Final Project Report

Monitoring the rate of native woody vegetation change in the NSW wheatbelt

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Cover photograph: Coolabah (*Eucalyptus coolabah*) open woodland.

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1 Executive Summary

This report presents the results of research on the rate of change of native woody vegetation in the Central New South Wales wheatbelt. The study was carried out over three years and analysed vegetation change between the 1980s and 2000.

1.1 Background to this study

Prior to European settlement, most of Central New South Wales supported a diverse suite of temperate woodlands in a broad band across the state from the Queensland border in the north to the Victorian border in the south. Within this band there were also areas of treeless native grasslands, shrublands and wetlands[1,2]. Today, temperate woodlands are among the most poorly conserved and threatened ecosystems in Australia[3]. Over the last two hundred years, the wheatbelt has been progressively cleared for agriculture and what remains of the original native vegetation is mostly present as remnants of various sizes. These are often highly fragmented and degraded and vulnerable to further threats such as weed invasion, altered fire regimes and overgrazing by domestic stock and feral animals[2,4].

Clearing has been identified as the single greatest threat to terrestrial biodiversity in New South Wales[5]. The responses of species populations to the loss and fragmentation of native vegetation are complex and often difficult to predict in detail,[6] but the overall consequences of such drastic change are clear and include population and species extinctions and genetic loss[2,7,8,9].

Consistent, accurate and detailed information on vegetation clearing is an essential requirement for conservation assessment, landuse planning, law enforcement, evaluation of policy and legislative initiatives and ecological research. Making such information publicly available through regular monitoring programmes encourages wider and more informed debate and discussion.

The New South Wales National Parks and Wildlife Service has been carrying out detailed field survey and mapping of remnant vegetation in the wheatbelt since the 1980s. The present project is an extension of this work.

1.2 Key project outputs

1.2.1 Development and testing of methods to map change in native woody vegetation

The project tested methods to map changes in native woody vegetation using direct visual inspection of readily available Landsat TM satellite imagery. NPWS mapping of native woody vegetation types within the wheatbelt provided the 1980s baseline

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[1] Beadle 1981

[2] Sivertsen and Clarke 2000

[3] Yates and Hobbs 2000

[4] Benson 1999

[5] EPA 2000

[6] For example, see Cunningham 2000

[7] Saunders 1994

[8] Ford et al. 1995

[9] EPA 1997

information for the study. Clearing was identified on the satellite images and digitised. The resulting clearing maps were used to produce updated maps of remaining native woody vegetation for each monitoring period.

Systematic validation of the mapping was done by comparison with specially flown, fine-scale aerial photography. Validation results showed that the mapping consistently and accurately distinguished between clearing and areas of no-change with typical accuracy rates of approximately 95%.

1.2.2 Maps of remaining native woody vegetation in the study area

Maps of the remaining native woody vegetation were derived for each monitoring period. For the northern section of the study area (Band A as shown in Figure 1, page 9) the monitoring periods were 1985-94, 1994-98, and 1998-2000. For the remainder of the study area the monitoring periods were 1980s-1998, and 1998-2000. The starting year varied between 1980 and 1989 according to the dates of aerial photography used for the NPWS baseline vegetation mapping (Figure 10). Hard copy maps at the 1:250,000 scale for each monitoring period and each band accompany this report.

1.2.3 Analyses of vegetation change mapping

Data on the extent of native woody vegetation were derived from the mapping. Rates of clearing and statistics on patch sizes were calculated for overall vegetation and individual vegetation types. Detailed results for change in the extent and level of fragmentation for individual vegetation types can be found on the CD-ROM that accompanies this report.

1.2.4 Publication of results

A paper describing the research methods and presenting results for the northern wheatbelt (Moree region)[10] has been independently reviewed and accepted for publication in the journal *Cunninghamia*. Publication in a peer-reviewed scientific journal is confirmation of the research methods and the significance of the project results.

1.3 Major findings of the study

1.3.1 Extent of clearing in the wheatbelt

Extensive clearing of native woody vegetation continued in the wheatbelt throughout the study period. The amount of clearing differed between parts of the study area. The highest values occurred in the northern wheatbelt (Band A: the Moree region; see Figure 1), where 17.8% of the native woody vegetation, 118,000 hectares, was cleared in the period 1985-2000. The lowest values were recorded for the Forbes and Gilgandra map sheets which lost 1.3% and 3.6% respectively of baseline native woody vegetation. These two map sheets were already the most highly cleared in the study area at the beginning of monitoring.

1.3.2 Rates of clearing

The length of the total monitoring period differed for different parts of the study area following the dates of the baseline NPWS vegetation mapping for each map sheet. For this reason, a simple comparison of absolute clearing rates between areas is not possible. However, different sections of the study area can be compared in terms of the average percentages of native woody vegetation cleared each year. On this basis,

[10] Cox et al. 2001

the Moree region (Band A; see Figure 1) had the highest clearing rate while the Forbes and Gilgandra map sheets were lowest.

Clearing rates in most of the study area have increased since 1998 based on a comparison of the 1998-2000 rate with that for the whole study period. For some areas, e.g. the Nyngan and Nymagee map sheets, this increase has been very marked. In contrast, the 1998-2000 clearing rate for the northern section of the study area (Band A, see Figure 1) was lower than for preceding monitoring periods. This was partly a reflection of very large clearing events in the 1994-98 period. More detailed analysis for Band A shows that in the most highly cleared central portion (Northern Outwash bioregional province[11]), where native woody vegetation cover is below 10%, clearing rates steadily increased over the study period.

For all areas, clearing rates differed substantially between vegetation types, with those types found in areas of higher agricultural value being cleared preferentially. While not unexpected, this highlights the importance of monitoring change at the vegetation type level. Basing management decisions solely on overall vegetation change data risks missing severe declines in some types of vegetation.

1.3.3 Comparison with previous studies

The results of this study were compared to two previous reports on statewide clearing rates in New South Wales, for 1995-97 and 1997-2000 respectively, which have been used for official estimates of clearing in New South Wales[12,13]. The mapping for these reports was derived from automated analysis of satellite data supplemented by visual inspection of areas identified as having potentially been cleared.

We compared the mapping for the 1995-97 report to our mapping for 1994-98 in the northern wheatbelt (Band A: Moree and adjacent map sheets). The comparison was made on the basis of average annual clearing rates. The clearing rate calculated from our mapping was approximately 8 times higher than that calculated from the previous report.

We compared the total extent of clearing mapped for the 1997-2000 report to that mapped by us for 1998-2000 across the whole study area. Overall, we detected 10 times more clearing than was mapped for the previous statewide report.

Given the consistently high rates of accuracy achieved with the mapping methods used in this project, we conclude that previous studies of statewide clearing rates have greatly underestimated the extent of clearing in the wheatbelt. The previous studies used methods intended to detect change in vegetation with at least 20% canopy cover while this project used a 5% cover threshold. Ideally, future reporting will incorporate the methods used in this study wherever possible.

1.3.4 Impacts of clearing on biodiversity

This study has not attempted to investigate the impacts of clearing on flora or fauna directly. However, given that native vegetation clearing is recognised as a major threatening process for native plant and animal populations[14], the continuing depletion and fragmentation of the remaining native vegetation recorded in this study can be interpreted as increasing the risk of population declines and extinctions.

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[11] Morgan and Terrey 1992

[12] ERIC 1998

[13] ERIC 2001

[14] For example, woodland birds: Reid 2000

[redacted]

2 Introduction

2.1 The significance of vegetation clearing to biodiversity conservation in the New South Wales wheatbelt

Temperate eucalypt woodlands are among the most poorly conserved and threatened ecosystems in Australia[15]. In the wheatbelt of Central New South Wales most of the original temperate woodlands have been cleared for agriculture over the last two hundred years[16]. The remaining native vegetation is mostly present as fragmented remnants which are subject to further threats such as weed invasion, altered fire regimes and overgrazing by domestic stock and feral animals.

Extensive clearing in Central New South Wales has continued over the last three decades, in part driven by high returns available from wheat and cotton cultivation compared to grazing[17,18]. The area sown to cotton in New South Wales increased by approximately 80% between 1989 and 1997, while that for wheat increased by approximately 50% between 1992 and 1998[19]. Sivertsen and Clarke[20] present a summary of the area of woody vegetation in the New South Wales northern wheatbelt showing dramatic declines between the 1970s and 1980s with lower, though still substantial, declines between the 1980s and 1990s.

The responses of biodiversity to the loss and fragmentation of native vegetation are complex and often difficult to predict in detail[21] but the overall consequences of habitat change of the magnitude seen in the wheatbelt are clear and include population and species extinctions and genetic loss[22,23,24,25,26]. Population declines and extinctions would be expected to continue long after clearing had occurred, possibly for several centuries[27].

The recognition that native vegetation clearance is the single greatest threat to terrestrial biodiversity in New South Wales[28] has prompted a number of legislative and policy responses. In 1995, State Environmental Planning Policy No. 46 on the protection and management of native vegetation was introduced in an attempt to control inappropriate land clearing. This was replaced by the Native Vegetation Conservation Act which began operation in 1998. In 2001, a preliminary determination was made to list clearing and fragmentation of native vegetation as a

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[15] Yates and Hobbs 2000

[16] Benson 1999

[17] Benson 1999

[18] Beare et al. 1999

[19] Australian Bureau of Statistics http://www.abs.gov.au

[20] Sivertsen and Clarke 2000

[21] For example, see Cunningham 2000

[22] Saunders 1994

[23] Ford et al.1995

[24] EPA 1997

[25] Reid 2000

[26] Sivertsen and Clarke 2000

[27] Tilman et al. 1994

[28] EPA 2000

Key Threatening Process under the New South Wales Threatened Species Conservation Act.

2.2 Previous studies of vegetation clearing in New South Wales

Several studies have used satellite imagery to map the distribution of clearing. The New South Wales component of a national study by Barson et al.[29] attempted to determine clearing rates from Landsat Thematic Mapper (TM) satellite data for the period 1991-95 using automated classification methods. This study only considered vegetation with an average tree canopy cover of at least 20% which excludes large areas of woodlands and shrublands with sparse cover[30].

Two recent studies of clearing rates in New South Wales have been undertaken by the Environmental Resources Information Consortium (ERIC) on behalf of the New South Wales Department of Land and Water Conservation[31,32]. These looked at the periods 1995-97 and 1997-2000 respectively and used an automated classification of Landsat TM data to identify areas of possible clearing followed by visual inspection of these areas. These studies claimed to detect vegetation with a minimum tree canopy cover of less then 20% in at least some cases and found significantly higher rates of clearing than the study by Barson et al.

Although an improvement, the ERIC studies still excluded many areas of sparse to open vegetation which will have high conservation significance. NPWS[33] mapped native woody vegetation with tree canopy cover down to 5% on the Forbes and Cargelligo map sheets in the wheatbelt and this threshold is being used for further wheatbelt mapping. Ideally, measurements of clearing would also consider vegetation down to this level of canopy cover.

2.3 Mapping clearing by visual interpretation of satellite images

Precise and accurate remote sensing methods are required to monitor vegetation loss over an area as large as the wheatbelt. Direct visual interpretation of satellite imagery is an alternative to automated classification methods and is supported by results from a number of local and overseas studies. Complex patterns involving irregular and diffuse boundaries are more reliably identified using visual interpretation and the human ability to assimilate shape, texture and spatial context is not yet matched by automated methods which only consider spectral information[34,35,36,37]. Hill and Kelly[38] found Landsat TM satellite imagery more suitable for visual interpretation than other forms of analysis when considering semi-arid woodlands in southern Queensland. Milne and O'Neill[39] commented that visual interpretation relies heavily on the skills

[29] Barson et al. 2000

[30] Benson 1999

[31] ERIC 1998

[32] ERIC 2001

[33] Sivertsen and Metcalfe 1995

[34] Chuveico and Martinez Vega 1990

[35] Kushwaha et al. 1994

[36] Janssen and van der Wel 1994

[37] Graetz et al. 1995

[38] Hill and Kelly 1987

[39] Milne and O'Neill 1989

of the observer and can be prone to inconsistency but they supported its use for identifying abrupt landcover changes such as vegetation clearing.

2.4 Objectives of this project

1. To develop practical and robust methods for monitoring native woody vegetation change from readily available satellite imagery and systematically test the accuracy of those methods.

2. To use the methods developed in Objective 1 to measure the remaining extent and rate of loss of native woody vegetation with average canopy cover down to 5% and provide mapping of extant native woody vegetation for a set of monitoring periods.

3. To measure the area and rate of loss of vegetation types and provide mapping of extant distributions for a set of monitoring periods.

4. To measure the degree of fragmentation of overall native woody vegetation and individual vegetation types.

5. To identify trends in clearing, overall and for individual vegetation types.

6. To compare the results of this study to previous studies of native vegetation clearing in New South Wales.

7. To comment on the implications of the project results for biodiversity conservation and identify needs for further monitoring and research.

[redacted]

3 Study area

3.1 Location

The study area (Figure 1) is located in central New South Wales and corresponds to the NPWS wheatbelt native vegetation mapping study area (Sivertsen and Metcalfe 1995). It occupies 11.4 million hectares and extends from the New South Wales state border southwards to the 34th parallel of latitude, and from the boundary of the state's Western Division eastwards to a line approximating the 300m contour interval.

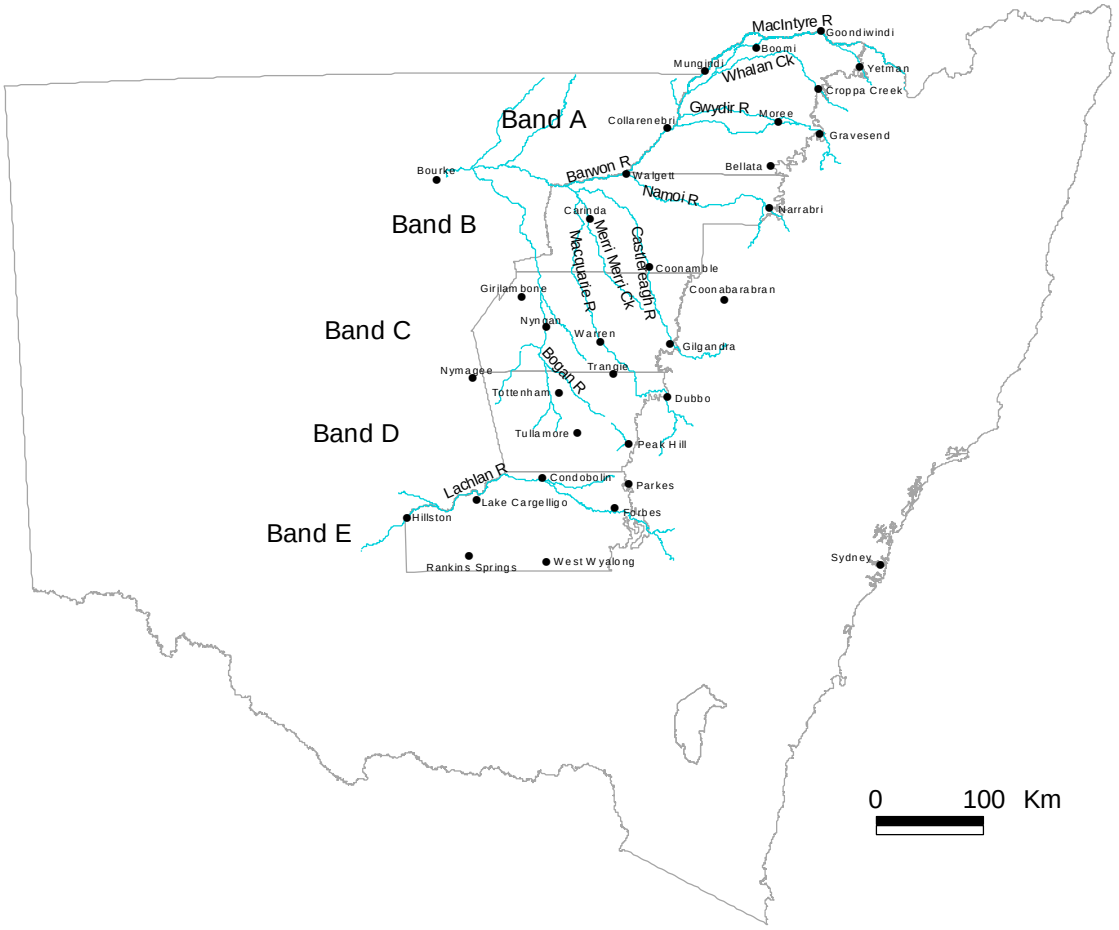

Figure 1. The NPWS vegetation mapping study area divided into 5 bands. Vegetation change results for Bands A, C, D and E are presented in this report.

The study area is wholly within the Murray Darling Basin. The McIntyre, Barwon, Gwydir, Namoi, Macquarie, Castlereagh, Bogan and Lachlan major inland river systems are significant physical, ecological and economic features.

For vegetation mapping purposes, NPWS divided the area into five bands, denoted here as A to E, see Figure 1. During the course of this project the draft NPWS vegetation mapping for Band B was judged to be inadequate as a basis for reliably identifying clearing within native woody vegetation (see section 4.1 for details on the use of the NPWS vegetation mapping as a baseline for the present study). Accordingly, it has been omitted from this report.

Bands A, C, D and E of the NPWS study area cover portions of 13 1:250,000 maps and together occupy 9,002,797 ha see Table 1 and Table 2.

Table 1.1:250,000 topographic map sheets overlapping the study area (listed north to south, west to east).

Map sheet	**Study area band**	**Study area extent (ha)**	**Percentage of map sheet**
St. George	A	348,316	51%
Goondiwindi	A	314,460	39%
Angledool	A	77,987	5%
Moree	A	1,442,191	89%
Inverell	A	235,667	15%
Cobar	C	528,996	34%
Nyngan	C	1,577,939	100%
Gilgandra	C	225,102	14%
Nymagee	D	457,018	29%
Narromine	D	1,364,484	87%
Dubbo	D	23,866	2%
Cargelligo	E	1,214,844	79%
Forbes	E	1,191,958	77%

Table 2. The extent of the study area bands (as shown in Figure 1).

Band	**Area (ha)**
A	2,418,296
C	2,332,013
D	1,845,416
E	2,407,072
Total	**9,002,797**

3.2 Topography, geology and soils

The broad alluvial floodplains associated with the major inland river systems of the Murray Darling Depression and Darling Riverine Plains Bioregion are the predominant topographic feature of the study area. Associated with these floodplains are river channels, drainage depressions and relict in-filled streams. In the south of the study area sandplains occur on low to gently undulating colluvial plains that increase in relief to the west. Characteristic of the Cobar Peneplain Bioregion are low rounded ridges and minor areas of higher ridges and sharper hills. In the east, associated with the South Western Slopes Bioregion are isolated, low rounded basalt hills that protrude from the surrounding plains and level to gently undulating plains with occasional low stony rises.

The geology of the study is extremely varied and complex, but the overlying sediments are largely unconsolidated Quaternary alluvium which form the basis of the alluvial floodplains. In the north, Quaternary alluvium overlies sandstone, siltstone and claystone from the Cretaceous Period and Warialda sandstone formations from the Jurassic Period. Small isolated hills scattered in the East are intrusions of Tertiary basalt. In the south west, Palaeozoic and Pre-Cambrian igneous rock and deformed sedimentaries underlie the alluvium and colluvium of the Cobar Peneplain. In the south east Quaternary sediments overlie Devonian, Silurian and Ordovician sediments and igneous rock.

A broad range of soil types are encountered across the study area. From the moderately fertile Black, Brown and Grey clays that are a feature of the floodplains to Red and Brown Earths associated with the more elevated parts of the plains. Gravelly Red Earths are found in the western peneplains, while sandy freely draining soils are found along the Castlereagh River. Sandplains contain calcareous red earths. The flat plains and moderately fertile soils make the area highly valuable for agricultural production.

3.3 Climate

Rainfall is moderate to low with summer dominant rainfall in the north (300-700mm) and winter dominant rainfall in the south (450-600mm). The highest average rainfall is in the north east of the study area with rainfall becoming increasingly sporadic, and with lower average falls, to the west. Temperatures range from 35^{o}C maximum in summer to 5^{o}C minimum in winter.

3.4 Vegetation

The study area was once part of the continuous belt of temperate woodlands that ran from Queensland to Victoria. Since European settlement, progressive clearing for agriculture has left the original woodlands severely depleted (Figure 2).

The Box Woodlands that predominate on the plains and low rises of the study area include Poplar Box (*Eucalyptus populnea*) (Figure 3 and Figure 5), Coolabah Box (*E. coolabah*) (cover photo), Black Box (*E. largiflorens*) (Figure 4), Red Box (*E. intertexta*), Grey Box (*E. microcarpa*) and Pilliga Box (*E. pilligaensis*). Associated with these woodlands are White and Black Cypress Pine (*Callitris glaucophylla* and *C. endlicheri*) and Belah (*Casuarina cristata*). Tall Forests of River Red Gum (*Eucalyptus camaldulensis)* are restricted to the major rivers and tributaries. Woodlands of Brigalow (*Acacia harpophylla*) and Carbeen (*Corymbia tessellaris*) are found in Band A of the study area. White Mallee (*Eucalyptus dumosa*), Red Mallee

(*E. socialis*), Green Mallee (*E. viridis*) and Narrow-leaved Red Mallee (*E. leptophylla)* are restricted to the sandplains and hills of Bands C, D and E. Open Woodlands and Tall Shrublands of Myall (*Acacia pendula*) occur in depressions and on gilgaied clays throughout all bands of the study area. Tall Shrublands of Leopardwood (*Flindersia maculosa*) occur on the clay pan and in association with Black Box Woodlands. A variety of Red Gums, Dwyer's (*Eucalyptus dwyeri*), Tumble-down (*E. dealbata*) and Dirty (*E. chloroclada*), are found in restricted areas. Ironbark Woodlands occur as part of complex associations with box species. In the east of the study area Narrow-leaved Red Ironbark (*Eucalyptus crebra*) and Silver-leaved Ironbark (*E. melanophloia*) occur with Poplar and Pilliga Box. Mugga Ironbark (*Eucalyptus sideroxylon*) occurs with Green Mallee on hillslopes, particularly in Band D of the study area.

3.5 Tenure and landuse

Most of the study area is under freehold title. There are seventeen Nature Reserves (Boomi, Boomi West, Boronga, Careunga, Midkin, Brigalow Park, Macquarie Marshes, Quanda, Coolbaggie, Tollingo, Woggoon, Loughnan, Gubbata, Langtree, Cocopara, Pulletop and The Charcoal Tank) and one National Park (Goobang). Together these account for 26,076 hectares or 0.29% of the study area.

Other public lands include State Forests, which occupy 109,960 hectares, 1.02% of the study area, and Travelling Stock Reserves.

Historically, the main landuse has been pastoralism with sheep grazing dominating in the east and cattle in the west. More recently, cereal cultivation has become an important and extensive land use. An increasing area is also devoted to dryland and irrigated cotton farming. The transition from grazing to cropping has been a major factor in recent extensive clearing of native vegetation.

Figure 2. Remnant native vegetation near Moree. Note the narrow corridors of vegetation connecting a larger remnant.

