categories	5
aspctnth	Aspect, reclassified into 6 categories relating to "northness"	1
aspct4ct	Aspect, reclassified into 4 categories	4
aspct8ct	Aspect, reclassified into 8 categories	1
Soils		
dlwcwhc	Estimated plant available water capacity	17
dlwcrootd	Estimated rooting depth	5
dlwcfert	Estimated soil fertility	30
dlwcdrain	Estimated soil drainage	6
Miscellaneous		
waterprox	Proximity to water	21
pstress	Plant stress index	3
longitude	Longitude	22
latitude	Latitude	16
climzone	Climatic zones based on average temperature and average rainfall	4
elevation	Elevation	0

Table 56: Importance of environmental variables in modelling of broad herbaceous species groups

Layer	Description	No. of Models Where Significant
Temperature		
avantemp	Annual mean temperature	2
mndiunrg	Mean Diurnal range (mean period max-min)	2
tempseas	Temperature Seasonality	16
maxtwp	Max Temperature of Warmest Period	0
mintcq	Min Temperature of Coldest Quarter	1
tempanrg	Temperature Annual Range	3
mntempwq	Mean Temperature of wettest quarter	1
mntempdq	Mean Temperature of driest quarter	3
mntempcq	Mean temperature of the coldest quarter	0
Precipitation		
avrain	Annual Precipitation	1
prcpdryp	Precipitation of driest period	1
prcpseas	Precipitation seasonality	1
prcpwetq	Precipitation of wettest quarter	1
prcpdryq	Precipitation of driest quarter	0
prcpwrmq	Precipitation of warmest quarter	13
prcpcldq	Precipitation of coldest quarter	1
Radiation		
anavrad	Annual mean Radiation	0
highprad	Highest period Radiation	0
lowprad	Lowest period radiation	1
radseas	Radiation of seasonality	10
radwetq	Radiation of wettest quarter	8
raddryq	Radiation of driest quarter	9
radwarm	Radiation of warmest quarter	2
radcold	Radiation of coldest quarter	0
Wetness		
nibwet25	Wetness gradient	4
Elevation/Topography		
topind5	Simple topographic index, 5 grid cell radius	3
topind10	Simple topographic index, 10 grid cell radius	1
rough5	Topographic roughness, 5 grid cell radius	1
rough3	Topographic roughness, 3 grid cell radius	0
rough10	Topographic roughness, 10 grid cell radius	1
slope	Slope	0
slopecat	Slope, reclassified into 5 categories	6
aspctnth	Aspect, reclassified into 6 categories relating to "northness"	1
aspct4ct	Aspect, reclassified into 4 categories	0
aspct8ct	Aspect, reclassified into 8 categories	0
Soils		
dlwcwhc	Estimated plant available water capacity	12
dlwcrootd	Estimated rooting depth	2
dlwcfert	Estimated soil fertility	13
dlwcdrain	Estimated soil drainage	5
Miscellaneous		
waterprox	Proximity to water	6
pstress	Plant stress index	2
longitude	Longitude	14
latitude	Latitude	8
climzone	Climatic zones based on average temperature and average rainfall	1
elevation	Elevation	0

Limitations and Future Work

GAM/GLM modelling was much more successful for woody species than for herbaceous species. This was only partly caused by the more even spread in number of presence sites among woody groups. Most broad herbaceous groups carried more than enough presences for fitting a number of variables, but the models still performed badly. Lumping up of species into broad groups may have actually blurred relationships with environmental variables by grouping together species which have very different responses to their environment. Regardless of grouping method, this result appears to indicate a higher level of statistical noise among survey data for herbaceous species. Several factors may be contributing to this, such as the seasonality of surveys and periodic drought, the inclusion of ephemeral species in the herbacous dataset, grazing and other perturbations affecting ground cover, and difficulties with accurate identification of herbaceous taxa and grasses. Further examination of variation in species occurrence between different surveys and with season of survey is highly recommended as part of future work.

It may be more difficult to collect suitable predictors for modelling herbaceous species. Factors such as microclimate effects and the influence of overstorey structure are difficult to represent. Layers relating to overstorey vegetation were not available for the entire study area and therefore were not used. Refinement of models using overstorey vegetation may be possible in future work due to recent completion of Aerial Photographic Interpretation vegetation maps in many parts of the bioregion.

Latitude and longitude were frequent predictors in models of all groups, but were slightly less common than in targeted flora models. The discussion on the implications of models for which latitude and/or longitude area predictors in targeted flora models (see section 2.5.5) is also relevent to species group models. Although ecological (eg dispersal) charactistics are unlikely to be the major cause of limited distribution of whole groups of species, species groups may very well be relicts of previously widespread communities. Such relicts may have been created by climatic changes over thousands of years, by natural disturbance history or by recent disturbance (such as clearing) by humans. More work needs to be carried out to refine models based on ecological characteristics of groups and group members.