*Figure 3. Poplar box (*Eucalyptus populnea ssp. bimbil*) remnant on the Bourke Road, north-west of Nyngan. Note native grasses and introduced pasture in foreground; stump indicating previous disturbance in midground; poplar box and white cypress pine* (Callitris glaucophylla) *in background.*

*Figure 4. Black box (*Eucalyptus largiflorens*) remnant near Nyngan with native grasses and lignum in the foreground and belah (*Casuarina cristata*) in the background.*

*Figure 5. Narrow corridor of poplar box (*Eucalyptus populnea ssp. bimbil*) and white cypress pine (*Callitris glaucophylla*) along a fence line between paddocks near Tottenham.*

Figure 6. Clearing in brigalow (Acacia harpophylla) remnant *near Dolgelly Bore. Note mature brigalow (foreground); recent clearing and burning of windrows (midground); isolated vegetation remnant (background).*

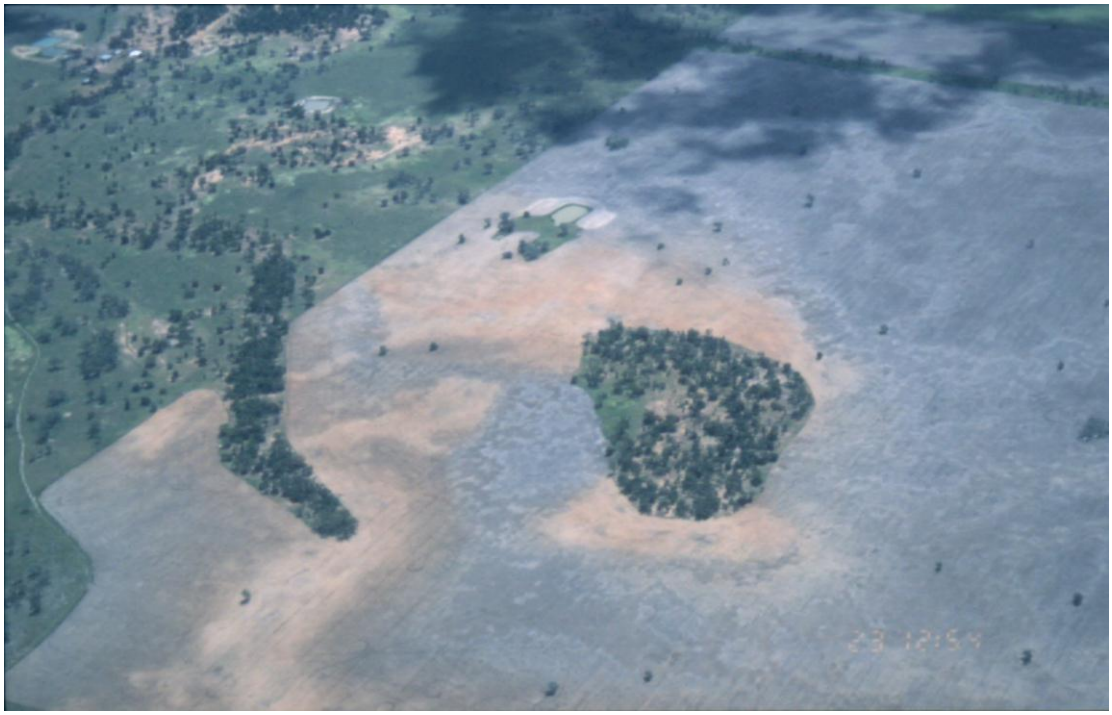

Figure 7. Clearing in Bunna Bunna, 1996. Note the isolated remnant and the corridor of native woody vegetation that has been left along a creek

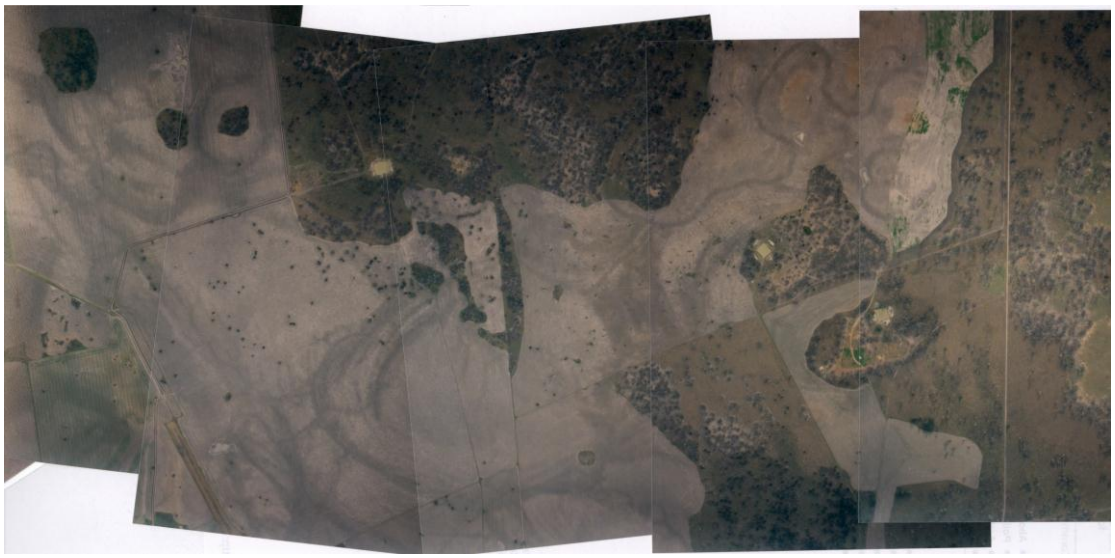

Figure 8. An example of 1:16,000 aerial photographs specifically flown for accuracy assessment. Random points allocated to areas of clearing, uncertainty and no change mapped from Landsat images can be checked against these photographs.

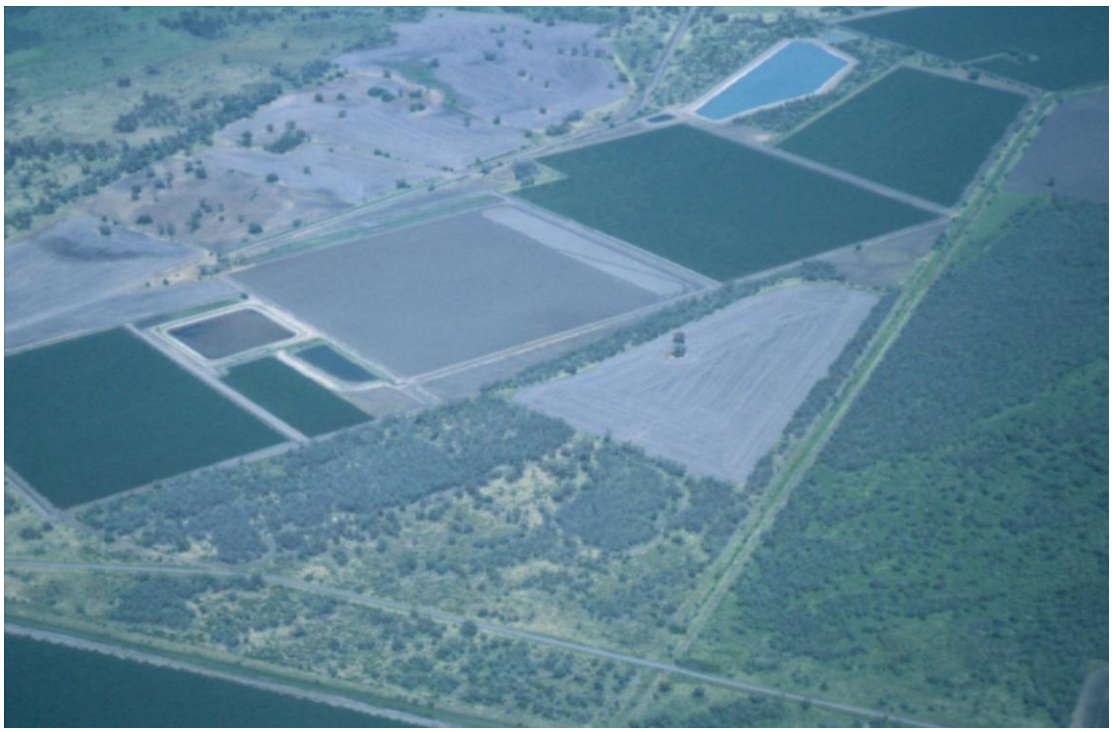

Figure 9. Clearing on Moree 1:250,000. Note complete removal of all woody native vegetation in fields and the narrow corridor of vegetation between established fields and recent clearing in the mid-ground.

4 Methods

4.1 Baseline native woody vegetation data

Vegetation change was monitored within native woody vegetation identified in NPWS mapping for the wheatbelt[40]. This mapping was derived from interpretation of 1980s aerial photography (Figure 10) combined with multivariate analysis of data from a large set of field survey plots (Figure 11).

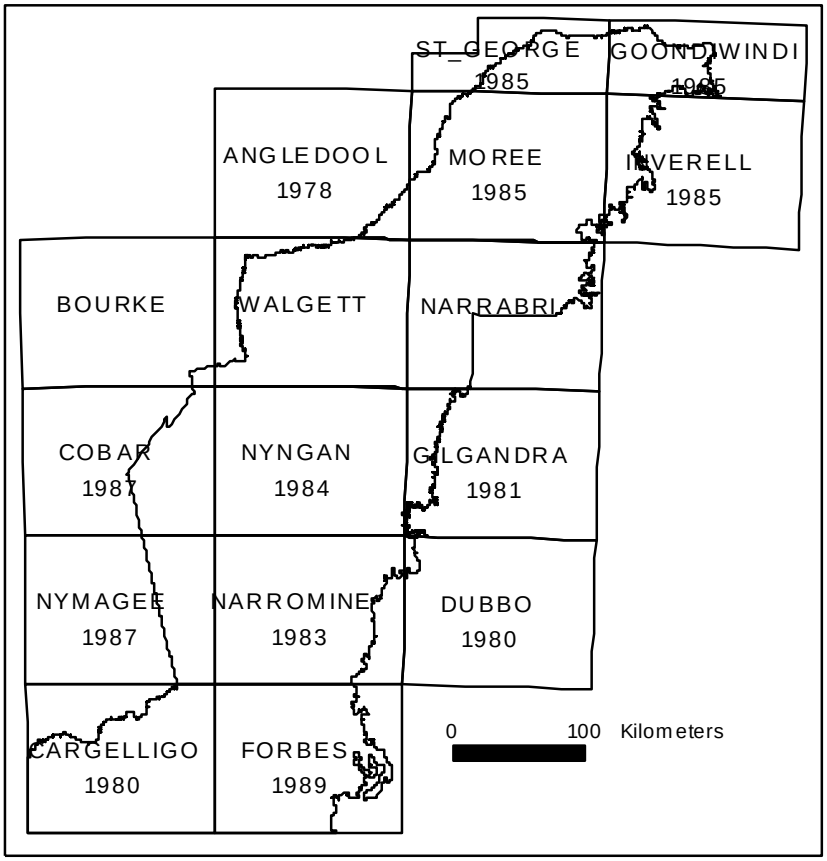

Figure 10. Dates of aerial photography used for NPWS vegetation mapping.

The woody vegetation types defined in the NPWS mapping include shrublands, woodlands and forests. Treeless native grasslands, highly modified native vegetation and areas with isolated scattered trees were not mapped. Some sedge dominated wetlands were mapped but these were omitted from the present study.

[40] Sivertsen and Metcalfe 1995 and unpublished

The NPWS mapping was generally restricted to vegetation remnants of at least 10 ha with an average tree canopy cover of at least 5% (treating canopies as solid objects). These thresholds were governed by the resolution of the aerial photography used for

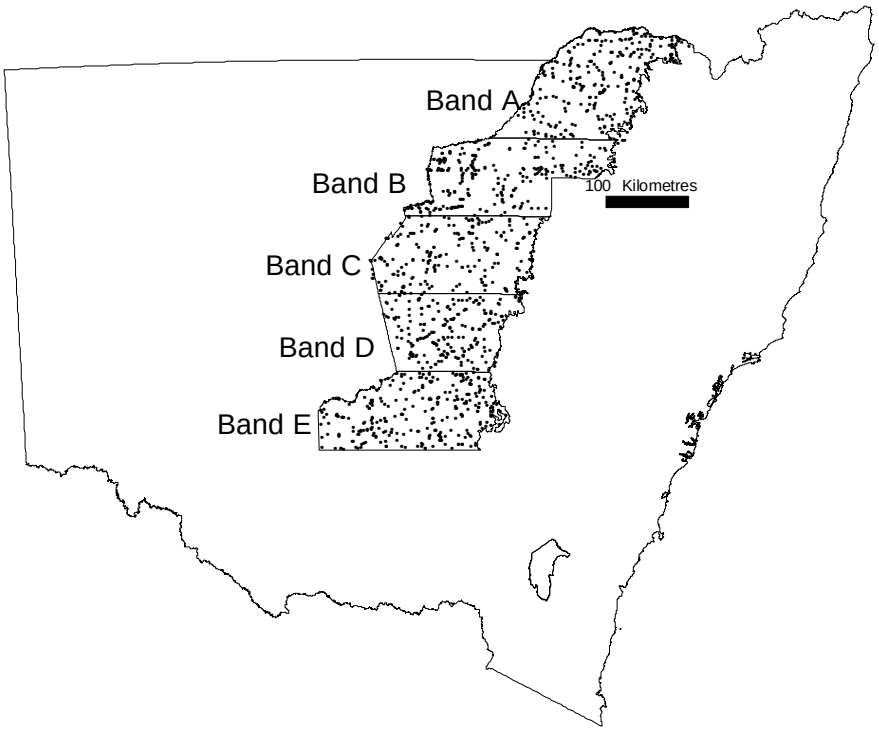

Figure 11. Location of 1248 NPWS vegetation survey plots.

the mapping. Smaller remnants, such as narrow road verges and areas of scattered trees were generally not mapped. As a result, the baseline data are a subset of the total native vegetation, omitting elements that will have important conservation values, and our analyses of vegetation loss are therefore conservative.

4.2 Definition of vegetation clearing used for this study

We defined clearing as a change in average canopy cover from greater than 5% to less than 5%, this being the threshold used for the NPWS vegetation mapping (see Figure 6, Figure 7 and Figure 9). In addition, clearing was characterised on the satellite images by the lack of near infra-red reflectance typical of vegetation, regular boundaries and more uniform texture and colour compared to adjacent areas of woody vegetation.

Some sites with sparse tree cover, where the understorey is completely removed and replaced by agricultural crops or fertilised pasture, will display a marked change in reflectance on satellite imagery even though the tree canopy cover does not change. We have included such instances in our definition of clearing since they represent effective destruction of native vegetation remnants.

The New South Wales Native Vegetation Conservation Act (1997) defines clearing to include any of the following actions:

> *(a) cutting down, felling, thinning, logging or removing native vegetation,*

(b) killing, destroying, poisoning, ringbarking, uprooting or burning native vegetation,

(c) severing, topping or lopping branches, limbs, stems or trunks of native vegetation,

(d) substantially damaging or injuring native vegetation in any other way.

The definition of clearing adopted for this study is much narrower, being constrained by the resolution of readily available satellite imagery. As such, our results for the extent and rate of clearing are conservative.

4.3 Monitoring areas and periods

Vegetation change mapping was carried out for each of the four Bands A, C, D and E (Figure 1). Analyses of data derived from the mapping were done by 1:250,000 scale map sheet for Bands C, D and E since the dates of aerial photography used for the baseline 1980s vegetation mapping differed between map sheets (Figure 10). The baseline mapping for Band A used 1985 aerial photography and we analysed data for this band as a whole. †

For Band A, vegetation change was analysed for 1985-94, 1994-98 and 1998-2000. For each 1:250,000 scale map sheet in Bands C, D and E the first monitoring period was from the date of the 1980s aerial photography to 1998, followed by 1998-2000.

4.4 Satellite image interpretation

Native woody vegetation clearance was mapped by direct visual interpretation of Landsat TM satellite imagery. For monitoring periods prior to 2000 we used hardcopy photographic images with 30x30m pixel size and bands 2 (visible), 4 (near infra-red) and 5 (mid infra-red). Clearing boundaries were drawn on a transparent overlay printed with the baseline vegetation mapping and fixed over each satellite image. The boundaries were then digitised. For the 2000 analysis we used Landsat digital data displayed with ERDAS Imagine 8.4 software on a UNIX workstation. The displayed images were visually interpreted and clearing boundaries were digitised directly on-screen. Figure 12 shows the satellite images used for this study.

Inspection of 1980s aerial photographs was used to assist with the interpretation of satellite images. Where an area had very sparse vegetation (down to 5% canopy cover) on the aerial photograph, and it was difficult to determine whether it had been cleared from the satellite image, the area was marked as uncertain.

We restricted our analysis to vegetation remnants with an area of at least 10 ha consistent with the limits of resolution of the satellite imagery and our methods.

There are a number of factors that contribute to uncertainty in interpretation. *Eucalyptus* and *Acacia* species and chenopods, common in most of the study area, have low reflectance at the near infra-red wavelengths used to distinguish vegetation and show little variation with substrate or seasonal change[41]. When vegetation is sparse, soil and bedrock are a dominant component of the spectral information. Soils with either very high or very low reflectance will narrow the range of spectral

† 1978 aerial photography was used for the Angledool map sheet, as opposed to 1985 for all other map sheets in the band, but no clearing was detected on this map prior to 1994.

[41] Milne and O'Niell 1989

information. These factors make it more difficult to distinguish between the presence and absence of sparse woody vegetation.

4.5 Accuracy assessment

As part of the testing of mapping methods in the first stage of the project, we assessed the accuracy of the visual interpretation procedure using additional 1996 Landsat imagery and 1:50,000 scale aerial photography, both of which were available for the Moree 1:250,000 scale map sheet (Band A; see Figure 1). The satellite images were interpreted using the methods described above. Next, random point locations were selected within the area covered by five runs of aerial photographs such that there were 60 points in the newly cleared category and 100 points in the no change category. Each point in the cleared category was then accurately plotted onto the corresponding 1996 aerial photograph to check for errors in identifying clearing. The points in the no change category were plotted onto both the 1996 and 1985 photographs to check for errors in identifying no change.

We subsequently carried out accuracy assessment of mapping from the 1998 satellite images for all study area bands using the same method. For this, we used specially flown 1:16 000 scale aerial photography (see Figure 8 and Figure 16).

We assessed the allocation of the uncertain category in our satellite image interpretation with a similar procedure. Within the Moree 1:250,000 scale map sheet, 60 random point locations were selected from areas identified as uncertain from the 1996 Landsat imagery and checked on the corresponding aerial photographs. The same procedure was carried out for areas marked as uncertain in the interpretation of 1998 satellite images for all study area bands.

For the 1994 interpretation in Band A we carried out aerial inspections of all uncertain areas and allocated them to either cleared or no change. Uncertain areas from the 1998 interpretation for Band E were also resolved, using field inspections and 1998 colour 1:50,000 scale aerial photography, with assistance from Department of Land and Water Conservation Central West Regional staff. Uncertain areas remain in the 1998 mapping for other bands and in the 2000 mapping for all bands. All remaining unresolved areas in the uncertain category have been excluded from the measurement of vegetation clearing presented here and our results are therefore conservative.

4.6 Updating maps of remaining native woody vegetation

For each monitoring period, maps of native woody vegetation types at the start of the period were updated by subtracting areas of clearing identified from the satellite imagery. Next, maps of overall native woody vegetation were derived by dissolving the internal boundaries between different vegetation types within remnants. Any polygons of less than 10 ha were then removed from these maps to comply with the limit of resolution adopted for this study. Most such polygons were the result of small errors in geographic registration between the original vegetation map and the digitised layer of cleared areas and their total area was negligible. The corresponding polygons were then removed from the maps of native woody vegetation types. In the updated maps of remaining native woody vegetation no individual polygons are less than 10 ha. However, patches of vegetation less than 10 ha in size are reported on where patches have been bisected by map sheet boundaries.

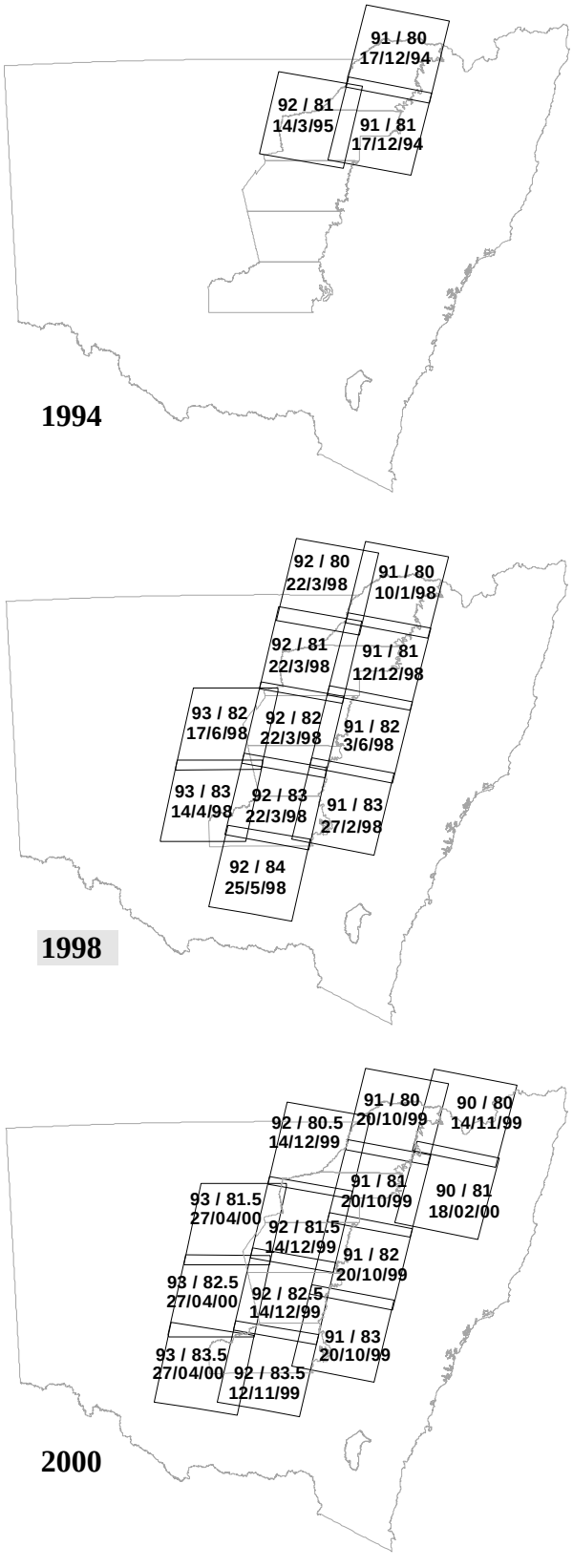

Figure 12. Satellite images (Landsat TM) used for this study with the path / row and date of each image.

4.7 Summary statistics for vegetation clearing

Analyses of the mapped data were carried out using ArcView 3.2 software. For the baseline 1980s mapping and subsequent mapping for each monitoring period we measured the total area of native woody vegetation and the area of individual vegetation types.