3.4 SIGNIFICANT PLANT COMMUNITIES

The conservation status of the plant communities known to occur within the BBS was reviewed with reference to the following sources of information, which are also detailed in Table 57:

(1) the *Conservation Atlas of Plant Communities in Australia* (Specht *et al.*, 1995);

(2) the *Stage One Brigalow Belt South Vegetation Survey and Mapping* report (Beckers and Binns, 2000);

(3) the New South Wales *Threatened Species Conservation Act 1995*;

(4) the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*; and

(5) the JANIS conservation criteria.

The results of the significant plant community search are summarised in Table 58 and detailed in Appendix 9. Each plant community is listed according to the following standard format:

- Community reference number
- Community name
- Floristic composition / diagnosis
- Conservation status
- API map layers (and polygon codes) or other relevant map data.

A map of each community derived from the relevant API layers and the corresponding polygon identification, is presented in Appendix 9.

Layers of predicted (reconstructed) cover of woody and herbaceous communities from GAM and GLM modelling were used as estimates of pre-clearing distribution in order to estimate levels of habitat loss. These values were used to highlight communities which are rare, vulnerable or threatened acording to JANIS criteria. JANIS conservation target values (Table 57) for modelled plant communities were calculated in three discrete steps: (1) the estimated pre-clearing extent of each community was calculated as the number of modelled hectares multiplied by the probability class value for each grid cell; (2) the estimated present extent of each community was calculated as the number of modelled hectares multiplied by the probability class value for each grid cell *only within* woody vegetation; (3) the proportional reduction in the extent of each community was calculated as the pre-clearing extent minus the present extent, divided by the pre-clearing extent. The resulting proportional reduction figure identifies which JANIS target applies to a particular community (ie. 100%. 60% or 15%).

TABLE 57: VEGETATION COMMUNITY CONSERVATION STATUS SOURCES, CATEGORIES AND CRITERIA

Source of Conservation Status Information		Categories of Significance	Criteria
1	Conservation Atlas of Plant Communities in Australia (Specht et al., 1995).	Poorly Conserved	The plant community is conserved in Australia in only one or two small reserves which are probably subject to human pressure. The range of biogeographic regions in which the community occurs is not represented and ecological diversity is not usually present in the reserves.
		Very poorly conserved	The plant community is conserved in Australia in only a few small reserves probably subject to human activities, which represent only a small component of the range of biogeographic regions in which the community occurs and ecological diversity is not present in the reserves; its conservation status is precarious.
		Not conserved	The plant community is not conserved in Australia in any conservation reserve.
2	Stage One BBS Vegetation Survey and Mapping report (Beckers and Binns, 2000).	Rare, threatened or highly cleared and modified vegetation overstorey types	The preliminary research findings of Beckers and Binns (2000), including comment based on Beeston (1980), Benson (1989, 1991, 1999), Robinson and Traill (1996) and the New South Wales Threatened Species Conservation Act 1995 (as amended).
3	New South Wales Threatened Species Conservation Act 1995 (as amended).	Endangered Ecological Community	Listed under the Act.
		Preliminary determination as an Endangered Ecological Community	Preliminary Listing under the Act.
4	Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (as amended)..	Threatened ecological community	Listed under the Act.
5	JANIS	Vulnerable Ecosystems	(a) An ecosystem approaching a reduction in areal extent of 70% within a bioregional context and which remains subject to threatening process; or (b) an ecosystem not depleted but subject to continuing and significant threatening processes which may reduce its extent.
		Rare Ecosystems	An ecosystem where its geographic distribution involves a total range of generally less than 10,000ha, a total area of generally less than 1000ha or patch sizes of generally less than 100ha, where such patches do not aggregate to significant areas.
		Endangered Ecosystems	An ecosystem where its distribution has contracted to less than 10% of its former erange or the total area has contracted to less than 10% of its former area, or where 90% of its area is in small patches which are subject to threatening processes and unlikely to persist.

TABLE 58: SIGNIFICANT PLANT COMMUNITIES OF THE GREATER BBS

No.	Significant Plant Community	Conservation Status
SPC-1	Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	Threatened Ecological Community (EPBC Act) Endangered Ecological Community (TSC Act) (Preliminary determinations) Plant community of possible conservation concern according to the IEP convened during Stage one of the BBS Bioregional Assessment.
SPC-2	Semi-evergreen vine Thickets	Threatened Ecological Community (EPBC Act) Endangered Ecological Community (Final determinations on the TSC Act)
SPC-3	Ooline	Endangered Ecological Community (TSC Act)
SPC-4	Carbeen Open Forest	Endangered Ecological Community (Final determinations on the TSC Act)
SPC-5	Grassy White Box Woodland	Threatened Ecological Community (EPBC Act)
SPC-6	Bluegrass Grasslands	Threatened Ecological Community (EPBC Act)
SPC-7	White Box – Yellow Box Blakely's Red Gum Woodland	Endangered Ecological Community (Final determinations on the TSC Act)
SPC-8	Native Vegetation on Cracking Clay Soils of the Liverpool Plains	Endangered Ecological Community (Final determinations on the TSC Act)
SPC-9	*Eucalyptus conica*	Rare, Threatened or Highly Cleared and Modified Vegetation Overstorey Type (Beckers & Binns, 2000)
SPC-10	*Eucalyptus dumosa*	Rare, Threatened or Highly Cleared and Modified Vegetation Overstorey Type (Beckers & Binns, 2000)
SPC-11	*Eucalyptus viridis*	Rare, Threatened or Highly Cleared and Modified Vegetation Overstorey Type; poorly reserved overstorey species (Beckers & Binns, 2000)
SPC-12	*Eucalyptus camaldulensis*	Rare, Threatened or Highly Cleared and Modified Vegetation Overstorey Type (Beckers & Binns, 2000) Plant community of possible conservation concern according to the IEP convened during Stage one of the BBS Bioregional Assessment.
SPC-13	*Eucalyptus populnea / E. pilligaensis*	Rare, Threatened or Highly Cleared and Modified Vegetation Overstorey Type (Beckers & Binns, 2000)
SPC-14	*Acacia pendula – Atriplex nummularia* low woodland	Poorly conserved community (Specht *et al.*, 1995)
SPC-15	*Acacia sparsiflora – Acacia burrowii* low open forest	Poorly conserved community (Specht *et al.*, 1995)
SPC-16	*Alectryon oleifolius – Convolvulus erubescens – Erodium cygnorum* savanna understorey to grassland	Poorly conserved community (Specht *et al.*, 1995)
SPC-17	*Allocasuarina luehumannii* low woodland	Poorly conserved community (Specht *et al.*, 1995)
SPC-18	*Arundinella nepalensis – Themeda triandra – Elymus scabrous – Aristida jerichoensis* savanna understorey	Poorly conserved community (Specht *et al.*, 1995)
SPC-19	*Atalaya hemiclauca (+/- E. terminalis)* low woodland	Poorly conserved community (Specht *et al.*, 1995)
SPC-20	*Brachychiton populneus*	Poorly conserved community (Specht *et al.*, 1995)
SPC-21	*Bursaria spinosa – Chrysocephalum apiculatum – Vittadinia sp. – Stipa eremophila*	Poorly conserved community (Specht *et al.*, 1995)
SPC-22	*Callistemon* spp.	Poorly conserved community (Specht *et al.*, 1995)
SPC-23	*Callitris endlicheri* low woodland – open forest	Poorly conserved community (Specht *et al.*, 1995)
SPC-24	*Eleocharis acuta – Potamogeton crispus – Typha* spp. Wetland	Poorly conserved community (Specht *et al.*, 1995)
SPC-25	*Eucalyptus intertexta (+/- E. populnea +/- Callitris glaucophylla)* low woodland	Poorly conserved community (Specht *et al.*, 1995)