For 1998 and 2000 (and 1994 in Band A) we calculated the following statistics for overall native woody vegetation and for each vegetation type:

- the area cleared since the last measurement date;
- the area remaining as a percentage of the 1980s baseline extent;
- the average annual clearing rate (hectares per year);
- the average annual clearing rate as a percentage of the 1980s baseline extent;
- the average annual clearing rate as a percentage of the area at the last measurement date.

Band A straddles Australian Map Grid Zones 55 and 56. The total area measurements for native woody vegetation were carried out for each map zone independently and the results combined to avoid distortions from reprojecting the data which would be in the order of 1% over-estimation. For measurements of individual remnant areas (see section 4.8) and the area of individual vegetation types we reprojected the smaller zone 56 portion of Band A into Zone 55 to produce a combined coverage.

4.8 Summary statistics for vegetation fragmentation

For a preliminary assessment of fragmentation of the remaining native woody vegetation we calculated the following statistics for total native woody vegetation and each vegetation type.

4.8.1 Number of patches

For overall vegetation this is the number of distinct remnants in the study area. Clearing can lead to both a decrease in this number, through the loss of remnants, and an increase, through the splitting of previously intact patches into new separate patches (Figure 13). For this reason the number of patches must be interpreted in conjunction with changes in total area.

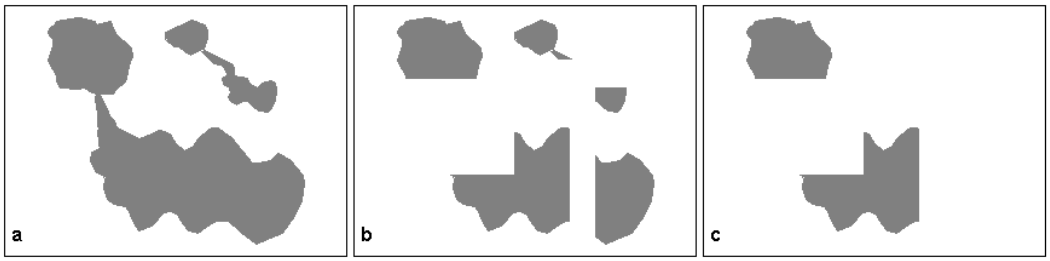

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Figure 13. Change in the number of remnants and the minimum remnant size with clearing. Initially there are two remnants (a). A clearing event leads to an increase in the number of remnants and a decrease in minimum remnant area (b). A further clearing event leads to a decrease in the number of remnants and an increase the minimum remnant area (c).

For vegetation types the number of patches means the number of spatially distinct stands of a given type. This is not the same as the number of remnants since stands can be surrounded by other types of native woody vegetation and more than one stand of a type can occur within a single vegetation remnant. However, following the number of patches of a vegetation type over time in conjunction with the total area of that type gives an indication of the degree to which its distribution is becoming fragmented.[†]

4.8.2 Minimum, median and maximum patch area

For overall vegetation these statistics relate to the area of spatially distinct remnants. Clearing can lead to either an increase in minimum patch area, through the loss of the previously smallest remnants, or a decrease, through the subdivision of existing remnants (Figure 13). As mentioned previously, the lower limit for remnant area in this study was 10 ha. We have reported on median rather than average areas because of the often highly skewed distribution of area values. While the minimum remnant size is 10 ha, patch sizes less than 10 ha have been reported where polygons have been bisected by map sheet boundaries in bands C, D, and E.

For vegetation types the patch area statistics refer to spatially distinct stands of a given type. The minimum patch area for types can vary in either direction as for overall vegetation. Note that the minimum patch area for a vegetation type may be less than 10 ha where the patch is part of a larger vegetation remnant.

4.8.3 Median perimeter to area ratio for patches

Perimeter to area ratio gives some indication of the vulnerability of a patch of vegetation to edge effects and relates to both the size and shape of a patch (Figure 14). For overall vegetation we calculated the ratio of the total perimeter length of a

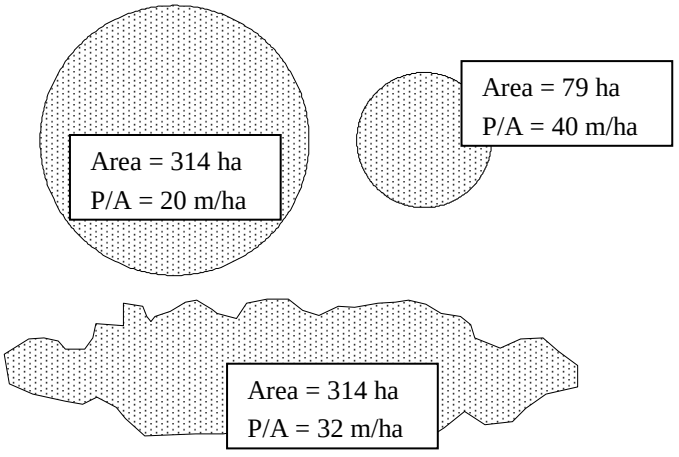


Figure 14. Illustration of perimeter to area ratio (values are in metres per hectare). The large circle has the smallest ratio of perimeter to area (P/A) of the three features, ie. it has the least proportion of its area near the edge. The irregular feature has the same area as the large circle but a higher P/A value due to its longer perimeter. The small circle has the highest P/A value, ie. the most proportion of area near the edge.

[†] Results on number of patches for vegtation types appear in additional tables on the CD-ROM

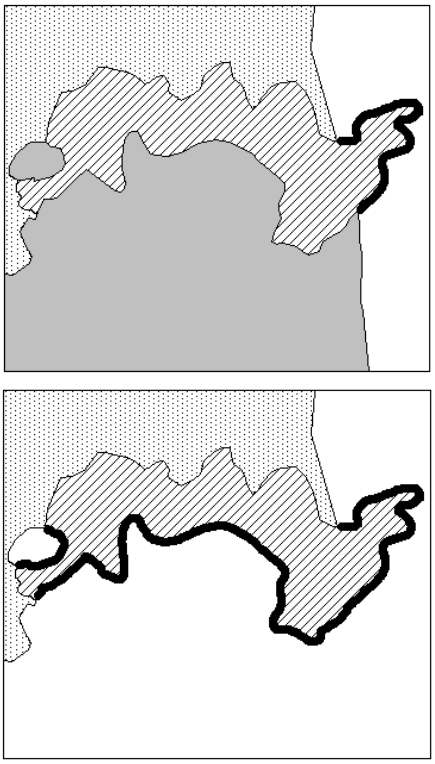


Figure 15.The length of the exposed perimeter, show in bold, for the cross-hatched vegetation type (above) increases after a clearing event (below).

vegetation remnant to its area. For vegetation types we only consider that part of the perimeter that is adjacent to cleared land (Figure 15). Accordingly we report on the number of patches that are immediately adjacent to cleared land and it is only these patches that are included in the calculations.

To account for the boundary of the study area we masked out those sections of patch perimeters that lay on the boundary.

4.8.4 Size distribution of patches

To further illustrate trends in the sizes of vegetation remnants and patches of individual vegetation types we present histograms showing the percentage of remnants or patches in different size classes.[†]

Note that our assessment of fragmentation is preliminary. A comprehensive assessment would also consider the spatial arrangement of vegetation, condition and disturbance attributes, the requirements and distribution of particular plant and animal taxa, and the interaction between these various elements.

4.9 Relative local clearing impacts

Some indication of the local impact of clearing is given by examining the proportion of vegetation lost within a neighbourhood. High proportional loss results not only from large clearing events, but also from small events in areas where the vegetation was already highly depleted.

To analyse local levels of clearing, we overlayed a regular 1km grid of points onto the study area and calculated the percentage of native woody vegetation cleared within the 10 km radius neighbourhood of each point.

4.10 Comparison with previous studies of clearing rates in New South Wales

We compared the results of our visual interpretation method with two previous studies of clearing rates in New South Wales commissioned by the NSW Department of Land and Water Conservation and undertaken by the Environmental Research and Information Consortium (ERIC)[42,43]. The studies cover the periods 1995-97 and 1997-

[†] Histograms showing percentage of remnants or patches in different size classes appear on the CD-ROM accompanying this report.

[42] ERIC 1998

[43] ERIC 2001

2000 respectively, and used an initial automated classification of Landsat imagery to identify areas of potential clearing which were then further examined by visual inspection. They reported greater than 90% accuracy in detection of clearing in vegetation with at least 20% average canopy cover.

For the 1995-97 ERIC study, we compared average annual rates of clearing to those calculated from our mapping for Band A, 1994-98. For the 1997-2000 ERIC study we compared the area of clearing detected for all bands.

[redacted]

5 Results

5.1 Accuracy of the vegetation change mapping

5.1.1 Distinguishing clearing from areas of no change

For an initial test of our mapping methods, we compared 1996 satellite image interpretations to aerial photography for the Moree 1:250,000 scale map sheet. The overall accuracy result of 96.8% indicated that our methods reliably distinguished between recent clearing and areas of no change (Table 3).

Table 3. Accuracy assessment of 1996 satellite image interpretation for the Moree 1:250 000 scale map sheet. Areas of recent clearing and no change were delineated on aerial photographs and randomly located points within these areas were compared to the satellite image interpretation.

	Aerial photography	
	Cleared	No change
Total number of points	60	100
Number mapped as cleared from satellite imagery	56	1
Number mapped as no change from satellite imagery	4	99
% accuracy	93.3	99.0

Overall accuracy (total correct / total points) 96.8%

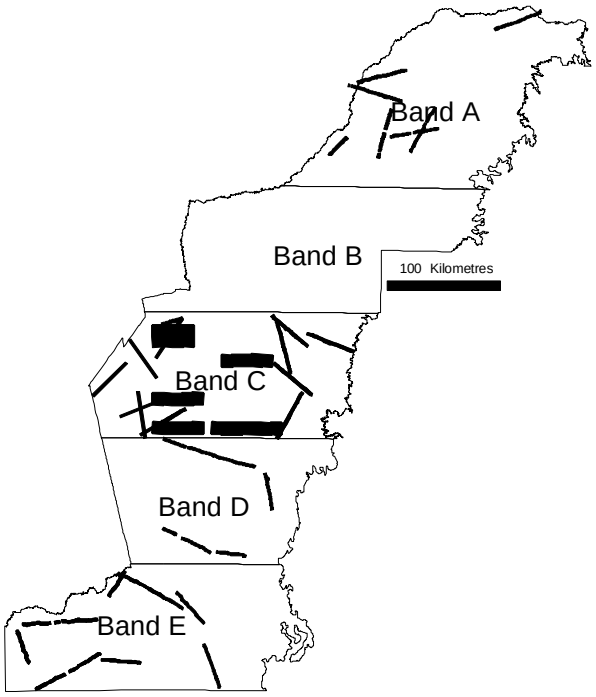


Figure 16. Aerial photograph runs used for accuracy assessment of 1998 satellite image interpretation.

We assessed the accuracy of our 1998 satellite image interpretations for all bands of the study area by comparing the interpretations to specially flown runs of colour 1:16,000 aerial photography (Figure 16). Overall accuracy varied between 94.7% and 99.3% (Table 4 to Table 7).

Table 4. Accuracy assessment of 1998 satellite image interpretation for Band A.

	Aerial photography	
	Cleared	No change
Total number of points	57	95
Number mapped as cleared from satellite imagery	54	5
Number mapped as no change from satellite imagery	3	90
% accuracy	94.7	94.7

Overall accuracy (total correct / total points) 94.7%

Table 5. Accuracy assessment of 1998 satellite image interpretation for Band C.

	Aerial photography	
	Cleared	No change
Total number of points	67	111
Number mapped as cleared from satellite imagery	65	5
Number mapped as no change from satellite imagery	2	108
% accuracy	97.0%	97.3%

Overall accuracy (total correct / total points) 97.1%

Table 6. Accuracy assessment of 1998 satellite image interpretation for Band D.

	Aerial photography	
	Cleared	No change
Total number of points	55	99
Number mapped as cleared from satellite imagery	53	5
Number mapped as no change from satellite imagery	2	94
% accuracy	96.4%	94.9%

Overall accuracy (total correct / total points) 95.4%

Table 7. Accuracy assessment of 1998 satellite image interpretation for Band E.

	Aerial photography	
	Cleared	No change
Total number of points	104	192
Number mapped as cleared from satellite imagery	103	1
Number mapped as no change from satellite imagery	1	191
% accuracy	99.0%	99.5%

Overall accuracy (total correct / total points) 99.3%

5.1.2 Examination of the areas mapped as uncertain

Random point locations within areas mapped as uncertain were checked for clearing on aerial photographs. The results are shown in Table 8. The uncertain category mostly represents areas with sparse woody vegetation at the lower end of resolution for our method, but the results indicate that this category is informative and, if resources were available, field or aerial inspections of these areas would detect further clearing.

Table 8. Examination of areas mapped as uncertain in the 1998 satellite image interpretations. Random point locations within uncertain areas were checked for clearing on aerial photographs.

Band	Number of validation points	Cleared	No change	Remained uncertain
A	60	19 (32%)	41 (68%)	0
C	70	29 (41%)	41 (59%)	0
D	60	52 (87%)	7 (12%)	1 (2%)
E[†]	60	53 (88%)	0	7 (12%)

The uncertain category has been excluded from our estimation of clearing for the monitoring periods ending 1998 and 2000. The total extent of areas mapped as uncertain for these periods is shown in Table 9. Excluding the uncertain category from our results ensures analyses of vegetation loss are conservative.

Table 9. Total extent of areas marked as uncertain in the 1998 and 2000 satellite image interpretations.

Band	1998 (ha)	2000 (ha)
A	17,822	7,531
C	31,333	17,141
D	9,394	4,485
E	0[‡]	2,003

[†] Band E results refer to the original 1998 mapping. All uncertain areas were subsequently allocated to clearing or no change (see Section 4.5).

[‡] For Band E, 6583 ha were originally mapped as uncertain. Subsequent field inspections and aerial photograph interpretation by DLC Central West Region staff identified 5725 ha (87%) as cleared. The 1998 mapping for Band E was then updated with these results.

5.2 Summary of results for vegetation change

The extent and rate of clearing across the study area is shown in Table 10 with the results sorted by clearing rate, expressed as the average annual percentage of the baseline extent of native woody vegetation cleared (second last column).

Clearing rates differed significantly between map sheets. For the whole study period, the average annual rates varied between 0.1% and 1.1% of the baseline extent of native woody vegetation. An increase in annual average clearing rates, to levels higher than the average rates for the whole study period, was recorded for all areas except Band A for the 1998-2000 period. For this final period average annual clearing rates varied between 0.24% and 2.0% of the baseline extent of native woody vegetation.

In terms of the proportion of baseline native woody vegetation mapped as cleared over the entire study period, Band A had the highest value with 17.8%. The Cobar, Nymagee and Cargelligo map sheets each lost more than 10%. These values are not directly comparable given the variable length of monitoring up to 1998, but they emphasise the degree of vegetation loss that has occurred in these areas.

Table 10. Summary of the extent and rates of clearing across the study area. The average annual rate for the study period is calculated by dividing total clearing extent by the length of the study period. The average annual rate for the 1998-2000 period is calculated by dividing clearing extent for the 1998-2000 period by 2.

Band or map sheet	Study period (years)	Baseline extent of native woody vegetation (ha)	Clearing over study period (ha and as % of baseline extent)	Average annual clearing rate for entire study period (ha and % of baseline extent per year)	Average annual clearing rate for 1998-2000 (ha and % of baseline extent per year)
Band A	15	661,238	117,999 (17.8%)	7,867 (1.2%)	7,353 (1.1%)
Cobar	13	346,508	39,478 (11.4%)	3,037 (0.9%)	5,815 (1.7%)
Nymagee	13	201,795	21,817 (10.8%)	1,678 (0.8%)	4,122 (2.0%)
Nyngan	16	489,466	45,973 (9.4%)	3,065 (0.6%)	9,064 (1.9%)
Cargelligo	20	237,544	28,185 (11.9%)	1,409 (0.6%)	1,626 (0.7%)
Narromine and Dubbo	17	259,813	21,720 (8.4%)	1,278 (0.5%)	3,503 (1.4%)
Gilgandra	19	24,384	875 (3.6%)	46 (0.2%)	148 (0.6%)
Forbes	11	142670	1,858 (1.3%)	169 (0.1%)	340 (0.24%)

At the beginning of this study, the native woody vegetation cover was above 30% in three of the eight areas examined (Table 11). The cover value for one of these, the Nyngan map sheet, fell below 30% during the study. Clearing was recorded in all bands of the study area and through all monitoring periods. In total, 270,232 ha were mapped as cleared across the whole study area and all monitoring periods. Native woody vegetation cover decline in all areas of the study area with the greatest decrease in cover recorded in the Cobar map sheet.

Table 11. Summary of change in native woody vegetation extent across the study area expressed as number of ha and percentage cover for each area.

Band or map sheet	Study period (years)	Extent in study area (ha)	Native woody vegetation extent at beginning of study (ha and % of study area)	Native woody vegetation extent at end of study (ha and % of study area)
Band A	15	2,417,860	661,238 27.3%	543,239 22.5%
Cobar	13	528,996	346,508 65.5%	307,030 58.0%
Nymagee	13	457,018	201,795 44.2%	179,978 39.3%
Nyngan	16	1,577,939	489,466 31.0%	443,493 28.1%
Cargelligo	20	1,214,844	237,544 19.9%	209,359 17.2%
Narromine and Dubbo	17	1,364,484	259,813 18.7%	238,093 17.4%
Gilgandra	19	225,102	24,384 10.8%	23,509 10.4%
Forbes	11	1,191,958	142670 12.0%	140,812 11.8%

5.3 Comparison with previous studies

The ERIC study of statewide clearing rates for 1995-97[44] mapped 2,714 ha as cleared within Band A. Taking this as a 2 year period gives an average clearing rate of 1,357 ha per year. In comparison, our mapping identified 42,776 ha of clearing for the period 1994 to 1998. Taking this as a 4 year period gives an average clearing rate of 10,694 ha per year, about 8 times the rate calculated from the ERIC data. This is an indicative comparison only, as it is probable that clearing rates were not uniform throughout the 1994-98 period.

A more direct comparison of our mapping for 1998-2000 and that for the ERIC 1997-2000[45] study is shown in Figure 17. Overall, the extent of clearing in our mapping was 10 times that mapped in the ERIC study. The size of the disparity differed across the study area with the results for Band A being notable.

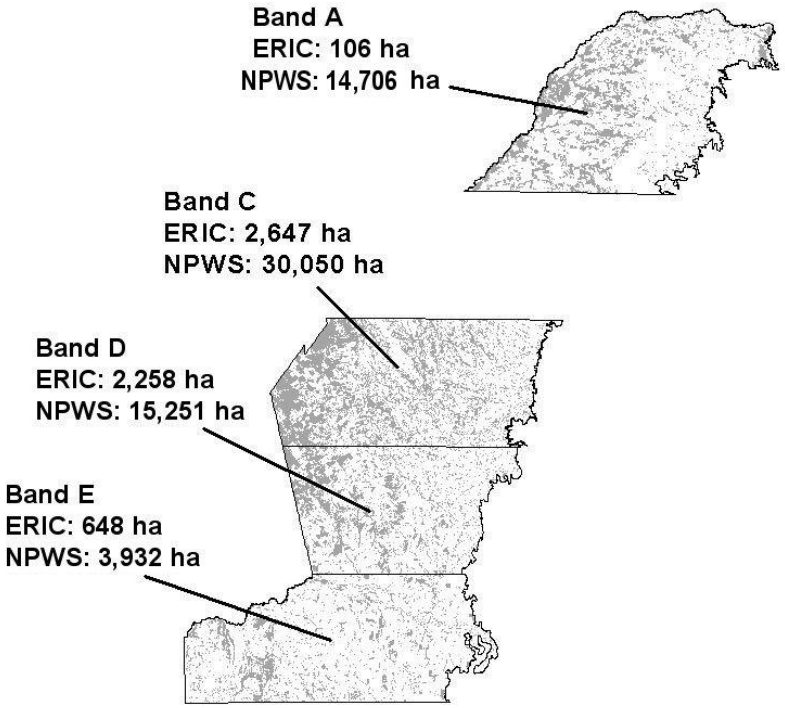


Figure 17. Comparison of the extent of native woody vegetation clearance detected in the NPWS (1998-2000) and ERIC (1997-2000) studies. The map shows extant native woody vegetation for 2000 as mapped by NPWS.

[44] ERIC 1998

[45] ERIC 2001

5.4 Results for vegetation change by band / map sheet

This section presents results for change in overall native woody vegetation for 1:250,000 scale map sheets in Bands C, D and E. For Band A, where the NPWS vegetation mapping was based on aerial photography from the same year[†], we present results for the whole band.

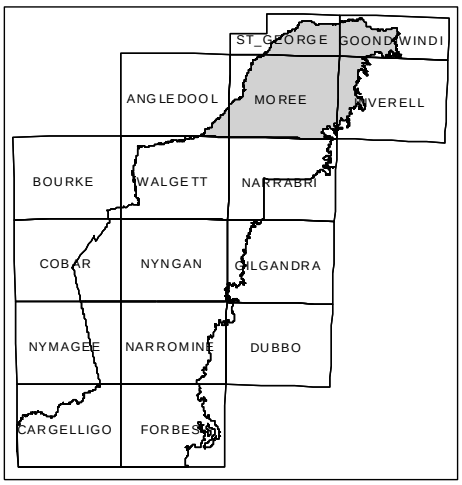
Additional tables with detailed results for change in the extent and level of fragmentation for individual vegetation types can be found on the CD-ROM that accompanies this report see Appendix I CD-ROM Contents. The extent of native woody vegetation for each monitoring period and for each band is presented in 1:250,000 scale hard copy maps that accompany the report. Digital coverages for the vegetation mapping and tables relating to the figures presented here are provided on the CD-ROM.

For more detail on the vegetation types referred to in the results see

[†]1978 aerial photography was used for the Angledool map sheet, as opposed to 1985 for all other map sheets in the band, but no clearing was detected on this map prior to 1994.

Appendix II Descriptions of vegetation types.

5.4.1 Vegetation change in Band A



Overall native woody vegetation

Clearing

Based on the NPWS vegetation mapping, the total area of native woody vegetation in Band A in 1985 was 661,238 ha, or 27.3% of the study area. Over the study period, 1985-2000, approximately 118,000 ha, 17.8% of the baseline vegetation extent, was mapped as cleared (Figure 18).

The average annual clearing rates differed substantially between monitoring periods. The highest rate, in excess of 10,000 ha per year was recorded for the 1994-98 period (Table 12).

Fragmentation

In addition to the substantial reduction in area, the remaining native woody vegetation became increasingly fragmented over the study period. The number of remnants steadily increased as formerly contiguous vegetation was divided by clearing. The creation of new remnants exceeded the complete clearing of other remnants. Note that the largest remnant size for all monitoring periods is in excess of 200,000 ha. A large proportion of the vegetation in the western part of Band A is inter-connected.

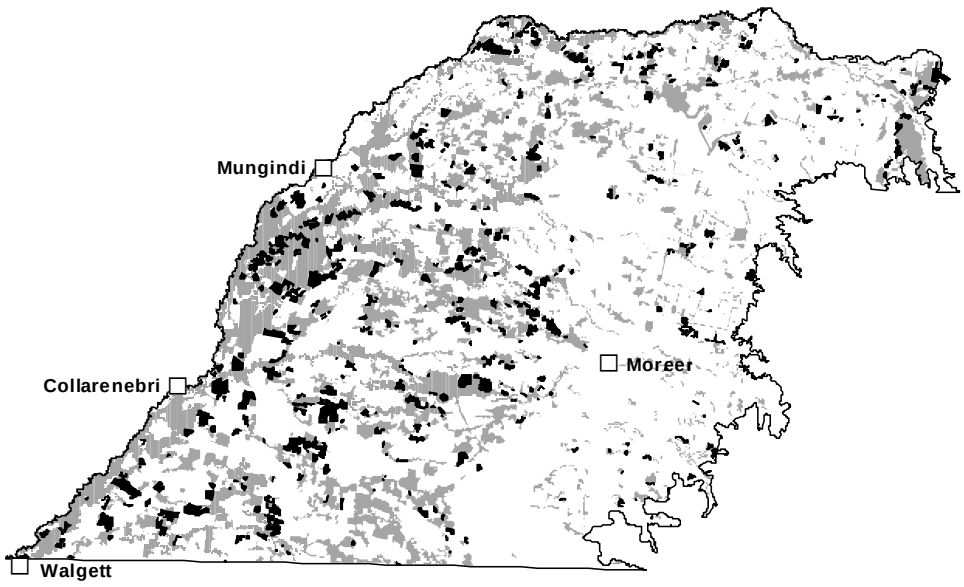


Figure 18. Native woody vegetation change in Band A. Black indicates clearing between 1985 and 2000; grey is remaining native woody vegetation.

Although some of the connections are very narrow, the whole of the connected portion is treated as a single remnant under our criterion of remnants being spatially distinct.

The results for median remnant area and perimeter to area ratio show that the vegetation is being successively reduced to smaller and more exposed fragments. The percentage of remnants with areas of 100 ha or less increased at the expense of remnants in larger size classes.

Relative impacts

The pattern of relative clearing impacts is more complex than a simple east - west gradient as shown in Figure 19. This map was derived from overlaying a regular 1km grid of points onto the study area and calculating the percentage of native woody vegetation present in 1985 that was cleared throughout the study period within a 10km radius of each point. It highlights areas in the eastern portion of the study area where small clearing events have had a high relative impact. For example, north-east of Moree, where native woody vegetation was already highly depleted in 1985, further clearing resulted in losses of over 40%.

Table 12. Band A: results for overall native woody vegetation.

	1985	**1994**	**1998**	**2000**	**Overall**
Extant vegetation (ha)	661238	600721	557945	543239	
(% study area)	(27.3%)	(24.8%)	(23.1%)	(22.5%)	
Area cleared (ha)	-	60517	42776	14706	**117999**
Area cleared (% 1985 vegetation)	-	9.2%	6.5%	2.2%	**17.8%**
Average annual clearing rate (ha/yr)	-	6724	10694	3517	**7867**
Average annual clearing rate (as % 1985 vegetation)	-	1.02%	1.62%	0.59%	**1.2%**
Average annual clearing rate (as % previous area)	-	1.02%	1.78%	0.63%	
Years to clear all native woody vegetation at this rate	-	89	52	157	**69**
Number of patches	535	588	665	683	
Median patch area (ha)	141	120	102	98	
(min - max)	(11-281564)	(10-242030)	(10-214617)	(10-209351)	
Median P/A ratio (m/ha)	55.5	60.0	64.1	66.2	

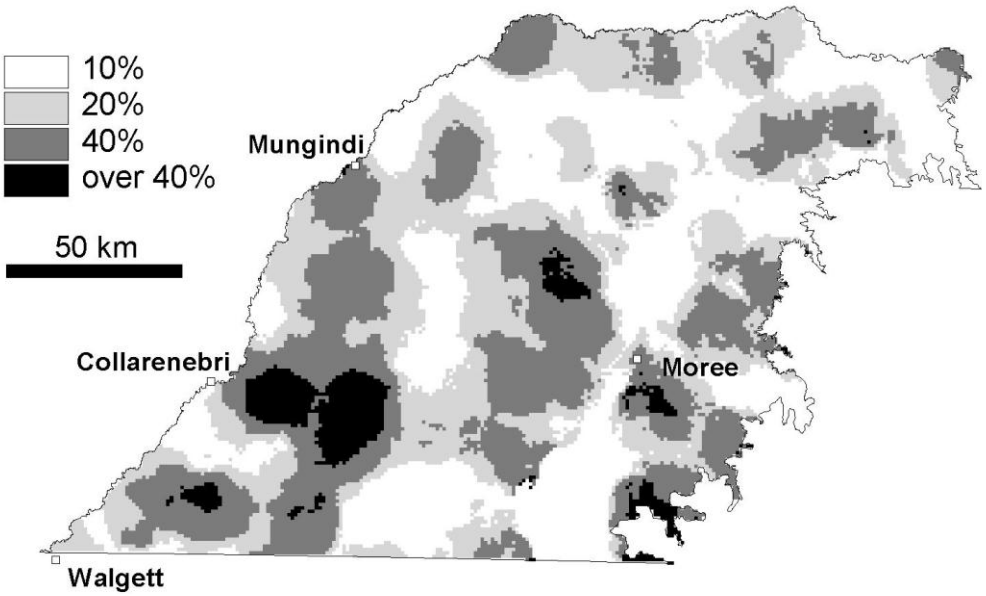


Figure 19. The relative impact of clearing within Band A during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

Vegetation types

Table 13 summarises the overall results by vegetation type ranked by the percentage of the baseline 1985 extent that was cleared over the study period.

The greatest percentage loss occurred in Type R4: Lignum Shrublands, but given its small total extent and the difficulty in mapping this type (see Appendix II) this is less significant than results for other types. The percentage loss for four extensive vegetation types exceeded the overall rate of vegetation loss for the study period. Only one highly restricted vegetation type had no clearing detected during the study period.

Table 13. Summary of the extent and rate of clearing for vegetation types in Band A arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period. The overall values (bottom row) are derived from the analysis of data for separate AMG map zones as described in the Methods and presented in Table 12. The values for vegetation types are derived from the analysis of data merged into AMG Zone 55.

Vegetation type	**Baseline (1985) area (ha)**	**Area cleared (ha)**	**Percentage of 1985 area**	**Average clearing rate (ha / yr)**	**Average clearing rate (% 1985 area)**
R4: Lignum Shrublands	1212	356	29.4%	24	1.96%
P9: Open Shrublands and Woodlands	186604	45036	24.1%	3002	1.61%
R2: Floodplain Mosaic	71586	14581	20.4%	972	1.36%
R10: Open Coolabah Woodlands	86689	17974	20.7%	1198	1.38%
P3: Open Poplar Box Woodlands	21954	4198	19.1%	280	1.27%
P8: Belah Woodlands	12172	2096	17.2%	140	1.15%
R3: Coolabah Woodlands	86064	13244	15.4%	883	1.03%
P10: Brigalow Woodlands	5792	905	15.6%	60	1.04%
H5: Yetman Hills Complex	17201	2424	14.1%	162	0.94%
R7: Coolabah - Poplar Box Woodlands	93935	12433	13.2%	829	0.88%
R8: White Cypress Pine - Carbeen Woodlands	16521	2039	12.3%	136	0.82%
R5: Myall Woodlands	8466	870	10.3%	58	0.68%
P4: Poplar Box Woodlands	11205	1103	9.8%	74	0.66%
H8: Basalt Hills	1649	146	8.9%	10	0.59%
F4: Yetman Footslopes Complex	697	19	2.8%	1	0.19%
R1: River Red Gum - Coolabah Forests	39415	561	1.4%	37	0.09%
P6: Iron Bark - White Cypress Pine Woodlands	132	0	0.0%	0	0.00%
Overall	**661238**	**117999**	**17.8%**	**7867**	**1.2%**

5.4.2 Vegetation change on the Cobar map sheet (Band C)

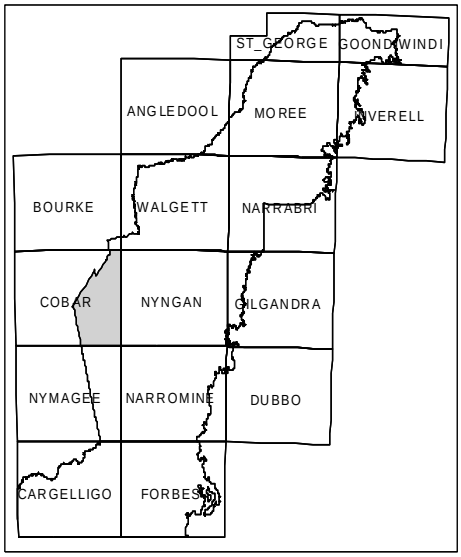


Figure 20. Native woody vegetation change within the Cobar map sheet. Black indicates clearing between 1987 and 2000; grey is remaining native woody vegetation.

Overall native woody vegetation

Clearing

Based on the NPWS vegetation mapping, the total extent of native woody vegetation on the Cobar map sheet in 1987 was 346,508 ha, or 65.5% of the total area. Over the study period, 1987-2000, 39,478 ha, 11.4% of the baseline vegetation extent, was mapped as cleared (Figure 20).

For the 1987-1998 period, the average annual clearing rate was 2,532 ha per year, while for 1998-2000 it was 5,815 ha per year (Table 14). If this latter rate was maintained, the remaining vegetation would be cleared in 53 years

Fragmentation

Overall, there was a negligible increase in fragmentation over the study period. In 1987, approximately 98% of the vegetation on the map sheet was spatially connected, and was therefore treated as a single remnant in this study. By 2000, clearing had reduced this slightly to 95%. The remainder of the vegetation is present as small remnants and it is these that are reflected in the median remnant size and perimeter to area ratio values in Table 14.

Relative impacts

Figure 21 shows the percentage of native woody vegetation cleared within a 10km radius throughout the study area on the Cobar map sheet. The highest proportional losses were in the south-eastern portion where the native woody vegetation cover was lowest at the start of the study period. Quanda Nature Reserve (885ha) is the only area on the Cobar map sheet managed exclusively for conservation and has been isolated from adjacent vegetation types by recent clearing events.

Table 14. Cobar map sheet (Band C): results for overall native woody vegetation.

	1987	1998	2000	Overall
Extant vegetation (ha) (% study area)	346508 (65.5%)	318659 (60.2%)	307030 (58.0%)	
Area cleared (ha)	-	27849	11629	**39,478**
Area cleared (% 1987 vegetation)	-	8.0%	3.4%	**11.4%**
Average annual clearing rate (ha/yr)	-	2532	5815	**3037**
Average annual clearing rate (as % 1987 vegetation)	-	0.73%	1.68%	**0.9%**
Average annual clearing rate (as % previous area)	-	0.73%	1.82%	
Years to clear all native woody vegetation at this rate	-	126	53	**101**
Number of patches	95	108	119	
Median patch area (ha) (min - max)	24 (1-340951)	24 (1-310635)	27 (1-297157)	
Median P/A ratio (m/ha)	99.9	98.7	95.0	

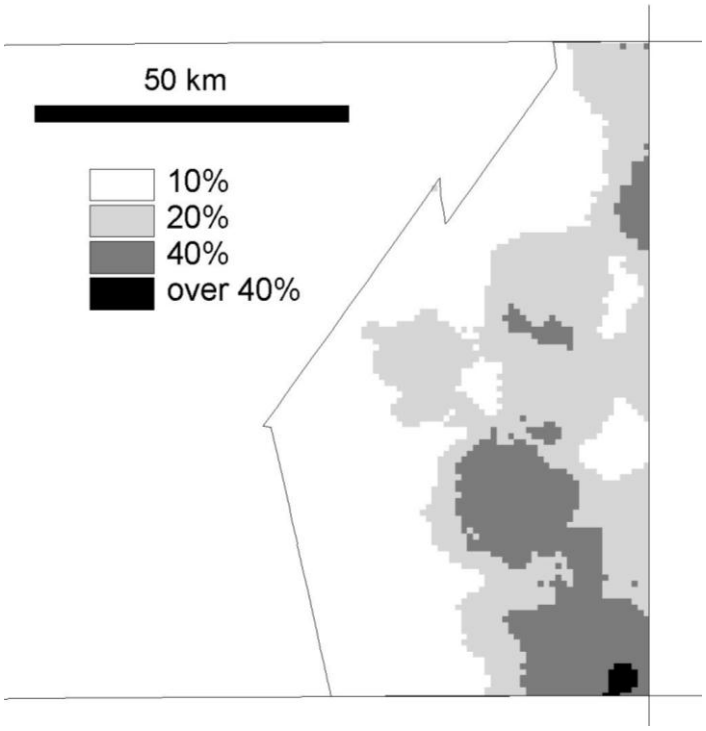


Figure 21. The relative impact of clearing on the Cobar map sheet during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

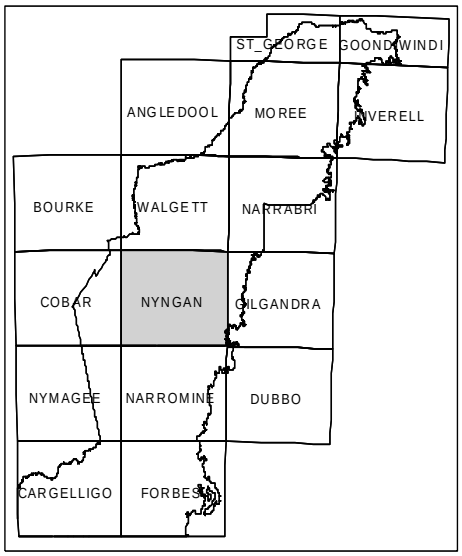
Vegetation types

Table 15 summarises the overall results by vegetation type ranked by the percentage of the baseline 1987 extent that was cleared over the study period. Two types, Western Poplar Box Woodlands and Red Box - Poplar Box – White Cypress Pine Woodlands, were cleared at rates greater than the average rate of native woody vegetation loss within the map sheet.

Table 15. Summary of the extent and rate of clearing for vegetation types within the Cobar map sheet arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period.

Vegetation type	**Baseline (1987) area (ha)**	**Area cleared (ha)**	**Percentage of 1987 area**	**Average clearing rate (ha / yr)**	**Average clearing rate (% 1987 area)**
P4West: Western Poplar Box Woodlands	62613	9626	15.4%	740	1.18%
P14: Red Box, Poplar Box and White Cypress Pine Woodlands	200565	24401	12.2%	1877	0.94%
U1: Red Box, Poplar Box, White Cypress Pine and Green Mallee Woodlands	33838	2844	8.4%	219	0.65%
H7: Mallee Woodlands on Rolling Hills	28547	2208	7.7%	170	0.59%
R1: River Red Gum Forests Woodlands	2142	160	7.5%	12	0.57%
P1: Mallee Woodlands on Plains	6894	199	2.9%	15	0.22%
P6: White Cypress Pine Woodlands	2861	18	0.6%	1	0.05%
H6: Open Grey Mallee Woodlands	6625	23	0.4%	2	0.03%
H1: Dwyer's Red Gum, Ironbark and Green Mallee Woodlands	2423	0	0.0%	0	0.00%
Overall	**346508**	**39478**		**3037**	

5.4.3 Vegetation change on the Nyngan map sheet (Band C)



Overall native woody vegetation

Clearing

Based on the NPWS vegetation mapping, the total extent of native woody vegetation on the Nyngan map sheet in 1985 was 489,466 ha, or 31.0% of the total area. For the study period, 1985-2000, 45,773 ha, 9.4% of the baseline extent of woody vegetation, was mapped as cleared (Figure 22).

For the 1985-1998 period, the average annual clearing rate was 2,142 ha per year, while for 1998-2000 it was 9,064 ha per year (Table 16). If this latter rate was maintained, the remaining vegetation would be cleared in less than 50 years.

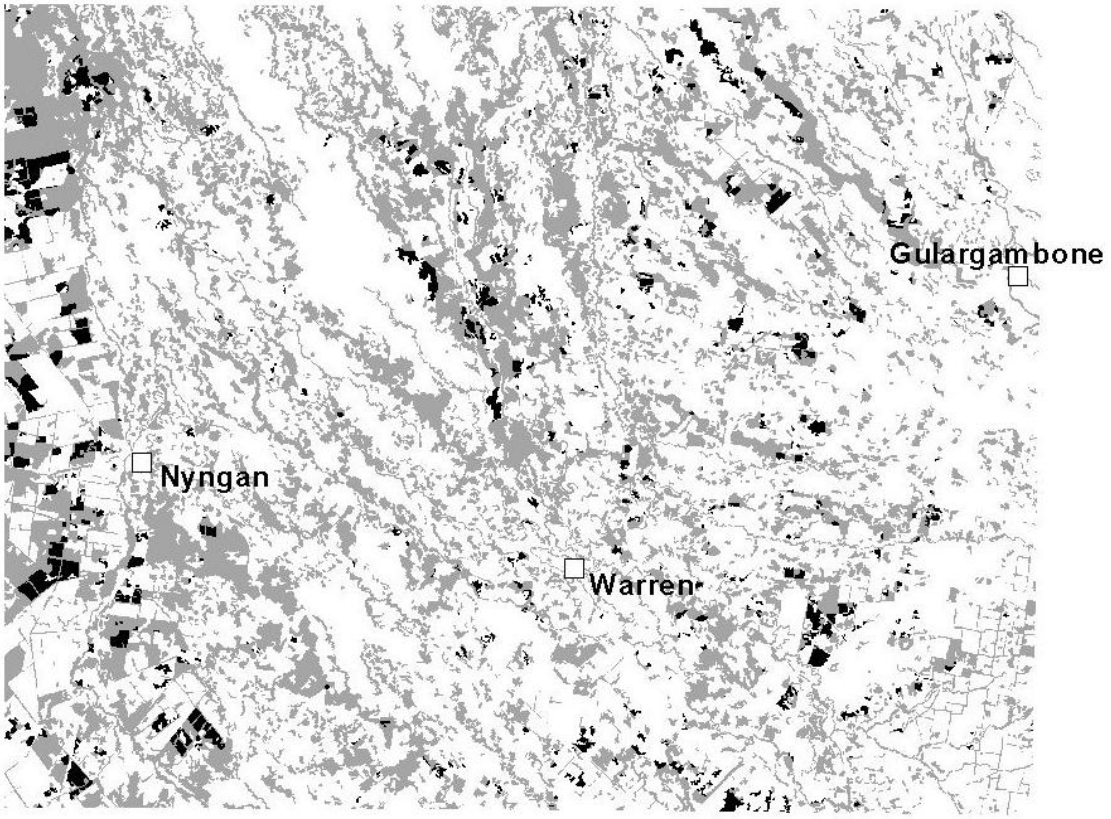


Figure 22. Native woody vegetation change on the Nyngan map sheet. Black indicates clearing between 1985 and 2000; grey is remaining native woody vegetation.

Fragmentation

Overall fragmentation, as measured by the remnant size and perimeter to area statistics, increased very slightly over the study period. In 1985, the largest interconnected remnant accounted for 18% of the native woody vegetation, falling to 15% in 2000. The remainder of the vegetation was present as more than 2000 smaller remnants. The median size of these remained relatively stable over the study period (Table 16).

Although further fragmentation for the map sheet as a whole was negligible, an analysis of localised fragmentation for areas with high proportional vegetation loss would show instances of significant deterioration, as is evident from Figure 22 and Figure 23.

Relative impacts

Figure 23 shows the percentage of native woody vegetation cleared within a 10 km radius throughout the study area on the Nyngan map sheet. A tiny portion of the Macquarie Marshes Nature (287ha) Reserve is the only area on the Nyngan map sheet managed exclusively for conservation.

Table 16. Nyngan map sheet (Band C): results for overall native woody vegetation.

	1985	**1998**	**2000**	**Overall**
Extant vegetation (ha) (% study area)	489466 (31.0%)	461621 (29.3%)	443493 (28.1%)	
Area cleared (ha)		27845	18127	**45973**
Area cleared (% 1985 vegetation)	-	5.7%	3.7%	**9.4%**
Average annual clearing rate (ha/yr)	-	2142	9064	**3065**
Average annual clearing rate (as % 1985 vegetation)	-	0.44%	1.85%	**0.6%**
Average annual clearing rate (as % previous area)	-	0.44%	1.96%	
Years to clear all native woody vegetation at this rate	-	216	49	**145**
Number of patches	2362	2379	2382	
Median patch area (ha) (min - max)	31 (1-88384)	30 (1-83256)	29 (1-64342)	
Median P/A ratio (m/ha)	95	97	98	

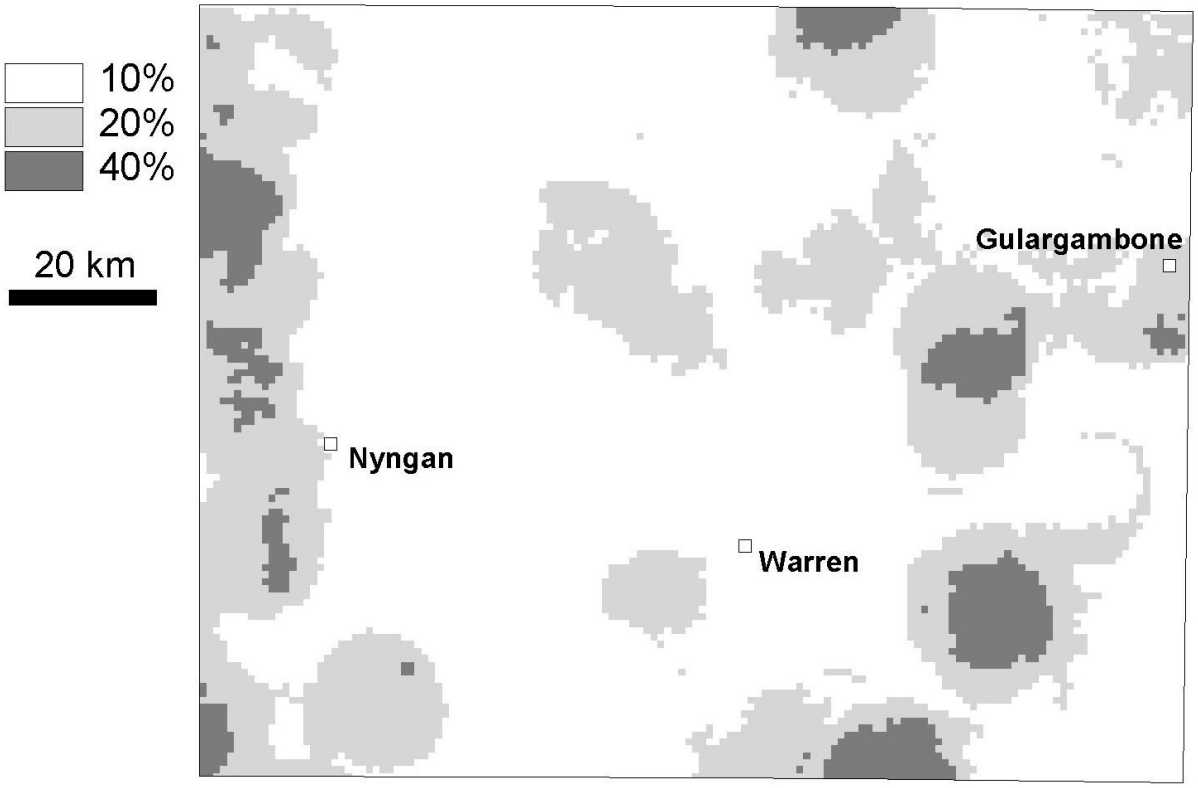


Figure 23. The relative impact of clearing on the Nyngan map sheet during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

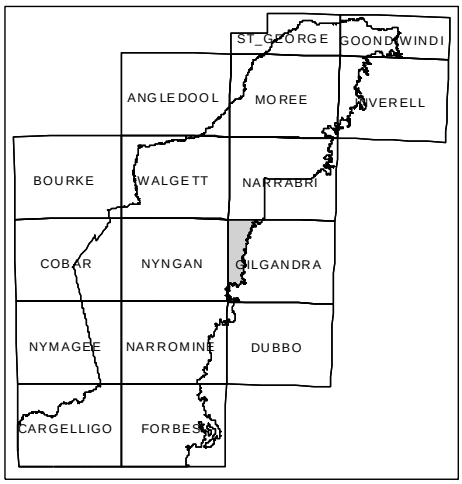
Vegetation types

Table 17 summarises the overall results by vegetation type ranked by the percentage of the baseline 1985 extent that was cleared over the study period. Three Box Woodland vegetation types and Myall Woodlands were cleared at rates greater than the average rate of native woody vegetation loss within the map sheet.