No.	Significant Plant Community	Conservation Status
SPC-26	*Eucalyptus microcarpa – E. albens*	Poorly conserved community (Specht *et al.*, 1995)
SPC-27	*Eucalyptus moluccana – E. siderophloia* woodland	Poorly conserved community (Specht *et al.*, 1995)
SPC-28	*Eucalyptus sideroxylon* woodland	Poorly conserved community (Specht *et al.*, 1995) Plant community of possible conservation concern according to the Independent Expert Panel (IEP) convened during Stage one of the BBS Bioregional Assessment.
SPC-29	*Eucalyptus socialis – E. dumosa* open scrub	Poorly conserved community (Specht *et al.*, 1995)
SPC-30	*Themeda triandra – Elymus scabrous – Aristida jerichoensis* savanna understorey	Poorly conserved community (Specht *et al.*, 1995)
SPC-31	Myall *Acacia pendula*	Plant community of possible conservation concern according to the IEP convened during Stage one of the BBS Bioregional Assessment.
SPC-32	Mallee *Eucalyptus* spp.	Plant community of possible conservation concern according to the IEP convened during Stage one of the BBS Bioregional Assessment.
SPC-33	Broombush *Melaleuca uncinata*	Plant community of possible conservation concern according to the IEP convened during Stage one of the BBS Bioregional Assessment.
SPC-34	Themeda Grasslands *Themeda* spp.	Plant community of possible conservation concern according to the IEP convened during Stage one of the BBS Bioregional Assessment.
SPC-35	Baradine Red Gum *Eucalyptus chloroclada*	Plant community of possible conservation concern according to the IEP convened during Stage one of the BBS Bioregional Assessment.
SPC-36	Rare shrub species on clay soils (Woody Community No. 80)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-37	Native Currant shrubland on rocky slopes (Woody Community No. 77) REDEFINED	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-38	River Red Gum-Coolibah forest (Woody Community No. 14)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-39	Bloodwood sandplain woodland (Woody Community No. 83)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-40	Sandalwood shrubland on rocky hillsides (Woody Community No. 82)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-41	Colonising shrubs on heavy soils (Woody Community No. 81)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-42	Black Box floodplain woodland on heavy clays (Woody Community No. 79)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-43	(Woody Community No. 76)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-44	Fuzzy Box forest on river banks or floodplains (Woody Community No. 73) REDEFINED	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-45	Sugarwood shrubs on saline, solonized brown soils (Woody Community No. 60)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-46	Beefwood-Waxflower woodland shrubs on rocky hills (Woody Community No. 59)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-47	Wyalong Wattle shrubland on sandy red earths (Woody Community No. 55)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-48	Green and White Mallee on sandy red earths (Woody Community No. 18)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-49	Mulga-Brigalow plains woodlands on red earths (Woody Community No. 17)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-50	Poplar Box-Belah semi-arid woodland on clays (Woody Community No. 15)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).

No.	Significant Plant Community	Conservation Status
SPC-51	Berry Saltbush in Woodland Community (Woody Community No. 44)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-52	Grey Box forest on granitic soils (Woody Community No. 43)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-53	(Woody Community No. *42)*	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-54	Silky Browntop in Waterway Community on Clay (Herbaceous Community No. 41)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-55	(Herbaceous Community No. *40)*	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-56	Tall Spike-rush Aquatic Community (Herbaceous Community No. 39)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-57	Twin-leaved Bedstraw in Perennial Moist Community on Clay Soil. (Herbaceous Community No. 38)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-58	Swampy Perennial Community (Herbaceous Community No. 36)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-59	London Rocket in Woodland (Herbaceous Community No. 96)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-60	(Herbaceous Community No. *73)*	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-61	Curly Wig in Sclerophyll Forest on Sandstone (Herbaceous Community No. 66)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-62	Giant Maidenhair in Rainforest (Herbaceous Community No. 62)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-63	Dainy Everlasting in Clay Soil (Herbaceous Community No. 51)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-64	(Herbaceous Community No. *50)*	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-65	Crested Goosefoot on Sandy Soil (Herbaceous Community No. 49)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-66	Delicate Lovegrass on Sandy Soil (Herbaceous Community No. 48)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-68	Paddock Lovegrass in Woodland (Herbaceous Community No. 46)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-69	Windmill Grass on Heavy Soil (Herbaceous Community No. 45)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-70	(Herbaceous Community No. *3)*	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-71	Pale Grass-lily in Creek Community on Sandy Soil (Herbaceous Community No. 24)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-72	New Species in Damp Sandy Soil (Herbaceous Community No. 22)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-73	Damp Community (Herbaceous Community No. 21)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-74	Wet Community with Slender Onion Orchid (Herbaceous Community No. 20)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-75	Toad Rush in Open Woodland on Sandy Soil (Herbaceous Community No. 1)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-76	Rainforest Community (Herbaceous Community No. 19)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-77	Bordered Panic in Rainforest Margin Community (Herbaceous Community No. 18)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-78	Scrambling Lily in Forest Fern Community (Herbaceous Community No. 17)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).

No.	Significant Plant Community	Conservation Status
SPC-79	Common Milk Vine on Rainforest Margin (Herbaceous Community No. 16)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-80	Sheltered Herb Community (Herbaceous Community No. 15)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-81	Mountain Silkpod in Damp Rocky Fern Community (Herbaceous Community No. 14)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-82	Common Fringe-Lily in Dry Sclerophyll Forest (Herbaceous Community No. 126)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-83	Red-flowered Lotus on Sandy Soil (Herbaceous Community No. 23b)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-84	Rock Fern in Open Forest on Rocky Ground (Herbaceous Community No. 120)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).
SPC-85	Tiger Orchid (Herbaceous Community No. 104)	A rare, vulnerable or threatened community based on JANIS criteria (JANIS, 1997).

4. DISCUSSION

4.1 CONTEXT

This report represents a landmark in the study of plant biodiversity in western NSW. It establishes the integrated data baseline upon which future research into the flora and vegetation of the Brigalow Belt will depend.