Table 17. Summary of the extent and rate of clearing for vegetation types within the Nyngan map sheet arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period.

Vegetation type	**Baseline (1985) area (ha)**	**Area cleared (ha)**	**Percentage of 1987 area**	**Average clearing rate (ha / yr)**	**Average clearing rate (% 1985 area)**
P4West: Western Poplar Box Woodlands	48100	10285	21.4%	686	1.43%
P14: Red Box, Poplar Box and White Cypress Pine Woodlands	14580	3078	21.1%	205	1.41%
P7: Belah, Poplar Box and White Cypress Pine Woodlands	6750	783	11.6%	52	0.77%
R5: Myall Woodlands	23714	2422	10.2%	161	0.68%
P4East: Eastern Poplar Box Woodlands	238585	20663	8.7%	1378	0.58%
P15: Dirty Red Gum, White Cypress Pine and Poplar Box Woodlands	16899	1307	7.7%	87	0.52%
R1: River Red Gum Forests Woodlands	66772	3672	5.5%	245	0.37%
P12: Woodlands of Jurassic Sandstone	9865	522	5.3%	35	0.35%
R3: Black Box Woodlands	61701	3223	5.2%	215	0.35%
H9: Dwyer's Red Gum Open Woodlands on Granite Hills	432	17	4.0%	1	0.27%
P6: White Cypress Pine Woodlands	1096	1	0.1%	0	0.00%
P1: Mallee Woodlands on Plains	676	0	0.0%	0	0.00%
P11: Leopardwood Open Woodlands	190	0	0.0%	0	0.00%
H8: Tumble-down Red Gum Woodlands on Basalt Hills	107	0	0.0%	0	0.00%
Overall		**45973**	**9.4%**	**3065**	**0.6%**

5.4.4 Vegetation change on the Gilgandra map sheet (Band C)



Overall native woody vegetation

Clearing

Little clearing was mapped in this already highly depleted part of the study area. Based on the NPWS vegetation mapping for 1981, the total extent of native woody vegetation in study area within the Gilgandra map sheet was 24,384 ha, or 10.8% of the total area. Over the study period, 1981-2000, 875 ha, 3.6% of the baseline vegetation, was mapped as cleared (Figure 24).

For the 1981-1998 period, the average annual clearing rate was 34 ha per year, while for 1998-2000 it was 148 ha per year (Table 18).

Figure 24. Native woody vegetation change within the Gilgandra map sheet. Black indicates clearing between 1981 and 2000; grey is remaining native woody vegetation.

Fragmentation

Remnant sizes and perimeter to area ratios were stable overall throughout the study period, but the very high values for perimeter to area ratio indicate a high vulnerability of remnants to edge effects.

Relative impacts

Figure 25 shows the percentage of native woody vegetation cleared within a 10km radius. Clearing was concentrated around the centre of the map sheet and the proportional local loss of vegetation in this area exceeded 10%. This map sheet has no areas managed exclusively for conservation.

Table 18. Gilgandra map sheet (Band C): results for overall native woody vegetation.

	1981	**1998**	**2000**	**Overall**
Extant vegetation (ha) (% study area)	24384 (10.8%)	23805 (10.6%)	23509 (10.4%)	
Area cleared (ha)	-	579	296	**875**
Area cleared (% 1981 vegetation)	-	2.4%	1.2%	**3.6%**
Average annual clearing rate (ha/yr)	-	34	148	**46**
Average annual clearing rate (as % 1981 vegetation)	-	0.14%	0.61%	**0.2%**
Average annual clearing rate (as % previous area)	-	0.14%	0.62%	
Years to clear all native woody vegetation at this rate	-	699	159	**510**
Number of patches	384	379	376	
Median patch area (ha) (min - max)	20 (1-1820)	20 (1-1686)	20 (1-1657)	
Median P/A ratio (m/ha)	131	132	133	

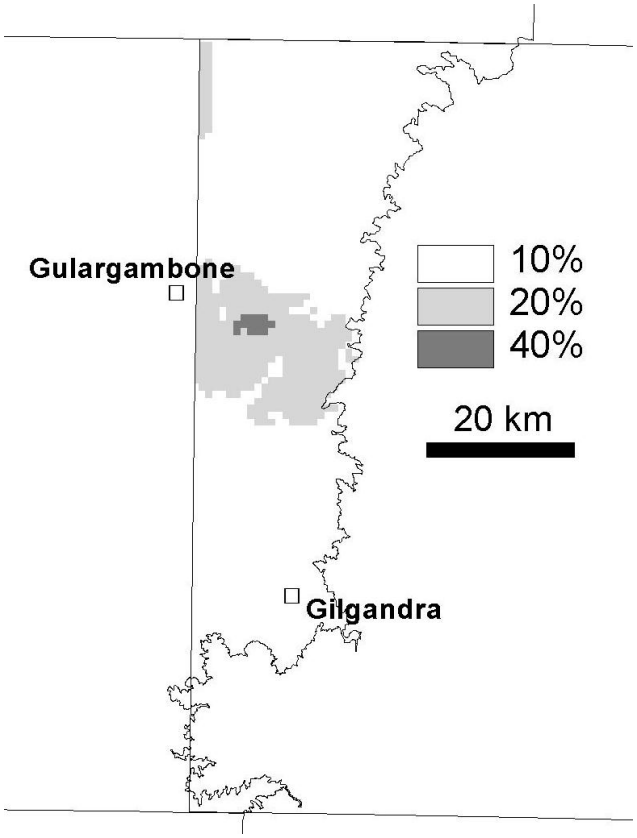


Figure 25. The relative impact of clearing on the Gilgandra map sheet during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

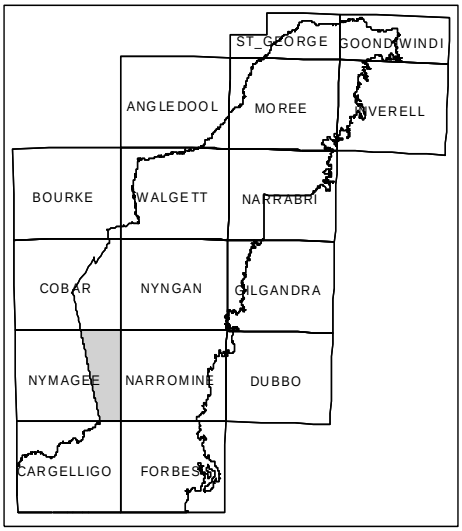
Vegetation types

Table 19 summarises the overall results by vegetation type ranked by the percentage of the baseline 1981 extent that was cleared over the study period. Clearing of Eastern Poplar Box Woodlands accounted for nearly 70% of total clearing.

Table 19. Summary of the extent and rate of clearing for vegetation types within the Gilgandra map sheet arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period.

Vegetation type	**Baseline (1981) area (ha)**	**Area cleared (ha)**	**Percentage of 1981 area**	**Average clearing rate (ha / yr)**	**Average clearing rate (% 1981 area)**
P4East: Eastern Poplar Box Woodlands	10286	601	5.8%	32	0.31%
P12: Woodlands of Jurassic Sandstone	6985	258	3.7%	14	0.19%
R1: River Red Gum Forests Woodlands	5645	16	0.3%	1	0.01%
R5: Myall Woodlands	115	0	0.0%	0	0.00%
P6: White Cypress Pine Woodlands	1131	0	0.0%	0	0.00%
P7: Belah, Poplar Box and White Cypress Pine Woodlands	45	0	0.0%	0	0.00%
H8: Tumble-down Red Gum Woodlands on Basalt Hills	175	0	0.0%	0	0.00%
Overall		**875**	**3.6%**	**46**	**0.2%**

5.4.5 Vegetation change on the Nymagee map sheet (Band D)



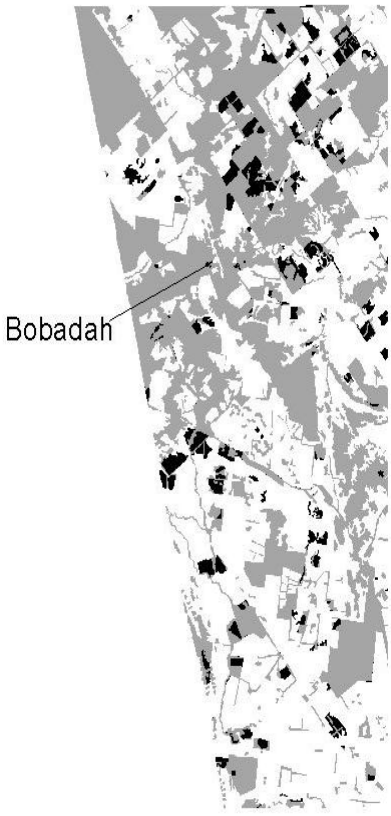


Figure 26. Native woody vegetation change on the Nymagee map sheet. Black indicates clearing between 1987 and 2000; grey is remaining native woody vegetation.

Overall native woody vegetation

Clearing

Based on the NPWS vegetation mapping, the total extent of native woody vegetation in the study area on the Nymagee map sheet in 1987 was 201,795 ha, or 44.2% of the total area. Over the study period 21,817 ha, 10.8% of the baseline vegetation extent, was mapped as cleared (Figure 26).

For the 1987-1998 period, the average annual clearing rate was 1,234 ha per year, while for 1998-2000 it was 4,122 ha per year (Table 20). If this latter rate of clearing was maintained, the remaining vegetation would be cleared in 44 years.

Fragmentation

Nymagee is another map sheet where the majority of the native woody vegetation was spatially connected at the beginning of the study. In 1987, 71% of the vegetation was connected. By 2000 this proportion was similar, though the actual extent of both total and connected vegetation had decreased (Table 20).

Overall fragmentation, as measured by the number of remnants, median remnant size and perimeter to area ratio, increased noticeably.

Relative impacts

Figure 27 shows the percentage of native woody vegetation cleared within a 10km radius. Localised losses of more than 20% were fairly common and the loss of more than 40% of local vegetation was recorded on the western margin of the map sheet. Two Nature Reserves (Tollingo 3,252ha and Woggoon 6123ha) are the only sites managed exclusively for conservation. In the area around Tollingo, 20% of the vegetation was cleared during the study period.

Table 20. Nymagee map sheet (Band D): results for overall native woody vegetation.

	1987	**1998**	**2000**	**Overall**
Extant vegetation (ha) (% study area)	201795 (44.2%)	188222 (41.2%)	179978 (39.4%)	
Area cleared (ha)		13572	8245	**21817**
Area cleared (% 1987 vegetation)	-	6.7%	4.1%	**10.8%**
Average annual clearing rate (ha/yr)	-	1234	4122	**1678**
Average annual clearing rate (as % 1987 vegetation)	-	0.61%	2.04%	**0.8%**
Average annual clearing rate (as % previous area)	-	0.61%	2.19%	
Years to clear all native woody vegetation at this rate	-	153	44	**107**
Number of patches	226	246	257	
Median patch area (ha) (min - max)	42 (1-143510)	38 (1-133119)	38 (1-127010)	
Median P/A ratio (m/ha)	78	82	84	

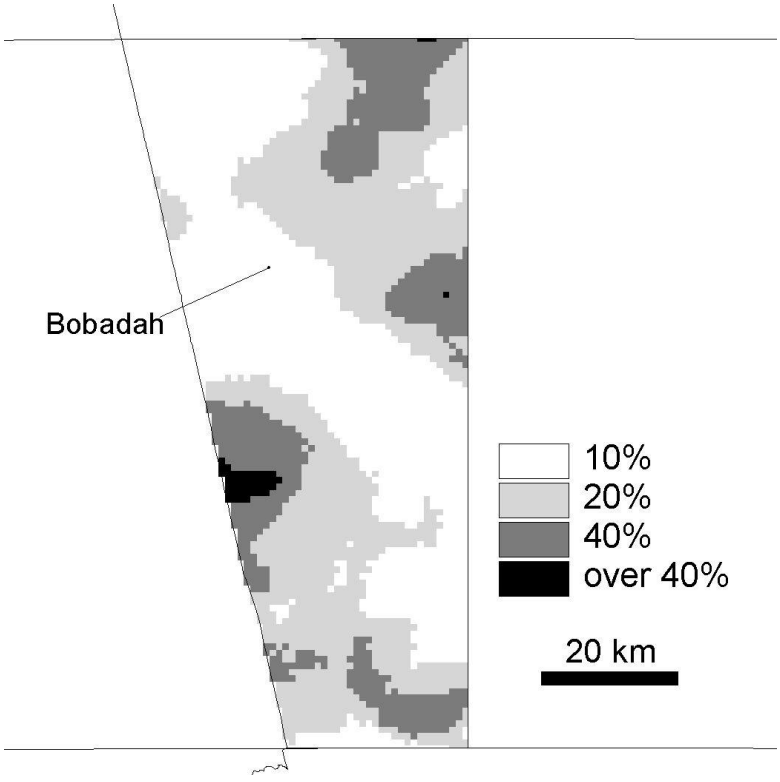


Figure 27. The relative impact of clearing on the Nymagee map sheet during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

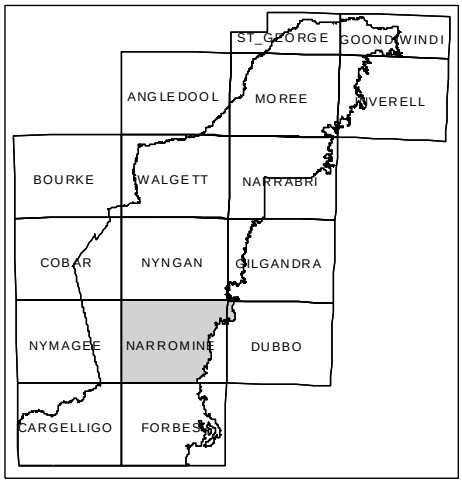
Vegetation types

Table 21 summarises the overall results by vegetation type ranked by the percentage of the baseline 1987 extent that was cleared over the study period. Six Woodland vegetation types were cleared at rates greater than the overall rate of native woody vegetation loss for the map sheet.

Table 21. Summary of the extent and rate of clearing for vegetation types within the Nymagee map sheet arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period.

Vegetation type	**Baseline (1987) area (ha)**	**Area cleared (ha)**	**Percentage of 1987 area**	**Average clearing rate (ha / yr)**	**Average clearing rate (% 1987 area)**
P4West: Western Poplar Box Woodlands	29663	5776	19.5%	444	1.50%
P13: Grey Box, Poplar Box and White Cypress Pine Woodlands	26320	4518	17.2%	348	1.32%
U1: Red Box, Poplar Box, White Cypress Pine and Green Mallee Woodlands	20192	2993	14.8%	230	1.14%
R3: Black Box Woodlands	1333	170	12.8%	13	0.98%
H7: Mallee Woodlands on Rolling Hills	6248	690	11.0%	53	0.85%
P14: Red Box, Poplar Box and White Cypress Pine Woodlands	52168	5453	10.5%	419	0.80%
U2: Red Box, Poplar Box and White Cypress Pine Woodlands on Granite Hillslopes	10021	826	8.2%	64	0.63%
P1: Mallee Woodlands on Plains	11121	659	5.9%	51	0.46%
H2: Green Mallee Woodlands	6976	383	5.5%	29	0.42%
R1: River Red Gum Forests Woodlands	5289	234	4.4%	18	0.34%
P7: Belah, Poplar Box and White Cypress Pine Woodlands	1653	55	3.3%	4	0.25%
H1: Dwyer's Red Gum, Ironbark and Green Mallee Woodlands	27331	60	0.2%	5	0.02%
P6: White Cypress Pine Woodlands	3478	0	0.0%	0	0.00%
Overall	**201795**	**21817**	**10.8%**	**1678**	**0.8%**

5.4.6 Vegetation change on the Narromine and Dubbo map sheets (Band D)†



Overall native woody vegetation

Clearing

Based on the NPWS vegetation mapping, the total extent of native woody vegetation on the Narromine map sheet in 1983 was 259,813 ha, or 18.7% of the total area. Over the study period, 1983-2000, 21,720 ha, 8.4% of the baseline extent, was mapped as cleared (Figure 28).

For the 1983-1998 period, the average annual clearing rate was 981 ha per year, while for 1998-2000 it was 3,503 ha per year (Table 22). If this latter rate was maintained, the remaining vegetation would be cleared in less than 70 years.

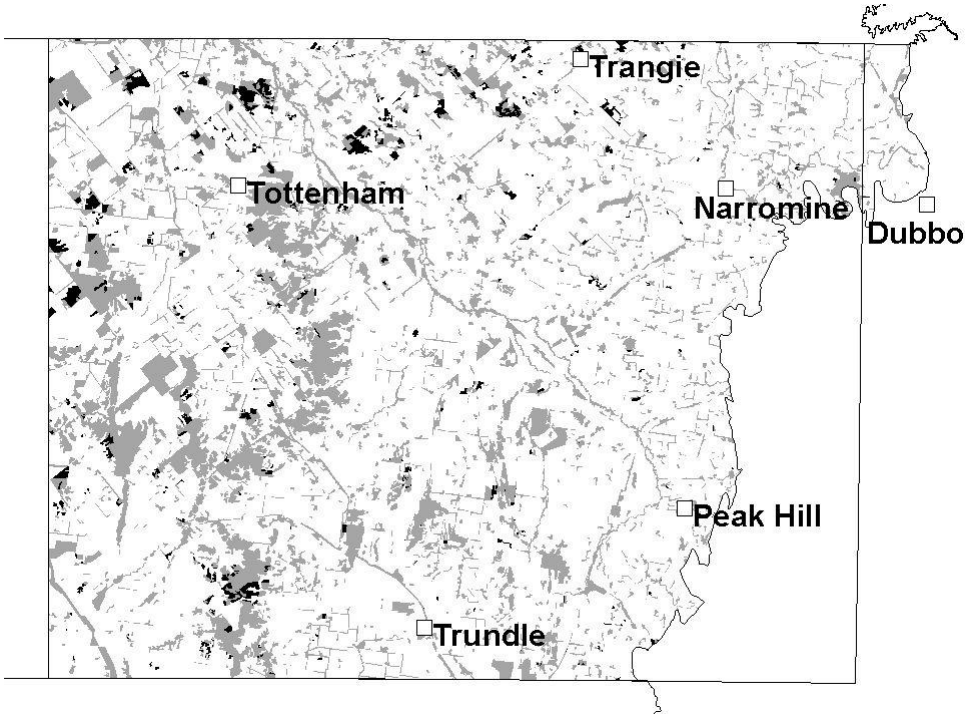


Figure 28. Native woody vegetation change on the Narromine and Dubbo map sheets. Black indicates clearing between 1983 and 2000; grey is remaining native woody vegetation.

†The Narromine and Dubbo map sheets have been combined here because of the very small extent of the study area within the Dubbo map. Although the dates of aerial photography differ for the two map sheets (1983 for Narromine; 1980 for Dubbo), there was no clearing mapped on the Dubbo map for 1980 - 1998.

Fragmentation

The native woody vegetation on the Narromine map sheet was already highly fragmented at the beginning of the study with the high median perimeter to area ratio indicating the vulnerability of remnants to edge effects (Table 22).

The number of remnants, remnant area and median perimeter to area ratio were stable over the study period. However, an analysis of localised fragmentation for areas with high proportional vegetation loss would show instances of significant deterioration as is evident in Figure 28 and Figure 29.

Relative impacts

Figure 29 shows the percentage of native woody vegetation cleared within a 10km radius throughout the study area on the Narromine and Dubbo map sheets. Clearing was concentrated in areas north and west of Tottenham and near Trangie with local losses of over 20% being recorded. No areas on the Narromine or Dubbo map sheets are managed exclusively for conservation by NPWS. However, 400ha of private land is managed under an NPWS Voluntary Conservation Agreement.

Table 22. Narromine and Dubbo map sheets (Band D): results for overall native woody vegetation.

	1983	**1998**	**2000**	**Overall**
Extant vegetation (ha) (% study area)	259813 (18.7%)	245098 (17.7%)	238092 (17.1%)	
Area cleared (ha)	-	14715	7006	**21720**
Area cleared (% 1983 vegetation)	-	5.7%	2.7%	**8.4%**
Average annual clearing rate (ha/yr)	-	981	3503	**1278**
Average annual clearing rate (as % 1983 vegetation)	-	0.38%	1.35%	**0.5%**
Average annual clearing rate (as % previous area)	-	0.38%	1.43%	
Years to clear all native woody vegetation at this rate	-	250	68	**186**
Number of patches	1461	1462	1469	
Median patch area (ha) (min - max)	33 (1-22605)	32 (1-20907)	32 (1-20052)	
Median P/A ratio (m/ha)	102	103	104	

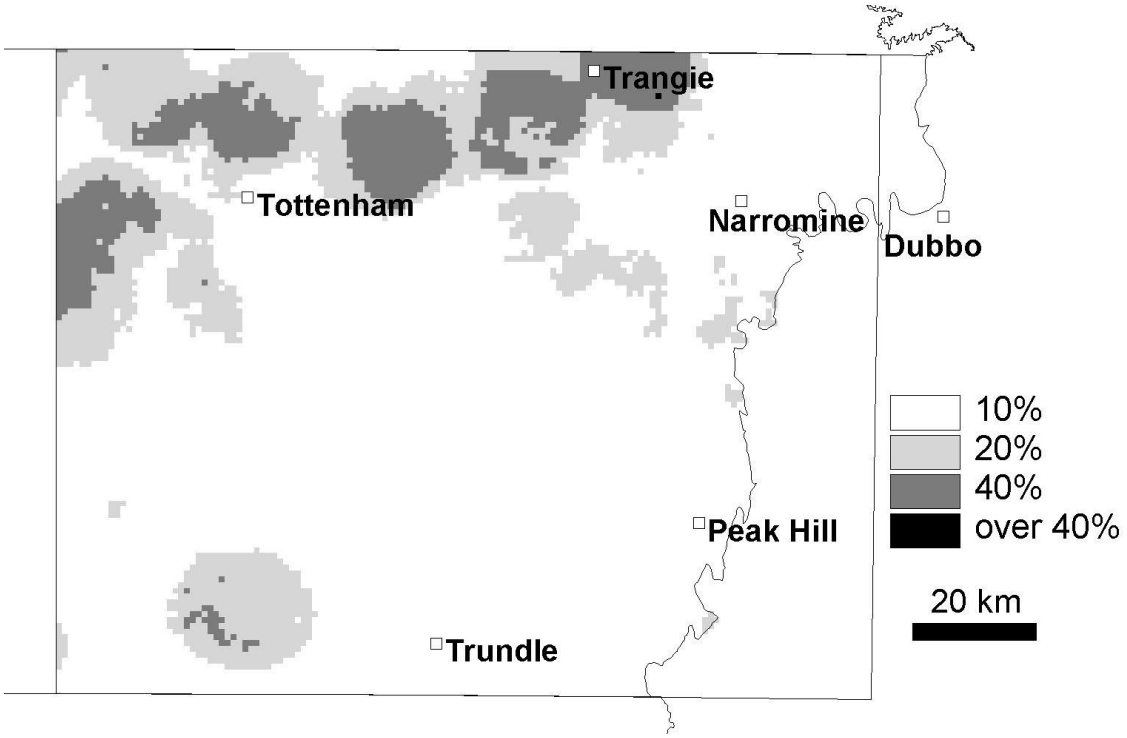


Figure 29. The relative impact of clearing on the Narromine and Dubbo map sheets during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

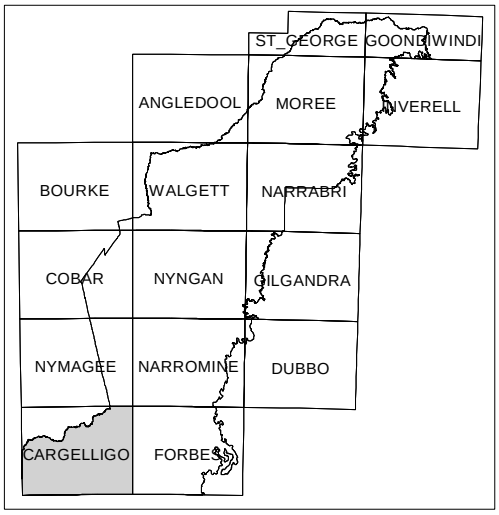
Vegetation types

Table 23 summarises the overall results by vegetation type ranked by the percentage of the baseline 1983 extent that was cleared over the study period. Six vegetation types including Mallee, Box and Myall Woodlands were cleared at rates higher than the overall rate of loss for native woody vegetation within the map sheet.

Table 23. Summary of the extent and rate of clearing for vegetation types within the Narromine and Dubbo map sheets arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period.

Vegetation type	Baseline (1983) area (ha)	Area cleared (ha)	Percentage of 1983 area	Average clearing rate (ha / yr)	Average clearing rate (% 1983 area)
H7: Mallee Woodlands on Rolling Hills	3413	645	18.9%	38	1.11%
R3: Black Box Woodlands	11535	1797	15.6%	106	0.92%
P4West: Western Poplar Box Woodlands	22907	3168	13.8%	186	0.81%
P7: Belah, Poplar Box and White Cypress Pine Woodlands	30887	3929	12.7%	231	0.75%
R5: Myall Woodlands	1872	236	12.6%	14	0.74%
P13: Grey Box, Poplar Box and White Cypress Pine Woodlands	42845	4684	10.9%	276	0.64%
P4East: Eastern Poplar Box Woodlands	41952	3419	8.1%	201	0.48%
P1: Mallee Woodlands on Plains	984	60	6.1%	4	0.36%
H1: Dwyer's Red Gum, Ironbark and Green Mallee Woodlands	60020	2709	4.5%	159	0.27%
H2: Green Mallee Woodlands	14915	615	4.1%	36	0.24%
P12: Woodlands of Jurassic Sandstone	4481	133	3.0%	8	0.17%
P6: White Cypress Pine Woodlands	11326	244	2.2%	14	0.13%
R1: River Red Gum Forests Woodlands	12635	82	0.6%	5	0.04%
U2: Red Box, Poplar Box and White Cypress Pine Woodlands on Granite Hillslopes	40	0	0.0%	0	0.00%
Overall	**259,813**	**21,270**	**8.4%**	**1,278**	**0.5%**

5.4.7 Vegetation change on the Cargelligo map sheet (Band E)



Overall native woody vegetation

Clearing

Based on the NPWS vegetation mapping, the total extent of native woody vegetation on the Cargelligo map sheet in 1980 was 237,544 ha, or 19.9% of the total area. Over the study period, 1980-2000, 28,185 ha, 11.9% of the baseline extent, was mapped as cleared (Figure 30).

For the 1980-1998 period, the average annual clearing rate was 1,385 ha per year, while for 1998-2000 it was 1,626 ha per year (Table 24).

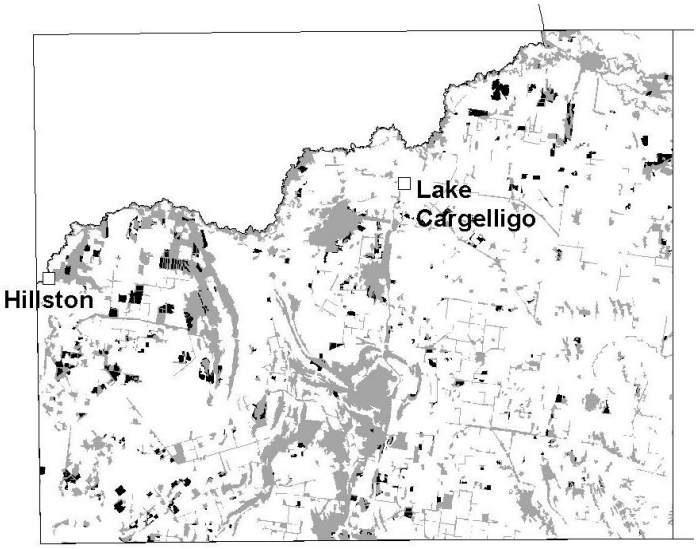


Figure 30. Native woody vegetation change on the Cargelligo map sheet. Black indicates clearing between 1980 and 2000; grey is remaining native woody vegetation.

Fragmentation

The native woody vegetation on the Cargelligo map sheet was already highly fragmented at the beginning of the study period. Between 1980 and 2000 the number of remnants increased through division of previously contiguous vegetation, while median remnant size decreased by about 25% (Table 24).

Relative impacts

Figure 31 shows the percentage of native woody vegetation cleared within a 10km radius throughout the study area on the Cargelligo map sheet. Clearing was most intense in vicinities east of Hillston and Lake Cargelligo townships, with local losses

sometimes exceeding 40%. Three small Nature Reserves (Loughnan 391 ha, Langtree 233 ha, and Pulletop 145 ha) exist as isolated remnants connected to surrounding vegetation via narrow vegetated road corridors. Cocoparra Nature Reserve (1370 ha) is part of an extensive remnant along Cocoparra Range.

Table 24. Cargelligo map sheet (Band E): results for overall native woody vegetation.

	1980	**1998**	**2000**	**Overall**
Extant vegetation (ha) (% study area)	237544 (19.9%)	212611 (17.8%)	209359 (17.6%)	
Area cleared (ha)	-	24933	3252	**28185**
Area cleared (% 1980 vegetation)	-	10.5%	1.4%	**11.9%**
Average annual clearing rate (ha/yr)	-	1385	1626	**1409**
Average annual clearing rate (as % 1980 vegetation)	-	0.58%	0.68%	**0.6%**
Average annual clearing rate (as % previous area)	-	0.58%	0.76%	
Years to clear all native woody vegetation at this rate	-	153	129	**149**
Number of patches	520	559	564	
Median patch area (ha) (min - max)	85 (1-58898)	67 (1-52813)	65 (1-51963)	
Median P/A ratio (m/ha)	69	75	76	

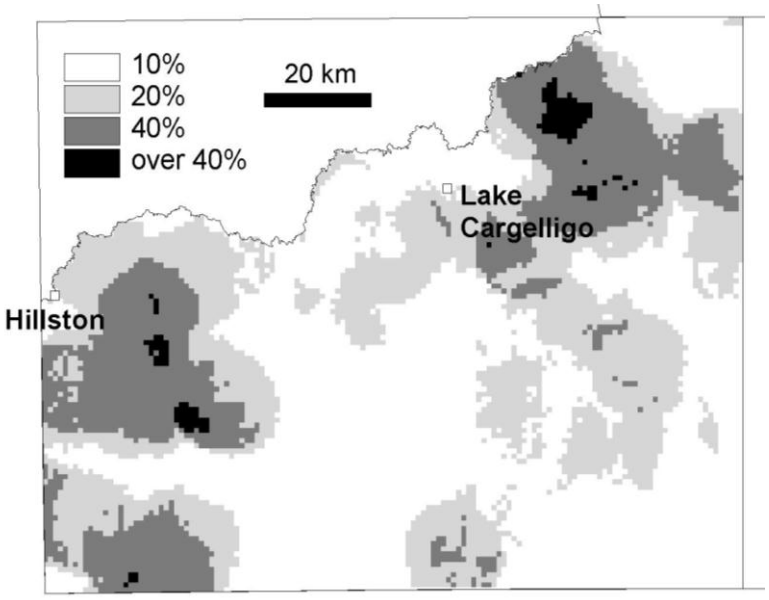


Figure 31. The relative impact of clearing on the Cargelligo map sheet during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

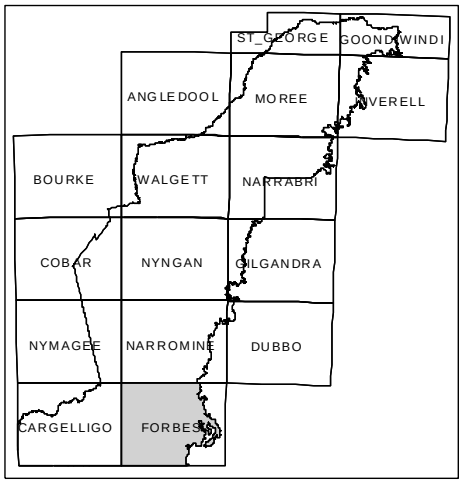
Vegetation types

Table 25 summarises the overall results by vegetation type ranked by the percentage of the baseline 1980 extent that was cleared over the study period. Six vegetation types including Mallee and Box Woodlands were cleared at rates higher than the overall rate of loss for native woody vegetation within the map sheet.

Table 25. Summary of the extent and rate of clearing for vegetation types within the Cargelligo map sheet arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period.

Vegetation type	**Baseline (1980) area (ha)**	**Area cleared (ha)**	**Percentage of 1980 area**	**Average clearing rate (ha / yr)**	**Average clearing rate (% 1980 area)**
P2: Open Mallee Woodlands	24804	8201	33.1%	410	1.65%
P1: Mallee Woodlands	14821	3846	26.0%	192	1.30%
F2: Open White Cypress Pine and Box Woodlands	16708	3335	20.0%	167	1.00%
P3: Open Box Woodlands	31669	5938	18.7%	297	0.94%
P5: Mallee/White Cypress Pine intergrade	4380	770	17.6%	38	0.88%
R3: Black Box Woodlands	11402	1888	16.6%	94	0.83%
F3: White Cypress Pine and Box Woodlands	8681	900	10.4%	45	0.52%
P4: Box Woodlands	10850	770	7.1%	39	0.35%
P6: White Cypress Pine Woodlands	7858	409	5.2%	20	0.26%
R2: Floodplain Mosaic	8166	355	4.3%	18	0.22%
H2: Green Mallee Woodlands	7370	257	3.5%	13	0.17%
H1: Dwyer's Red Gum and White Cypress Pine Woodlands	58720	678	1.2%	34	0.06%
H4: White Cypress Pine Woodlands	13592	141	1.0%	7	0.05%
R1: River Red Gum Forests	13912	85	0.6%	4	0.03%
H3: White Cypress Pine and Poplar Box Open Woodlands	571	0	0.0%	0	0.00%
Overall	**237,544**	**28,185**	**11.9%**	**1,409**	**0.6%**

5.4.8 Vegetation change on the Forbes map sheet (Band E)



Overall native woody vegetation

Clearing

Based on the NPWS vegetation mapping, the total extent of native woody vegetation on the Forbes map sheet in 1989 was 142,670 ha, or 12% of the total area. Over the study period, 1989-2000, 1,858 ha, 1.3% of the baseline extent, was mapped as cleared (Figure 32).

For the 1989-1998 period, the average annual clearing rate was 131 ha per year, while for 1998-2000 it was 340 ha per year (Table 26).

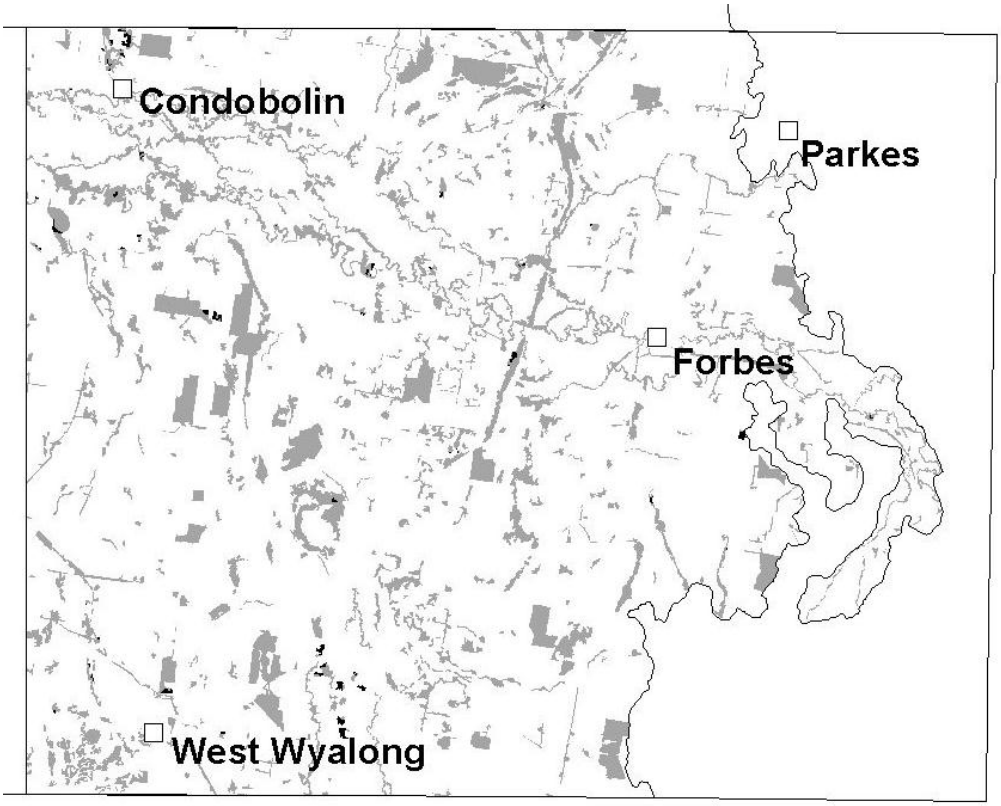


Figure 32. Native woody vegetation change on the Forbes map sheet. Black indicates clearing between 1989 and 2000; grey is remaining native woody vegetation.

Fragmentation

The native woody vegetation on the Forbes map sheet was already highly fragmented at the beginning of the study. There was a negligible increase in overall fragmentation during the study period with the number of remnants, remnant size and perimeter to area ratio remaining relatively stable (Table 26).

Relative impacts

Figure 33 shows the percentage of native woody vegetation cleared within a 10km radius throughout the study area on the Forbes map sheet. Most clearing occurred on the southern edge of the map sheet, near West Wyalong, where local losses of mostly 10-20% were recorded. The Charcoal Tank Nature Reserve (83 ha) is the only area managed exclusively for conservation.

Table 26. Forbes map sheet (Band E): results for overall native woody vegetation.

	1989	**1998**	**2000**	**Overall**
Extant vegetation (ha) (% study area)	142670 (12.0%)	141492 (11.9%)	140812 (11.8%)	
Area cleared (ha)	-	1178	680	**1858**
Area cleared (% 1989 vegetation)	-	0.8%	0.5%	**1.3%**
Average annual clearing rate (ha/yr)	-	131	340	**169**
Average annual clearing rate (as % 1989 vegetation)	-	0.09%	0.24%	**0.1%**
Average annual clearing rate (as % previous area)	-	0.09%	0.24%	
Years to clear all native woody vegetation at this rate	-	1081	414	**834**
Number of patches	637	641	643	
Median patch area (ha) (min - max)	63 (1-6928)	63 (1-6928)	61 (1-6843)	
Median P/A ratio (m/ha)	81	82	83	

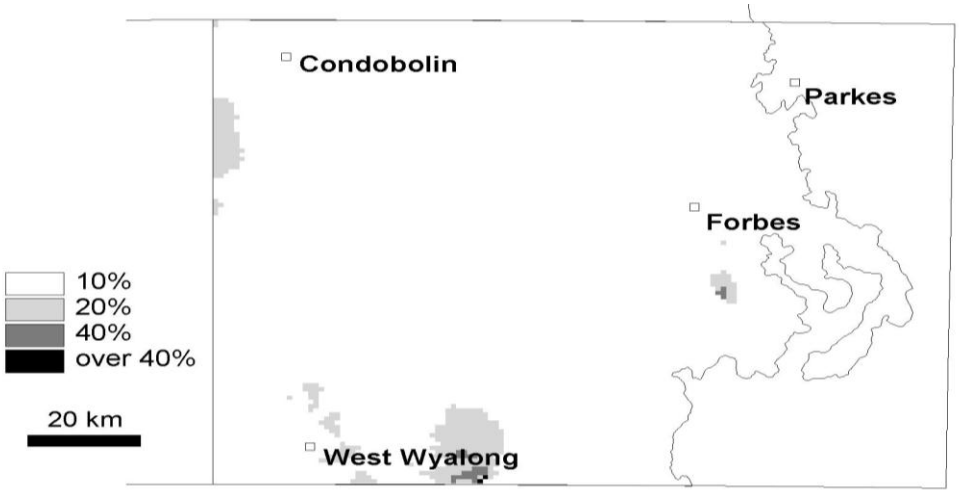


Figure 33. The relative impact of clearing on the Forbes map sheet during the study period expressed as the percentage of native woody vegetation cleared within a 10km radius.

Vegetation types

Table 27 summarises the overall results by vegetation type ranked by the percentage of the baseline 1989 extent that was cleared over the study period. Five vegetation types were cleared at rates higher than the overall rate of loss for native woody vegetation within the map sheet. Seven out of eighteen vegetation types recorded no clearing for either of the monitoring periods.

Table 27. Summary of the extent and rate of clearing for vegetation types within the Forbes map sheet arranged in decreasing order of proportional loss. The bold horizontal line indicates the average percentage rate of vegetation loss over the study period.

Vegetation type	Baseline (1989) area (ha)	Area cleared (ha)	Percentage of 1989 area	Average clearing rate (ha / yr)	Average clearing rate (% 1989 area)
F2: Open White Cypress Pine and Box Woodlands	4301	395	9.2%	36	0.83%
P7: Bulloak/Belah Woodlands	14847	580	3.9%	53	0.36%
P3: Open Box Woodlands	7309	149	2.0%	14	0.19%
H1: Dwyer's Red Gum and White Cypress Pine Woodlands	20721	320	1.5%	29	0.14%
P4: Box Woodlands	13908	170	1.2%	15	0.11%
R2: Floodplain Mosaic	4285	37	0.9%	3	0.08%
R3: Black Box Woodlands	12856	81	0.6%	7	0.06%
H2: Green Mallee Woodlands	3281	11	0.3%	1	0.03%
R1: River Red Gum Forests	24650	56	0.2%	5	0.02%
P6: White Cypress Pine Woodlands	25337	53	0.2%	5	0.02%
H4: White Cypress Pine Woodlands	6971	4	0.1%	0	0.00%
R5: Myall Woodlands	215	0	0.0%	0	0.00%
R6: Yellow Box River / Red Gum Forests	2157	0	0.0%	0	0.00%
P1: Mallee Woodlands	511	0	0.0%	0	0.00%
P2: Open Mallee Woodlands	137	0	0.0%	0	0.00%
P5: Mallee/White Cypress Pine intergrade	48	0	0.0%	0	0.00%
F3: White Cypress Pine and Box Woodlands	1078	0	0.0%	0	0.00%
H3: White Cypress Pine and Poplar Box Open Woodlands	59	0	0.0%	0	0.00%
Overall	**142,670**	**1,858**	**1.3%**	**169**	**0.1%**

[redacted]

6 Discussion

6.1 Mapping methods

This project has shown that accurate mapping of native woody vegetation change can be achieved using visual interpretation of readily available Landsat TM satellite imagery. Systematic validation of the mapping gave consistently high rates of accuracy. Resolution of clearing to lower levels of average canopy cover resulted in a greater area of clearing being detected than in previous studies

Combining this mapping method with sufficiently detailed baseline vegetation mapping allows change to be monitored for individual vegetation types. We conclude that adopting these mapping and analysis methods for future reporting of clearing in New South Wales would provide more comprehensive and reliable information than has been possible to date.

6.2 The importance of monitoring change for vegetation types

Our results show marked differences in the extent and rate of clearing between vegetation types. Those types that are associated with areas of higher agricultural value were cleared preferentially. While not unexpected, this result confirms that monitoring of change at the vegetation type level is essential to inform regional vegetation management and conservation planning. Data on only gross changes in vegetation cover will not identify the severe declines in some vegetation types recorded in this study.

6.3 The importance of localised analyses of vegetation change

We derived data on the extent and rate of clearing, change in native woody vegetation cover and levels of fragmentation from the mapping compiled in this study. However, tabulating such information for areas as large as map sheets, local government areas or bioregions, as is commonly done, can obscure significant local impacts.

Maps of change within local spatial neighbourhoods, such as those of the percentage of native woody vegetation cleared with a 10 km radius (e.g. Figure 19), can highlight changes that are likely to have substantial consequences for biodiversity. Similar localised analyses can be done for other measures of change, but only when detailed and accurate mapping of vegetation change is available.

6.4 Extent and rates of clearing in the wheatbelt

Substantial clearing of native woody vegetation continued in the wheatbelt between the 1980s and 2000 and clearing rates increased in most areas in the 1998-2000 monitoring period.