The *BBS Targeted Flora Survey and Mapping Project* was established to provide biodiversity information on the flora of the NSW Brigalow Belt South Biogeographic Region (BBS) for use in the development of a Regional Forest Agreement (RFA) and in the design of regional conservation and resource management strategies. The project was funded by the *Resource and Conservation Assessment Council* (RACAC) as part of the regional assessments of western New South Wales. RACAC advises the State Government on land use planning and resource allocation issues.

As detailed in the project specifications (WRA 16), the objectives of the Targeted Flora Survey and Mapping Project were to:

1. Provide new data using targeted flora surveys on the distribution and, if possible abundance of specified flora for use in verifying future habitat mapping, species and habitat modelling

2. Collect information on specified flora and their habitat to fill as many gaps as possible, focusing on rare and threatened (ROTAP), regionally significant, overstorey dependant species or communities and old growth components

3. Collate information on the known and predicted regional distribution of each targeted species to provide regional context to the project

4. Assist in the identification of High Conservation Values (HCV)

5. Assist the identification of a Comprehensive, Adequate and Representative (CAR**)** Protected Area Network

6. Assist in developing conservation protocols as part of Ecologically Sustainable Forest Management (ESFM)."

Whilst these project objectives were clearly ambitious, they were not matched by sufficient project funding.The NSW National Parks and Wildlife Service, in recognition of the importance of the project for biodiversity conservation and bioregional planning, provided significant additional in-kind support. This support included resources from the WRA Unit for scientific research and review, data entry and analysis, documentation, administration, survey equipment and logistics support and GIS assistance. Additional support was also provided in the form of expert botanical input from the NPWS Western Directorate, NPWS Northern Directorate, and specialist analytical input from the NPWS GIS Research and Development Unit based at Armidale. Despite this additional support, the short timeframes meant that not all of the many project objectives could be met. In particular, an assessment of the distribution and status of old growth forest and overstorey dependent species or communities was beyond the scope of this project. Furthermore, significant additional research is required to evaluate project outputs before areas of high conservation value can be conclusively identified.

4.2 PROJECT OUTPUTS

Notwithstanding these limitations, the targeted flora project has met the majority of its project objectives and delivered a comprehensive suite of plant biodiversity information products of fundamental importance to the evaluation of regional conservation and resource management options for the BBS. These project outputs include:

1. an integrated abiotic dataset for use in spatial modelling and analysis
2. a comprehensive, attributed checklist of the vascular flora
3. a preliminary assessment of plant species richness by geographic province
4. an inventory of rare or threatened plant species
5. a comprehensive review of the state of knowledge of all rare or threatened species
6. ecological profiles for all species listed on the NSW TSC
7. habitat models and population maps for selected threatened species
8. an inventory of plant communities based on pre-existing research
9. an inventory and diagnosis of woody and herbaceous plant species groups based on a numerical classification of floristic data
10. habitat models for many of the woody and herbaceous plant species groups
11. an inventory and atlas of significant plant communities
12. a preliminary assessment of woody vegetation cover and habitat connectivity across the bioregion.

4.3 SUMMARY OF FINDINGS

The following paragraphs provide a concise overview of the key research findings.

Plant Species Inventory. A total of 116,563 plant locality records were collated and analysed, resulting in the identification of 2,458 vascular plant taxa for the Greater BBS, including 2,075 native and 383 exotic species (section 2.2.6).

Plant Species Richness. The plant species richness of the BBS was found to exceed the total native flora of Tasmania (1627). The Greater BBS also has a larger number of native taxa than regions within Western Australia and most regions within Queensland. Within the bioregion plant species richness was found to be concentrated within the Northern Basalts and the Talbragar Valley provinces. In contrast, the Northern Outwash province was found to be relatively depauperate in plant species, possibly due to the extent of vegetation loss (refer section 2.2.9).

Significant Plant Species. Botanical research including expert input resulted in the identification of 100 rare or threatened plant species for the Greater BBS, including 2 species considered extinct, 24 species listed as endangered, 24 species listed as vulnerable on the NSW Threatened Species Conservation Act (section 2.3.3). This amounts to 4% of the total vascular flora recorded for the Greater BBS. At least a further 7 taxa are likely be recognised as new to science, including new species of *Dianella*, *Oxalis*, *Platysace*, *Plectranthus* and *Ptilotus*.

Autecology of Significant Species. Targeted research and data collation has assembled all readily available ecological information for significant species, including ecological profiles for every plant species listed on the Threatened Species Conservation Act (Appendix 5). The state of ecological knowledge of every significant species has also been reviewed (section 2.3.6).