Our results for the extent of clearing are conservative for a number of reasons:

- only woody vegetation was considered;
- the smallest remnants examined were 10 ha;
- areas mapped as uncertain were excluded from the analyses;
- the definition of clearing was much narrower than that used in the Native Conservation Act.

6.5 Implications for biodiversity and landuse planning

Theoretical and empirical studies suggest that there can be a substantial time lag between habitat loss or modification and the onset of population declines and extinctions, an effect referred to as extinction debt[46,47]. This implies that in an extensively cleared region, predicting the implications of further habitat loss, or setting thresholds for maximum acceptable modification of the landscape, becomes increasingly precarious.

Other studies suggest that the relationship between habitat reduction and species loss in a region is likely to be highly non-linear and that there may be critical levels of habitat reduction beyond which the loss of species greatly accelerates[48,49]. One mechanism is the sudden loss of spatial connectivity between vegetation remnants when the total vegetation cover is reduced below a certain point. Our ignorance on these issues is profound. It is difficult to say which groups of species will display population behaviour of the type seen in theoretical models or what the critical thresholds might be for different groups.

This study has not attempted to investigate the impacts of native woody vegetation clearing on flora or fauna directly. However, given that native vegetation clearing is recognised as a major threatening process for native plant and animal populations[50], the previous and continuing depletion and fragmentation of native vegetation recorded in this study can be interpreted as increasing the risk of population declines and extinctions in the wheatbelt. The existing conservation network, occupying only 0.29% of the study area, is inadequate both spatially and in terms of its biological representativeness.

Various schemes for setting landuse limits within agricultural landscapes have been proposed [51] that attempt to either prevent native vegetation cover falling below some critical point or, where it is already highly depleted, to restore the level of native vegetation to some level. Current proposals include:

- setting targets for the retention or restoration of native vegetation cover;
- setting limits on the extent of overall vegetation or individual vegetation types that can be cleared;
- setting limits on the proportion of vegetation types that can be converted to intensive land uses such as cropping;
- increasing the area managed for conservation to some proportion through reserves, Voluntary Conservation Agreements or other mechanisms.

There is little science on which to base the setting of any such targets and limits, but values between 30-40% for retention of native woody vegetation cover have been widely advocated. Native woody vegetation cover for most of the map sheets within the study area was below this level in the 1980s and decreased further over the study period. Additional clearing will narrow the remaining options to conserve a minimal

[46] Saunders et al. 1991

[47] Tilman et al. 1994

[48] Andren 1994

[49] Green 1994

[50] For example, woodland birds: Reid 2000

[51] For example, Freudenberger et al. 1997; McIntyre 2000; Reid 2000

level of native woody vegetation cover and attempt to expand remnants in the most highly depleted areas.

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8 Appendices

8.1 Appendix I CD-ROM Contents

1 Report

Report.doc

2 Metadata

Metadata.xls	proforma for capture of digital data
Mapunits.xls	summary of mapunit categories across all bands
Report_appendixII.doc	detailed description of the mapunit categories.

3 Data and Analysis

Revised Band A

RA1 Shapefiles - contains shapefiles showing extant native woody vegetation remaining in Band A at each year of analysis (revised February 2002).

banda_1980s_veg.shp	- baseline 1980s vegetation mapping;
banda_1994_veg.shp	- native woody vegetation remaining in 1994;
banda_1998_veg.shp	- native woody vegetation remaining in 1998;
banda_2000_veg.shp	- native woody vegetation remaining in 2000.

RA2 Statistics

bastatistics.xls	- summary statistics of remnant data from each year of analysis for Band A;
baz5556statistics.xls	- summary statistics of patch data from each year of analysis for Band A with data from AMG zones 55 and 56 treated separately;
basummary.xls	- analysis of data from Band A.

Band C

C1 Shapefiles - contains shapefiles showing extant native woody vegetation remaining in each 1:250 000 mapsheet within Band C at each year of analysis.

C1a Cobar

bccob80v.shp	- baseline 1980s vegetation mapping;
bccob98v.shp	- native woody vegetation remaining in 1998;
bccob00v.shp	- native woody vegetation remaining in 2000.

C1b Gilgandra

bcgil80v.shp	- baseline 1980s vegetation mapping;
bcgil98v.shp	- native woody vegetation remaining in 1998;
bcgil00v.shp	- native woody vegetation remaining in 2000.

C1c Nyngan

bcnyn80v.shp	- baseline 1980s vegetation mapping;
bcnyn98v.shp	- native woody vegetation remaining in 1998;
bcnyn00v.shp	- native woody vegetation remaining in 2000.

C2 Statistics

bccobnyngil.xls	- summary statistics of remnant and patch data from each year of analysis for Band C;
sumbccob.xls	- analysis of data from the area of Band C within the Cobar 1:250000 mapsheet;
sumbcgil.xls	- analysis of data from the area of Band C within the Gilgandra 1:250000 mapsheet;
sumbcnyn.xls	- analysis of data from the area of Band C with the Nyngan 1:250000 mapsheet.

Band D

D1 Shapefiles - contains shapefiles showing extant native woody vegetation remaining in each 1:250 000 mapsheet within Band D at each year of analysis.

D1a Nymagee

bdnym80v.shp	- baseline 1980s vegetation mapping;
bdnym98v.shp	- native woody vegetation remaining in 1998;
bdnym00v.shp	- native woody vegetation remaining in 2000.

D1b Narromine and Dubbo

bdndub80v.shp	- baseline 1980s vegetation mapping;
bdndub98v.shp	- native woody vegetation remaining in 1998;
bdndub00v.shp	- native woody vegetation remaining in 2000.

D2 Statistics

bdnymndub.xls	- summary statistics of remnant and patch data from each year of analysis for Band D;
sumbdnym.xls	- analysis of data from the area of Band D within the Nymagee 1:250000 mapsheet;
sumbdndub.xls	- analysis of data from the area of Band D within the Narromine and Dubbo 1:250000 mapsheets.

Band E

E1 Shapefiles - contains shapefiles showing extant native woody vegetation remaining in each 1:250 000 mapsheet within Band E at each year of analysis.

E1a Cargelligo

becar80v.shp	- baseline 1980s vegetation mapping;
becar98v.shp	- native woody vegetation remaining in 1998;
becar00v.shp	- native woody vegetation remaining in 2000.

E1b Forbes

befor80v.shp	- baseline 1980s vegetation mapping;
befor98v.shp	- native woody vegetation remaining in 1998;
befor00v.shp	- native woody vegetation remaining in 2000.

E2 Statistics

becarfor.xls	- summary statistics of remnant and patch data from each year of analysis for Band E;
sumbefor.xls	- analysis of data from the area of Band E within the Forbes 1:250000 mapsheet;
sumbecar.xls	- analysis of data from the area of Band E within the Cargelligo 1:250000 mapsheet.

4 Wheatbelt Study Area Shapefile

wheatbelt.shp	- the Wheatbelt study area boundary including bands.

8.2 Appendix II Descriptions of vegetation types

DRAFT REMNANT DESCRIPTIONS FOR
THE ST GEORGE, GOONDIWINDI ANGLEDOOL, MOREE AND INVERELL 1:250 000 VEGETATION SHEETS
(BAND A)

THE MAPPING UNITS

The following map unit descriptions summarise the landforms, soils, vegetation structures and species occurring in each unit. These remnants are not homogeneous with respect to all of these factors, hence, the descriptions deal with the most common and characteristic features. Variations will be discussed in the 'comments' section.

Each mapping unit will be described in the following terms:

Name: Map Unit Code (Characteristic Vegetation Type) Map Unit Number.

Sites: List of all the formal sites located in the mapping unit.

Landforms: Most frequently occurring Morphological Terrain Types.

Soils: Main soil types encountered. This typing of soils is based on field observations (as previously described) and, where available, mapped information; they should not be interpreted as resulting from formal profile descriptions.

Structure: Main vegetation structural types, following Walker and Hopkins (1984).

Species: Dominant and most frequently occurring species in each stratum are listed. Recognition of strata in the field is based solely on height, however, the strata observed relate to growth form and approximate the following categories: 'Trees', 'Low Trees (L/Trees)', 'Tall Shrubs (T/Shrubs)', 'Shrubs', 'Herbs' and 'Grasses'. Where one or more of these strata do not commonly occur they will be omitted.

Comments: This section is devoted to general descriptions of the unit and descriptions of the range of variation expected.

NB Exotic species are indicated with an asterisk.

Table 1 – Details of Aerial Photography Interpreted

1:250 000 Map sheet	Scale	Date(s) Flown
St George	1:50 000	1985
Goondiwindi	1:40 000	1984
Moree	1:50 000	1985
Angledool	1:60 000	1978
Inverell	1:50 000	1985

RIPARIAN AND FLOODPLAIN REMNANTS

NAME: R1 (River Red Gum/Coolabah Forests) 9001

SITES: 48, 51, 52, 57, 60, 69, 71, 81, 84, 98, 117, 161, 175, 198, 279.

LANDFORMS: Banks, channel benches and backplains.

SOILS: Alluvial clays, grey cracking clays, minor sandy alluvium.

STRUCTURE: Very Tall to Tall Open Forests, Tall to Mid-High Open Woodlands.

SPECIES:

Eucalyptus camaldulensis, *Eucalyptus coolabah*;

Acacia salicina, Acacia stenophylla, Acacia filicifolia, Atalaya hemiglauca;

Muehlenbeckia cunninghamii, Acacia farnesiana, Alstonia constricta, Eremophila bignoniiflora, Alectryon oleifolius, Melaleuca bracteata;

*Sclerolaena birchii, Ludwigia peploides, Calotis scapigera, Goodenia fascicularis, *Onopordium acanthium,*

Stipa scabra, *Leptochloa digitata*, Cynodon dactylon, (*Eleocharis plana, Eleocharis sphacelata*, *Cyperus pygmaeus*, *Cyperus difformis*).

COMMENTS: This remnant type is confined to the clay plains and occurs along most streamlines and ox-bows.

The understorey is variable; the shrub layer is very patchy and is frequently absent, the herbaceous layer varies considerably in composition from sites to site. *Eucalyptus coolabah* is frequently dominant along minor streamlines whilst *E. camaldulensis* dominates along major streams and rivers. However, both species are present in most sites.

NAME: R2 (Floodplain Mosaic) 9002

SITES: 62, 146, 169, 194, 196, 202, 226, 267, 268, 280, 302.

LANDFORMS: Backplains, floodplains and banks.

SOILS: Grey cracking clays.

STRUCTURE: Tall Open Forests, Mid High Open Woodlands Low Woodlands, Grasslands and Sedgelands.

SPECIES:

Eucalyptus coolabah, Eucalyptus largiflorens, Casuarina cristata, (Eucalyptus camaldulensis, Eucalyptus populnea subsp. *bimbil)*;

Alectryon oleifolius, Atalaya hemiglauca , Eremophila mitchellii, Geijera parviflora;

Sclerolaena muricata; *Sclerolaena birchii, Einadia hastata;*

*Abutilon oxycarpum, *Medicago polymorpha, Oxalis chnoodes, *Rapistrum rugosum, Marsilea drummondii*;

Eleocharis pallens, Cynodon dactylon,

COMMENTS: This remnant type comprises a mosaic of types R1, R3, Grasslands and Sedgelands where the individual elements are too small to map separately. It is mainly associated with the backplains of major streamlines.

NAME: R3 (Coolabah Woodlands) 9003

SITES: 1, 19, 50, 61, 72, 73, 74, 154, 156, 158, 163, 164, 165, 166, 167, 188, 193, 197, 199, 203, 204, 206, 209, 257, 258, 259, 260, 264, 284, 285, 286, 287, 288, 290, 295, 296, 297.

LANDFORMS: Floodplains, closed depressions and very gentle rises.

SOILS: Grey cracking clays.

STRUCTURE: Tall to Mid-High Open Forests, Tall Woodlands, Woodlands and Open Woodlands.

SPECIES:

Eucalyptus coolabah, Eucalyptus camaldulensis, Casuarina cristata;

Acacia stenophylla, Acacia salicina, Alectryon oleifolius, Eremophila bignoniiflora, Eremophila mitchellii;

Muehlenbeckia florulenta, Acacia farnesiana, Rhagodia spinescens;

Sclerolaena muricata, Einadia nutans, Sclerolaena birchii,

*Marsilea drummondii, Goodenia fascicularis, Plantago cunninghamii, Oxalis chnoodes, *Phyla nodiflora, *Medicago polymorpha, *Rapistrum rugosum, *Verbena officinalis, *Sonchus oleraceus;*

Enteropogon acicularis, Paspalidium aversum, Paspalidium distans, Juncus aridicola, Chloris truncata, Eleocharis pallens.

COMMENTS: Remnant type R3 is associated with broad floodplain areas, often containing minor streamlines and shallow closed depressions. Small areas of relatively higher ground supporting *Casuarina cristata* and *Eucalyptus populnea* subsp. *bimbil* also occur. These remnants are typified by Coolabah (*E. coolabah*) woodlands with a herbaceous understorey. Small tree (*Acacia stenophylla*) and shrub layers (*Muehlenbeckia florulenta*) are infrequent and scattered.

NAME: R4 (Lignum Shrublands) 9004

SITES: 223, 271, 289.

LANDFORMS: Banks, flats and swamps on alluvial floodplains.

SOILS: Grey cracking clay.

STRUCTURE: Very Tall to Low Shrublands.

SPECIES:

Muehlenbeckia florulenta, Acacia stenophylla;

*Juncus aridicola, *Medicago polymorpha, Persicaria hydropiper.*

COMMENTS: Restricted to narrow bands near water courses. This remnant type is often difficult to identify from aerial photography. It therefore may be more extensive than is indicated by the mapping.

NAME: R5 (Myall Woodlands) 9005

SITES: 27, 34, 38, 176, 177, 291.

LANDFORMS: Gilgaied flats.

SOILS: Grey and brown cracking clays.

STRUCTURE: Mid-High Woodland to Open woodland, minor Low Open Woodland.

SPECIES:

Acacia pendula, Geijera parviflora, Alectryon oleifolius, Acacia farnesiana;

Sclerolaena muricata, Einadia nutans, Atriplex semibaccata, Rhagodia spinescens;

*Plantago cunninghamii, Rhagodia spinescens, *Medicago polymorpha, *Rapistrum rugosum;*

Enteropogon acicularis, Astrebla lappacea, Stipa verticillata, Danthonia linkii.

COMMENTS: Tall shrublands with variable low chenopod shrub understorey associated with gilgais. This remnant type is often difficult to distinguish on aerial photography. It therefore may be more extensive than is indicated by the mapping.

NAME: R7 (Coolabah/Poplar Box Woodlands) 9007

SITES: 2, 3, 10, 11, 75, 76, 78, 79, 85, 131, 173, 180, 182, 183, 184, 189, 208, 217, 221, 222, 225, 254, 255, 269, 272, 273, 274, 275, 276, 281, 294, 298, 299, 300, 301, 303.

LANDFORMS: Flats on alluvial plains.

SOILS: Yellow Earth and Grey Clay soils dominate.

STRUCTURE: Tall to Mid-High Open Woodlands to Woodlands with Tall Open Grasslands.

SPECIES:

Eucalyptus populnea subsp. *bimbil, Eucalyptus coolabah, Casuarina cristata*;

Geijera parviflora, Eremophila mitchellii, Capparis mitchellii, Alectryon oleifolius, Acacia pendula, Atalaya hemiglauca;

Capparis lasiantha, Apophyllum anomalum, Muehlenbeckia florulenta;

*Einadia nutans, Sclerolaena birchii, Sclerolaena muricata, Rhagodia spinescens, Abutilon oxycarpum, Enchylaena tomentosa; Oxalis chnoodes, Goodenia fascicularis, *Medicago polymorpha, *Rapsitrum rugosum, *Sonchus oleraceus, *Tetragonia tetragonoides, *Verbena officinalis, *Opuntia stricta;*

Enteropogon acicularis, Danthonia linkii var. linkii, Stipa scabra, Chloris truncata, Paspalidium aversum.

COMMENTS: This remnant type occurs on the interzone between the black soil dominated alluvial plain and the more elevated earthy soil dominated peneplain. It comprises elements of both in a complex mosaic. The grasslands referred to occur in sinuous bands which seem to follow relict, infilled watercourses.

NAME: R8 (White Cypress Pine/Carbeen Woodlands) 9008

SITES: 53, 55, 58, 59, 63, 64, 65, 67, 68, 70, 149, 152, 155, 157, 170, 171, 172, 174, 282, 283.

LANDFORMS: Flats and very gentle rises.

SOILS: Siliceous Sands with minor Earthy Sands and Clayey Sands.

STRUCTURE: Tall Open Forests, and Tall Woodlands to Tall Open Woodlands.

SPECIES:

Callitris glaucophylla, Corymbia tessellaris, Eucalyptus populnea subsp. *bimbil, Corymbia dolichocarpa, Eucalyptus camaldulensis, Casuarina cristata, Allocasuarina luehmannii*;

Geijera parviflora, Atalaya hemiglauca, Alstonia constricta, Petalostigma pubescens, Eremophila mitchellii, Acacia salicina, (*Alectryon oleifolius, Capparis mitchellii)*;

Acacia farnesiana, (Acacia excelsa, Lycium ferocissimum);

Einadia nutans, Sclerolaena birchii, Rhagodia spinescens, Abutilon oxycarpum;

*Crinum flaccidum, *Medicago polymorpha, *Rapistrum rugosum, *Opuntia stricta, (Cymbidium canaliculatum);*

Stipa scabra ssp. scabra, Chloris truncata, Panicum decompositum, Aristida calycina.

COMMENTS: This chain of sandy lenses, which occur mainly in the western half of the area, seem to follow ancient watercourses. The sandy soils support a very different suite of species than the surrounding clays.

Species composition is quite variable among the lower strata, particularly the small tree and shrub layers. A number of grasses, other than those listed above, were routinely encountered in this remnant type but could not be identified because no fertile specimens were available.

NAME: R9 (Sedge Dominated Wetlands) 9009

SITES: 82, 83, 147.

LANDFORMS: Closed depressions, minor banks and backplains.

SOILS: Grey clays.

STRUCTURE: Tall Closed Sedgelands.

SPECIES:

Monochoria cyanea, Typha domingensis, Eleocharis plana, Juncus continuus, Cynodon dactylon, Azolla filiculoides, Ludwigia peploides, .

COMMENTS: Treeless wetlands (occasionally with scattered trees including , *Eucalyptus camaldulensis* and *Eucalyptus coolabah*) usually occurring in ox-bows or depressions in the beds of intermittent streams.

NAME: R10 (Open Coolabah Woodlands) 9010

SITES: 50, 159, 179, 181, 211, 213, 214, 215, 227, 228, 256, 261, 262, 263, 270, 277, 292, 293, 933.

LANDFORMS: Flats and banks on Alluvial Plains.

SOILS: Grey Cracking clays.

STRUCTURE: Mid-High to Tall Open Woodlands to Woodlands.

SPECIES:

Eucalyptus coolabah, Casuarina cristata;

Acacia stenophylla, Alectryon oleifolius;

Eremophila bignoniiflora, Acacia farnesiana, Apophyllum anomalum, Capparis lasiantha

Einadia nutans, Sclerolaena muricata, Rhagodia spinescens

*Abutilon oxycarpum, *Rapistrum rugosum, *Medicago polymorpha, Goodenia fascicularis, Plantago cunninghamii, Marsilea drummondii, Oxalis chnoodes, *Sonchus oleraceus, Pycnosorus globosus;*

Enteropogon acicularis, Paspalidium aversum, Chloris truncata, Cynodon dactylon, Eragrostis setifolia.

COMMENTS: Open Coolabah woodlands with degraded understorey. Shrub layer frequently comprise introduced species or is completely lacking. Few grasses or herbaceous understorey species were recorded from the sites within this remnant type.

PENEPLAIN REMNANTS

NAME: P3 (Open Poplar Box Woodlands) 9033

SITES: 17, 29, 30, 31, 36, 37, 87, 112, 128, 191, 192, 195, 220, 224, 242, 243, 244, 248, 249, 250.

LANDFORMS: Flats, gentle slopes and low crests.

SOILS: Loamy Red Earths with some Grey Clays.

STRUCTURE: Mid-High to Tall Open Woodlands and Mid-High Woodlands and minor Tall Open Forests.

SPECIES:

Eucalyptus populnea subsp. *bimbil, Casuarina cristata, Acacia harpophylla, Eucalyptus melanophloia;*

Eremophila mitchellii, Geijera parviflora, Alectryon oleifolius, Apophyllum anomalum, Capparis mitchellii, Capparis lasiantha, Acacia excelsa;

Einadia nutans, Rhagodia spinescens, Sclerolaena birchii, Sclerolaena muricata, Parsonsia eucalyptophylla;

*Abutilon oxycarpum, Ixiolaena tomentosa, *Opuntia stricta, Oxalis chnoodes, *Rapistrum rugosum, Pycnosorus globosus;*

Enteropogon acicularis, Danthonia linkii var. linkii, Stipa ramosissima, Stipa scabra ssp. scabra, Eragrostis cilianensis.

COMMENTS: This remnant type has a generally sparse and patchy canopy cover and contains few species of native grasses. Field evidence suggests that it has been partially cleared and is heavily grazed. Compare this with the following remnant, P4.

NAME: P4 (Poplar Box Woodlands) 9034

SITES: 4, 5, 12, 18, 22, 23, 25, 26, 28, 32, 66, 80, 86, 99, 123, 124, 151, 153, 205, 245, 246, 247.

LANDFORMS: Flats, very gentle slopes and low crests.

SOILS: Loamy Red Earths, minor Grey and Brown Clays.

STRUCTURE: Tall Open Woodlands, Mid-High to Tall Woodlands, minor Open Forests.

SPECIES:

Eucalyptus populnea subsp. *bimbil , Casuarina cristata, Callitris glaucophylla, Eucalyptus melanophloia;*

Geijera parviflora, Eremophila mitchellii, Capparis mitchellii, Alectryon oleifolius, Santalum lanceolatum;

Apophyllum anomalum, Pittosporum phylliraeoides;

Rhagodia spinescens, Sclerolaena birchii, Sclerolaena muricata, Sclerolaena tetracuspis, Pimelea pauciflora, Salsola kali;

*Einadia nutans ssp. nutans, Brunoniella australis, Abutilon oxycarpum, Cheilanthes austrotenuifolia, Dichondra repens, Goodenia fascicularis, *Opuntia stricta, Oxalis chnoodes, Sclerolaena birchii, *Verbena officinalis;*

Enteropogon acicularis, Eragrostis cilianensis, Paspalidium constrictum, Stipa scabra ssp. scabra, Thellungia advena, Themeda australis.

COMMENTS: These Box Woodlands are very similar to P3 in species composition. The structure differs in that P4 has a generally more uniform and less patchy canopy. P4 also has more diverse small tree/shrub layers which are generally missing in P3. In addition the intensity of clearing and grazing tend to be less severe in P4.

NAME: P6 (Ironbark/Callitris Pine Woodlands) 9036

SITES: 107.