Targeted Flora Surveys. A total of 156 targeted flora searches were undertaken across the BBS, resulting in the confirmation of 14 existing rare plant localities and the location of 14 new rare plant localities (section 2.4.3).

Abiotic Modelling Dataset. An integrated suite of abiotic layers was assembled for modelling purposes and a number of new abiotic layers were derived (Appendix 10).

Rare Plant Habitat Modelling. Habitat models were derived for 18 threatened species using generalised additive and generalised linear modelling (Appendix 7). The majority of these models represented a good fit to the plant locality data.

Plant Community Inventory. A comprehensive inventory of the plant communities of the Greater BBS was undertaken with reference to existing API mapping, the Conservation Atlas of Specht *et al.* (1995) and the results of Stage 1 of the BBSal assessment (RACD, 2000). A total of 2,695 vegetation map codes were collated from 36 API datasets and 50 plant communities were identified in the Conservation Atlas, along with the 60 broad overstorey types recognised during Stage 1. Maps of each significant community are included in Appendix 9 where API mapping is available.

Plant Community Analyses. A suite of plant community analyses were conducted on a dataset of 5,221 full floristic sites located across western NSW, including site and species group classifications and ordinations using the PATN, S-Plus and ArcView software to manipulate, analyse and display the data. As result, 76 woody and 109 herbaceous plant species groups were diagnosed based on their species composition and autecology (3.3.5).

Plant Community Modelling. Habitat models were derived for 71 woody species groups, 54 fine herbaceous species groups and 30 broad herbaceous species groups. Overall, the majority of these models represented a good fit to the plant locality data.

Significant Plant Communities. A total of 35 plant communities were recognised as significant due to their listing on the Commonwealth Environment Protection and Biodiversity Conservation Act, the NSW Threatened Species Conservation Act, the Conservation Atlas of Specht *et al.* (1995) and Stage 1 of the BBSal assessment. A further 50 plant species groups identified by this study met the JANIS criteria for conservation as rare, vulnerable or endangered ecosystems (section 3.4).

5. CONCLUSION

5.1 OVERVIEW

The BBS Targeted Flora Survey and Mapping Project was established to provide biodiversity information on the flora of the BBS for use in the development of a Forest Agreement and in the design of regional conservation and resource management strategies.

In light of the project constraints, in terms of both timelines and available funding, a realistic but nonetheless challenging series of project aims were formulated to address most of the objectives set out in the project specifications:

- Collate all readily available information on the vascular flora and vascular plant communities of the Greater BBS and (where appropriate) store this information in an accessible digital format.
- Compile a list of all vascular plant species known to occur with the bioregion.
- Identify vascular plant species listed on the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the NSW *Threatened Species Conservation Act 1995* (TSC Act) or the Rare or Threatened Australian Plants (ROTAP) list of Briggs and Leigh (1996).
- Identify vascular plant species of conservation priority at a bioregional level using explicit criteria and/or expert botanical input.
- Undertake targeted rare plant surveys in order to validate existing locality records, collect autecological information, and to locate previously undiscovered rare plant populations.
- Where possible, undertake appropriate analyses in order to model the distribution of rare plant species.
- Undertake appropriate analyses in order to identify, characterise and map the vascular plant communities of the bioregion.
- Undertake appropriate research in order to identify any vascular plant communities of conservation priority that occur within the bioregion, including any communities listed on the EPBC Act or the TSC Act or otherwise considered to be of conservation priority by Specht *et al.* (1995) or other botanical experts.
- Identify areas of priority for the conservation of plant biodiversity within the BBS.

Each of these aims have been met, although project outputs will need to be integrated with a suite of additional bioregional planning layers (including vegetation ‘condition’) before areas of high conservation value for plant biodiversity can be conclusively identified (but refer Figure 13). Implementation of this ‘integration’ process is beyond the scope of this project.

5.2 PROJECT OUTPUTS

This report establishes a plant biodiversity data baseline for the Greater BBS built upon a comprehensive series of biodiversity information products:

1. an integrated abiotic dataset for use in spatial modelling and analysis (Appendix 10);
2. a comprehensive, attributed checklist of the vascular flora (Appendix 1);
3. a preliminary assessment of plant species richness by geographic province (refer section 2.2.9);
4. an inventory of rare or threatened plant species (Appendix 2, section 2.2.3);
5. a comprehensive review of the state of knowledge of all rare or threatened species (Table 37);
6. ecological profiles for all species listed on the NSW Threatened Species Conservation Act (Appendix 5);
7. habitat models and population maps for selected threatened species (Appendix 7);
8. an inventory of plant communities based on pre-existing research (section 3.2);
9. an inventory and diagnosis of woody and herbaceous plant species groups based on a numerical classification of floristic data (section 3.3);
10. habitat models for many of the woody and herbaceous plant species groups (Appendix 11);
11. an inventory and atlas of significant plant communities (section 3.4, Appendix 9);

5.3 KEY FINDINGS

This study has established that the flora of the Greater BBS is surprisingly diverse, with at least 2,075 native taxa. This tally exceeds the total native flora of Tasmania by more than 25%. The vegetation of the bioregion is also regarded as complex, with at least 75 woody and 109 herbaceous communities now recognised. The plant communities range from Snow Gum forests to rainforest, to sclerophyll woodland, mallee and heath. Communities more widespread in far western NSW are also represented, including Poplar Box-Belah semi-arid woodland and River Red Gum-Coolabah forest. New plant species continue to be discovered and this report lists 7 taxa awaiting formal description. At least 100 other species are considered to be rare or threatened. Several areas of rare plant concentrations have been identified in the vicinity of the Warrumbungles, Kaputar National Park, Warialda State Forest and Severn State Forest.

In addition to the research findings that directly relate to the flora and vegetation of the BBS, this study has applied state-of-the-art analytical techniques to the modelling of plant community distributions, including Generalised Additive Modelling (GAM) and Generalised Dissimilarity Modelling (GDM). The correspondence between the outputs of these quite different modelling techniques demonstrates the power of the geostatistical approach to the study of plant-environment relationships.

5.4 RECOMMENDATIONS

Targeted Flora Survey and Mapping Project (TFP)

Firstly and foremost, it is recommended that the outputs of the TFP are used to inform plant biodiversity conservation and land management in the bioregion, including the development of a comprehensive, adequate and representative reserve system.

Validating and Updating TFP Outputs

In order for outputs to be fully utilised, validation and refinement of models is a high priority for future work. Expert opinion should be utilised and independent validation data collected for the purposes of validation of model outputs. Uncertainty analysis of models using such datasets and other available sources would inform future users or the quality and reliability of each model.

Refinement should be carried out on a species/community specific basis and further layers (such as vegetation floristics and cover) introduced if/when extra datasets become available. Subsetting of absence records to exclude those which are well away from the ecological niche of species should be trialled, as this may improve levels of model fit. Inclusion of opportunistic records with an accuracy rating of '1000m' might also improve results for species which mainly occur in flat areas. For these species such records are less likely to report erroneous values against topographic variables than for species in hilly parts of the bioregion.

The outputs of the TFP establish a data baseline for the BBS. It is recommended that this baseline is maintained by updating and redistributing copies of the relevant appendices on an annual basis to land management and planning agencies and other interested researchers or research organisations.

Databases

It is recommended that NPWS update its floristic and rare plant databases in light of the results of the TFP. The design and maintenance of the systematic sites database should be revised to accommodate additional data fields and to limit the number of data export problems associated with the complexities of plant nomenclature.

Preserving Research Expertise

It is strongly recommended that the research expertise built up during the TFP is conserved and project outputs safeguarded through the creation of more permanent research positions. Without staff continuity, bioregional assessment units will simply disappear along with their accumulated intellectual capital. Bioregional assessment should be regarded as a core activity of land resource management and planning in NSW rather than as ‘sunset’ enterprises.

Rare Plant Research and Conservation

Whilst this study represents a major step forward in the study of plant diversity and rare plant ecology within the bioregion, the level of knowledge of many rare plant species is not adequate to conduct even a preliminary population viability assessment (see Burgman *et al.*, 2000). As a consequence, it is not possible to prepare meaningful recovery plans for these species. Clearly, targeted research and surveys should be undertaken as a matter of priority to fill major gaps in the biological and ecological knowledge of these rare species (refer Table 37).

Rare plant surveys should be concentrated over the Spring months in order to obtain sufficient botanical material for accurate identifications. The survey methods detailed in section 2.4 can be used to guarantee a minimum dataset for preliminary population viability assessments (specifically, population mapping to estimate plant density). Surveys should be conducted across all tenures, provided that a properly resourced public liaison strategy is implemented prior to the survey effort. In most other respects, surveys should follow the recommendations of Cropper (1993).

The rare plant and plant community habitat models presented in Appendix 7 and 12 (respectively) can be used to identify target search areas. The rare plant locality spreadsheet presented in Appendix 3 should serve as the primary reference for a future validation surveys. These surveys are required where the accuracy of plant species location data needs to be improved or questionable records confirmed or rejected.

This report includes specific recommendations for the conservation of plant species within the bioregion that are listed on the TSC Act (Appendix 5).

Additional Systematic Surveys

Despite recent gap-filling surveys undertaken for the Joint Vegetation Mapping Project (JVMP), major deficiencies remain in the sampling of environmental heterogeneity across the bioregion, particularly within freehold tenure (refer Figure 11). Until survey sites can be located within these poorly sampled areas, the flora and vegetation of the bioregion will remain poorly known. It is recommended that a major survey program is planned and funded and that this program is supported by a well resourced public relations team.

Future systematic surveys should utilise the gap analysis and site selection software developed by the NPWS GIS Research and Development Unit in order to maximise the sampling of environmental heterogeneity. Use of this software during recent surveys has significantly improved the power of the floristic dataset, as evidenced by the greater clarity of plant species group diagnoses derived after gap-filling surveys compared to group diagnoses derived using the pre-existing dataset.

Plant Communities

Due to time constraints, diagnoses for the herbaceous plant communities remain at a preliminary stage. It is therefore recommended that further research is undertaken to finalise the diagnoses. It is also recommended that the 5,221 site analysis of the combined Darling Riverine Plains, BBS and Nandewar bioregions, upon which all plant community diagnoses were based (section 3.3), is published as a separate report into the plant biodiversity of western NSW.

Vegetation Mapping

Whilst there are over 30 individual vegetation map datasets with some coverage of the BBS, these datasets differ in their floristic classification, have inconsistent levels of map resolution and accuracy, were produced at different times over a 20 year period, and collectively provide only partial coverage of the study area. This information is nonetheless of considerable potential value in the conservation of plant biodiversity and in the management of natural resources *per se*. It is therefore recommended vegetation mapping is undertaken to fill gaps in the coverage of existing data layers. This mapping should be managed as a series of small, discrete projects rather than as a large and overly bureaucratic mapping program in order to guarantee steady progress. In the interim, a composite API map should be developed following the approach utilised for the Darling Riverine Plains (NPWS, in prep.).

Monitoring

Due to the general lack of time-series observations, the ecology of most plant communities is poorly understood. It is therefore recommended that a long-term plot-based monitoring program is established to study vegetation change (refer Likens, 1989). These plot based surveys could be supplemented by space-for-time substitution surveys over the short-term. The primary goal of monitoring would be to assess the temporal response of plant communities to ecological perturbations such as fire or to anthropogenic impacts such as logging.

Abiotic Data Layers

The integrated suite of data layers assembled for this study (Appendix 10) should be augmented by a suite of vegetation ‘condition’ and ‘disturbance’ layers. In particular, vegetation growth stage and historical land use data should be compiled on a bioregional basis. Scope also exists to derive a series of proximity functions (such as distance from woody vegetation) based on existing data layers. Soil property and soil type layers require further refinement, especially in the 15 km buffer zone surrounding the BBS. There is also a continuing need for a reliable land tenure layer.

Habitat Models

It is recommended that rare plant and plant community habitat models presented in Appendix 7 and 12 (respectively) are utilised for conservation planning purposes. The rare plant models can be used as inputs to population viability analyses or to delineate target search areas. The plant community models can be used as surrogates for biological diversity within landscape planning software (see Ferrier and Watson, 1997; Pressey, 1996). Whilst the rare plant and plant community habitat models presented in this report represent the ‘pure’ outputs of the GAM/GLM and GDM modelling approaches, these outputs can be further ‘refined’ for a range of purposes. There is scope, for example, to constrain both the rare plant and the plant community models with reference to the findings of autecological research. It is recommended that the habitat models are regarded as flexible planning tools that relate plant biodiversity entities to both niche parameters and geographic space.

Distribution Modelling

Whilst the GAM/GLM software utilised for the TFP ultimately delivered critical project outcomes, it is recommended that the NPWS evaluate the use of more modern software packages such as GRASP (Lehmann et al. 2002).

The correlation between GAM/GLM outputs and the results of GDM substantiate the value of this technique for plant community modelling. Work should be carried out to quantitatively evaluate outputs from this and other studies using GDM modelling. Given the greater efficiency of GDMcompared to GAM/GLM and its alternative analytical foundation, further development and application of this technique is strongly recommended. In particular, NPWS should support the development of a software package for use by non-specialists.

Software Development

A number of software applications have been developed to a basic prototype stage to meet the scientific challenges and timelines of the TFP. These GIS applications include: (1) a batch printing script; (2) a suite of grid manipulation tools designed to enhance the functionality of the ArcView GIS; (3) a vegetation map validation tool which measures map classes against systematic sites data; (4) a spatial correspondence reporting tool which assesses differences between two related layers; and (5) a descriptive modelling tool for use in circumstances where more robust techniques (such as GLM/GAM or GDM) may not be suitable. It is recommended that the expertise behind this developing technology is retained and that the continued development of these software products is supported by NPWS.

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APPENDICES

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