LANDFORMS: Flat

SOILS: Red Earth

STRUCTURE: Mid-High Open Forests

SPECIES:

Eucalyptus melanophloia, Callitris glaucophylla, Eucalyptus populnea subsp. *bimbil;*

Eremophila mitchellii, Geijera parviflora, Capparis mitchellii,

Acacia deanei, Parsonsia eucalyptaphylla, Pimelea pauciflora;

Poa larbillardieri, Stipa scabra ssp. scabra.

COMMENTS: These Mid-High Open Forests of Silver-leaved Ironbark and White Cypress pine are found in the eastern portion of the study area, there distribution and extent are limited as they represent the transition to flora of the North West Slopes.

NAME: P8 (Belah Woodlands) 9038

SITES: 8, 9, 13, 14, 15, 54, 56, 77, 110, 111, 113, 129, 162, 168, 185, 186, 187, 190, 252, 253.

LANDFORMS: Flats, very gentle slopes and minor streamlines.

SOILS: Grey and Brown Clays.

STRUCTURE: Woodlands in the Tall to Mid-High classes with minor occurrences of Open Forest and Open Woodlands.

SPECIES:

Casuarina cristata, (Acacia harpophylla, Eucalyptus populnea subsp. *bimbil, Eucalyptus microcarpa);*

Erempophila mitchellii, Geijera parviflora, Alectryon oleifolius, Atalaya hemiglauca;

Apophyllum anomalum, Capparis lasiantha, Cassine australis var. angustifolia;

*Carissa ovata, Rhagodia spinescens, Sclerolaena birchii, Sclerolaena muricata, Jasminum lineare, *Lycium ferocissimum;*

*Abutilon oxycarpon, Einadia nutans ssp. nutans, Oxalis chnoodes, * Rapistrum rugosum, Solanum parvifolium., *Opuntia stricta;*

Enteropogon acicularis, Stipa scabra ssp. scabra, Chloris truncata, (Aristida leptopoda, Thellungia advena).

COMMENTS: This remnant type is quite variable in structure, although typically the understorey strata are sparse; ground cover is frequently absent.

NAME: P9 (Low Open Shrublands and Woodlands) 9039

SITES: 6, 7, 148, 160, 178, 200, 201, 207, 210, 212, 216, 218, 219, 265, 266.

LANDFORMS: Flats, open depressions and gentle rises.

SOILS: Grey clays.

STRUCTURE: Low to Mid-High Open Shrublands, Mid-High Woodlands to Open Woodlands.

SPECIES:

Casuarina cristata, Eucalyptus coolabah, Eucalyptus largiflorens, Eucalyptus populnea subsp. *bimbil*;

Eremophila mitchellii, Eremophila bignoniiflora, Alectryon oleifolius;

Acacia farnesiana, Capparis lasiantha, Muehlenbeckia florulenta;

Sclerolaena muricata, Einadia nutans ssp. nutans, Sclerolaena birchii;

*Pycnosorus globosus, Daucus glochidiatus, Goodenia fascicularis, Marsilea drummondii, Oxalis chnoodes, Geranium solanderi var. solanderi, *Medicago polymorpha, *Rapistrum rugosum, *Sonchus oleraceus;*

Dichanthium sericeum ssp. sericeum, Enteropogon acicularis, Panicum decompositum, Stipa ramosissima, Thellungia advena, Paspalidium aversum.

COMMENTS: This remnant type is typically very open and patchy. The remaining woody vegetation is frequently so sparse, and exotic species so prevalent, that it was difficult to know whether or not to include this as remnant native vegetation. Large areas of trees have been previously cleared, ring-barked or poisoned and the woody

vegetation observed at the time of survey was frequently regrowth. Species from the fourth, fifth and sixth layers frequently form the upper stratum.

NAME: P10 (Brigalow) 9040

SITES: 16, 20, 21, 24, 33, 88, 89, 106, 108, 125, 126.

LANDFORMS: Flats, frequently with shallow gilgai, and gentle rises.

SOILS: Brown clays.

STRUCTURE: Mid-High Woodlands to Tall Open Forests.

SPECIES:

Acacia harpophylla, Casuarina cristata, Eucalyptus populnea subsp. *bimbil;*

Geijera parviflora, Eremophila mitchellii, Capparis mitchellii;

Apophyllum anomalum, Rhagodia spinescens,

Sclerolaena diacantha, Sclerolaena birchii, Einadia nutans, Enchylaena tomentosa, Pimelea pauciflora,

*Solanum parvifolium, Vittadinia cuneata, *Rapistrum rugosum, *Opuntia aurantiaca, *Opuntia stricta;*

Danthonia linkii var. linkii, Stipa scabra ssp. scabra, Enteropogon acicularis, Paspalidium caespitosum, , Chloris truncata, Leptochloa divaricatissima.

COMMENTS: Typified by the dominance of Brigalow (*Acacia harpophylla*), this remnant type also contains pockets dominated by Belah (*Casuarina cristata*) and Poplar Box (*Eucalyptus populnea* subsp. *bimbil*). The upper stratum species dominance seems to relate to site drainage characteristics, the Belah favouring the less well drained sites and the Poplar Box favouring the better drained sites.

The main canopy tends to be moderately dense with small trees, shrubs and grasses occurring as scattered individuals rather than as recognisable strata.

FOOTSLOPE REMNANTS

NAME: F4 (Yetman Footslopes Complex) 9064

SITES: 41, 42.

LANDFORMS: Sandy streamlines, slopes and flats.

SOILS: Siliceous and earthy sands.

STRUCTURE: Tall to Very Tall Woodlands and Open Forests.

SPECIES:

Angophora costata, Eucalyptus chloroclada, Eucalyptus blakelyi, (*Eucalyptus melanophloia, Callitris glaucophylla*);

Acacia deanei, Acacia burrowii;

Aristida ramosa, Aristida caput-medusae, (*Setaria geniculata, Sporobolus mitchellii, Stipa verticillata*).

COMMENTS: This remnant type is associated with sandy streamlines and flats in the hills near Yetman and Bebo. Absolute identifications of the red gums in this area are difficult to get. It is possible that the species identified as *E. chloroclada* and *E. blakelyi* may in fact be hybrids with *E. camaldulensis*.

HILLS REMNANTS

NAME: H5 (Yetman Hills Complex) 9080

SITES: 39, 40, 43, 44, 45, 46, 47, 49, 90, 91, 92, 93, 94, 109, 114, 115, 116.

LANDFORMS: Crests, slopes, flats and minor drainage lines.

SOILS: Sandy red and yellow earths, siliceous sands, some clays.

STRUCTURE: Very variable; Tall Woodlands, Mid-High Open Woodlands to Open Forests and Low Open Forests.

SPECIES

Callitris glaucophylla, Allocasuarina luehmannii, Angophora costata, Eucalyptus crebra, Corymbia dolichocarpa, Eucalyptus dealbata, Eucalyptus melanophloia;

Acacia burrowii, Acacia flexifolia, Eremophila mitchellii, Geijera parviflora, Notelaea microcarpa;

Acacia deanei, Melichrus urceolatus, Maireana microphylla, Styphelia triflora;

*Cheilanthes austrotenuifolia, Cheilanthes distans, Lomandra longifolia, Lomandra multiflora, *Opuntia aurantiaca, *Opuntia stricta;*

Stipa scabra ssp. scabra, Aristida ramosa var. speciosa, Chloris truncata, Enteropogon acicularis, Eragrostis brownii, Panicum queenslandicum, (*Setaria geniculata, Sporobolus mitchellii, Stipa verticillata*).

COMMENTS: A variable complex of species assemblages in which the component units are too small to map separately at this scale.

The tall communities (*Eucalyptus crebra, Angophora costata* and *Eucalyptus melanophloia* dominant) tend to support a secondary tree and shrub layer; the shrub layer frequently consisting of dense *Acacia burrowii* thickets.

Triodia scariosa sens lat is associated with sandy outwash fans in the area and usually occurs with a low to mid-high overstorey of *Allocasuarina luehmannii* and/or *Eucalyptus crebra*.

As with the previous remnant type there is some doubt with the identifications of the red gums; in addition there is a strong possibility that the species identified as *Eucalyptus microcarpa* and *Eucalyptus pilligaensis* are in fact the same species, probably *E. pilligaensis*. These doubts arise mainly because there was no fertile material (buds and fruits) available to aid identification at the time the field work was undertaken.

NAME: H8 (Basalt Hills) 9083

SITES: 35, 118, 127.

LANDFORMS: Slopes and crests of gentle rises.

SOILS: Euchromzem, lithosols and basalt derived clays.

STRUCTURE: Mid-High Open woodlands and shrublands.

SPECIES:

Casuarina cristata, Eucalyptus populnea subsp. *bimbil, Callitris glaucophylla, Corymbia dolichocarpa, Brachychiton populneus*;

Geijera parviflora, Alectryon oleifolius, Senna artemisioides, Eremophila mitchellii, Pittosporum phylliraeoides, Alstonia constricta, Capparis lasiantha, Notelaea microcarpa,

Pimelea pauciflora, Pimelea microcephala, Dodonaea boroniifolia, Dodonaea sinuolata subsp. *sinuolata, Ventilago viminalis, Parsonsia lanceolata, Parsonsia eucalyptophylla, Jasminum lineare, Pandorea pandorana, Clematis microphylla, Ragodia spinescens, Sclerolaena birchii, Korhtalsella rubra, Maytenus cunninghamii, Carissa ovata, Cassine australis* var. *angustifolia, Einadia nutans* subsp. *nutans,*

Medicago polymorpha, Oxalis chnoodes, Calotis scabiosifolia, Cheilanthes distans.

COMMENTS: This remnant type is associated with gentle rises to 300m high where the soils have a high clay and silt content . Access was limited in these areas and site information recorded indicates the vegetation has been modified, with the canopy species thinned. Field observations and the location of the site within the dendrogram suggest that the overstorey may have been dominated by *Casuarina cristata*. This remnant type occurs on the eastern limit of the mapping. The increasing diversity of understorey species present represents a transition to the vegetation of the North Western Slopes and the fertility of the basalt soils. There are very few basalt hills in the study area and most of these have been cleared. Access to this remnant type is also very difficult since little occurs on public land.

AREAS NOT MAPPED AS WOODY VEGETATION

NAME: Null (Non-Woody Vegetation) 9999

The area identified as Null on the map consists of four categories; a) exotic vegetation, b) highly modified native vegetation, c) no vegetation and d) native vegetation difficult to be accurately identified on high level aerial photography.

The categories are defined in the following way;

exotic vegetation is land that is highly modified, under crop production and areas where current land management activity will not allow vegetation to revert to a natural state, for example plantations, crops, orchards.

highly modified native vegetation occurs where native species composition and density is low. The area is usually dominated by exotic species, this is often as a result of intensive thinning, tilling and grazing. The area was not under cultivation at the time of the survey or ground truthing.

areas where no vegetation is present due to natural or management induced physical conditions, for example; scars, scalds, tilled or ploughed earth and off river storage.

d) native vegetation difficult to be accurately identified on high level aerial photography are patches of native vegetation less than 10 ha in size and vegetation types such as Lignum, Myall, Chenopod Shrublands, wetlands and naturally treeless plains (grasslands) that are difficult to discern on photographs of a scale of less than 1:50 000. 1:50 000 is the highest resolution photographs used in the wheatbelt mapping.

Grasslands are present in the area and exist under Open Woodlands. Pure grassland is not mapped because of the difficulty in distinguishing grassland from improved pasture and some chenopod shrublands. Grasslands need to be mapped at a larger scale with landuse information indicating the extent of pasture improvement and time since last tilling.

DRAFT REMNANT DESCRIPTIONS FOR
THE COBAR, NYNGAN & GILGANDRA 1:250 000 VEGETATION SHEETS
THE NYMAGEE, NARROMINE AND DUBBO 1:250 000 VEGETATION SHEETS
(BAND C AND D)

THE MAPPING UNITS

The following map unit descriptions summarise the landforms, soils, vegetation structures and species occurring in each unit. These remnants are not homogeneous with respect to all of these factors, hence, the descriptions deal with the most common and characteristic features. Variations will be discussed in the 'comments' section.

Each mapping unit will be described in the following terms:

Name: Map Unit Code (Characteristic Vegetation Type) Map Unit Number.

Sites: The number of formal sites described in the mapping unit for Series 4 followed by sites for Series 5.

Landforms: Most frequently occurring Morphological Terrain Types.

Soils: Main soil types encountered. The typing of soils is based on field observations (as previously described) and, where available, mapped information; they should not be interpreted as resulting from formal profile descriptions.

Geology: Main geological types encountered. The geological formations for Series 4 are interpreted from: Cobar 1:250 000 Metallogenic map sheet (1994) and Geological map sheet (1969) and accomapanying notes; Nyngan 1:250 000 Geological map sheet (1996) and accompanying notes, and; Gilgandra 1:250 000 Geological map sheet (1968). The geological formations for Series 5 are interpreted from: Nymagee 1:250 000 Geological map sheet (1968), Narromine 1:250 000 Geological map sheet (1972) and Dubbo 1:250 000 Geological map sheet (1971).

Structure: Main vegetation structural types, following Walker and Hopkins (1984).

Species: Dominant and most frequently occurring species in each stratum are listed. For convenience the strata are labelled 'Trees', 'Low Trees', 'Tall Shrubs', 'Shrubs', 'Herbs' and 'Grasses'. Where one or more of these strata do not commonly occur they will be omitted.

Comments: This section is devoted to general descriptions of the unit and descriptions of the range of variation expected.

Table 1 – Details of Aerial Photography Interpreted

1:250 000 Map sheet	Scale	Date(s) Flown	Band
Cobar	1:80 000	1987-88	C
Nyngan	1:85 000	1984-85	C
Gilgandra	1:50 000	1981-82	C
Nymagee	1:83 900	1987	D
Narromine	1:50 000	1983	D
Dubbo	1:50 000	1980	D

In total twenty one (21) Vegetation Types or Map Units have been identified for Series 4 and Series 5. Eighteen (18) of these Units occur on the Cobar, Nyngan and Gilgandra 1:250 000 vegetation sheets (Series 4) and sixteen (16) Units occur on the Nymagee, Narromine and Dubbo 1:250 000 vegetation sheets (Series 5).

RIPARIAN AND FLOODPLAIN REMNANTS

NAME: R1 (River Red Gum Forests and Woodlands) 4001

SITES: 29 (502, 504, 505, 532, 551, 564, 576, 581, 586, 587, 588, 594, 596, 599, 606, 607, 609, 611, 621, 649, 654, 658, 667, 669, 671, 677, 679, 681, 682) 12 (20, 23, 26, 27, 61, 64, 92, 35, 48, 52, 64, 85)

LANDFORMS: Banks, channels, depressions, cowals and backplains of the Bogan, Macquarie and Castlereagh River's alluvial plains. Banks and flats of major tributaries in the Cobar and Pilliga peneplains.

SOILS: Grey cracking clays, polygenetic alluvial soils.

GEOLOGY: Unconsolidated Quaternary alluvials. Note that these alluvials overly the Ordovician fine grained quartzose metasediments of the Girilambone geological group in the Cobar peneplain and the Jurassic Pilliga sandstone in the Pilliga peneplain region.

STRUCTURE: Tall to Very Tall Open Forests and Mid-High to Tall Open Woodlands.

SPECIES: Trees *Eucalyptus camaldulensis, Eucalyptus largiflorens, Eucalyptus populnea (Eucalyptus melliodora);*

Low Trees *Acacia stenophylla, Acacia salicina;* Tall Shrubs *Acacia deanei;*

Shrubs *Muehlenbeckia florulenta, Einadia nutans* subsp. *nutans, Lycium ferocissimum;*

Herbs *Calostemma pupureum, Commelina cyanea, Eleocharis pallens, Eleocharis plana, Marrubium vulgare, Marsilea drummondii, Medicago polymorpha, Oxalis chnoodes, Solanum esuriale, Cyperus gymnocaulos;* Grasses *Enteropogan acicularis, Leptochloa digitata, Stipa scabra, Paspalidium gracile (Paspalidium constrictum, Carex spp).*

COMMENTS: This map unit is typically characterised by Tall to Very Tall Open Forests dominated by, *Eucalyptus camaldulensis,* primarily confined to the banks and channels of the major river systems (Bogan, Macquarie and Castlereagh). It usually occurs on perennial streams, in depressions and around cowals and also on intermittent streams in the west of the study area. These forests grade into Mid-High and Tall Open Woodlands on the marshes, cowals and open depressions of the Bogan and Macquarie River system. A particularly good example of an extensive area of Mid-high Open River Red Gum Woodland is found 25 kms north of Warren.

The low trees *Acacia stenophylla* and *Acacia salicina* are commonly associated in the upper strata. These low trees are replaced by species such as *Eucalyptus largiflorens* (Black Box), and *Eucalyptus populnea* (Poplar Box). Along the Bogan River, Bulbodney and Crowie Creeks of the Narromine 1:250 000 map sheet, *E. largiflorens*

commonly co-dominates. On sandier soils, particularly in the eastern part of study area (Narromine, Peak Hill, Dubbo, Gilgandra and Tenandra 1:100,000 sheets), along upper tributaries of the Castlereagh and Macquarie River and Coolbaggie Creek *E. conica* (Fuzzy Box), *E. melliodora* (Yellow Box) and *Callitris glaucophylla* (White Cypress Pine) occasionally occur with River Red Gum.

The understorey is characterised by a patchy shrub layer which is frequently absent, and a ground layer of herbs and grass species, often exotics, that vary considerably between sites.

NAME: R3 (Black Box Woodlands) 4003

SITES: 23 (516, 517, 522, 524, 529, 531, 533, 535, 542, 591, 595, 597, 598, 608, 613, 615, 616, 617, 618, 620, 623, 624, 947) 3 (750, 772, 827)

LANDFORMS: Floodplains, banks, depressions, cowals and flats of the Bogan-Macquarie floodplain.

SOILS: Mainly grey cracking clays, minor red and red-brown earths.

GEOLOGY: Quaternary alluvium.

STRUCTURE: Mid-High Open Forests, Mid-High Woodlands and Mid-High Open Woodlands.

SPECIES: Trees *Eucalyptus largiflorens, Eucalyptus camaldulensis, Eucalyptus populnea, Casuarina cristata;* Low Trees *Acacia stenophylla;* Tall Shrubs *Geijera parviflora, Apophyllum anomalum;* Shrubs *Einadia nutans* subsp *nutans, Enchylaena tomentosa, Rhagodia spinescens, Sclerolaena muricata, Meuhlenbeckia florulenta, Solanum esuriale;* Herbs *Marsilea drummondii, Oxalis chnoodes, Tribulis terrestris;* Grasses *Enteropogan acicularis, Leptochloa digitata and Thyridolepis mitchelliana.*

COMMENTS: This map unit is characterised by Mid-High Open Woodlands of *Eucalyptus largiflorens* (Black Box). Black Box Woodlands are most commonly found on grey cracking clays of the broad floodplain of the Bogan-Macquarie system and north of the Lachlan River (Narromine 1:250 000 map sheet). Mid-High Woodlands and Mid-High Open Woodlands dominated by *Eucalyptus largiflorens* occur along the banks of the Bogan River (Nyngan 1:250 000 map sheet) and on the slow draining flats, depressions and seasonally flooded low-lying areas. Black Box Woodlands are generally absent in the study area east of the Macquarie River.

Along the Bogan River, *Eucalyptus camaldulensis* and *Acacia stenophylla* occur in the overstorey. Away from the main river channels, on the higher ground where the soils grade between grey cracking clays and red earths, a floodplain mosaic comprising minor areas of *Eucalyptus populnea* and *Casuarina cristata* occurs within this map unit.

The understorey within this map unit changes with local land use practice and environmental variables such as soil type, soil moisture content. It is typically composed of scattered low trees and tall shrubs such as *Geijera parviflora* and *Apophyllum anomalum.* Generally a low shrub layer is lacking, where it is present, chenopods usually dominant. The ground layer may be sparse or absent and is often

dependant on seasonal influences. In those areas subject to periodic inundation, the shrub *Muehlenbeckia florulenta,* may occur.

NAME: R5 (Myall Woodlands) 4005

SITES: 4 (523, 540, 963, 964) 10 (26, 27, 07, 08, 09, 10, 11, 43, 60, 71)

LANDFORMS: Flats of the alluvial plains subject to gilgai development and extending to the flats of the Pilliga peneplain.

SOILS: Grey and brown clays, rarely on deeper red and brown earths

GEOLOGY: Quaternary alluvium.

STRUCTURE: Mid-High Woodland and Mid-High Open Woodland. Minor Low Open Woodlands.

SPECIES: Low Trees *Acacia pendula;* Tall Shrubs *Geijera parviflora, Apophyllum anomalum, (Eremophila* subsp.*);* Shrubs *Atriplex vesicaria, Maireana aphylla, Einadia nutans* subsp. *nutans, Rhagodia spinescens, Sclerolaena muricata, Amyema quandang;* Grasses *Enteropogan aciculari.*

COMMENTS: Small stands of Mid-High Woodlands and Mid-High Open Woodlands of *Acacia pendula* (Myall or Boree) are scattered across the flats of the alluvial floodplain of the Bogan and Macquaire River and Boggy Cowal. These small stands may be isolated remnants in roadside reserves, or pockets amongst taller woodlands. Myall Woodlands most frequently occur on the heavy grey and brown clay gilgais. Occasionally Myall Woodlands are found on the red and brown earths of the flats of the Pilliga peneplain. The understorey is characterised by many species of low chenopod shrubs and grasses. *Amyema quandang* is a common stem parasite of *Acacia pendula*

Myall Woodlands are characteristically monospecific. However, regrowth box species and tall shrubs such as *Geijera parviflora, Eremophila mitchellii* and *Apophyllum anomalum* may occur with *Acacia pendula.* This is the case in the more open examples of this map unit and where it is adjacent to Poplar Box or Black Box Woodlands. Small isolated remnants in roadside reserves, or as pockets amongst taller woodlands

Note that Myall Woodlands are difficult to distinguish from pasture and grasslands on aerial photography at the scale interpreted for this project, and hence, may be more common than is indicated by the mapping.

UNDULATING PENEPLAIN REMNANTS

NAME: P1 (Mallee Woodlands on Plains) 4031

SITES: 5 (547, 548, 728, 731) 8 (51, 52, 53, 54, 55, 57, 58, 59)

LANDFORMS: Flats in the east of the Cobar peneplain.

SOILS: Red Earths

GEOLOGY: Honeybugle Ordovician basic intrusion and Ordovician metasediments common in the Cobar peneplain.

STRUCTURE: Very Tall to Extremely Tall Closed Mallee Forest.

SPECIES: Trees *Eucalyptus dumosa, Eucalyptus socialis, Eucalyptus viridis, Brachychiton populneus, Eucalyptus intertexta;* Tall Shrubs *Acacia deanei, Acacia tetragonophylla, Eremophila mitchellii, Hakea leucoptera, Eremophila longifolia, Geijera parviflora;* Shrubs *Bertya cunninghamii, Bossiaea walkeri, Eremophila glabra, Olearia pimeleoides;* Herbs *Solanum ellipticum, Solanum ferocissimum;* Grasses *Triodia scariosa, Thyridolepis mitchelliana, Stipa scabra.*

COMMENTS: This map unit occurs west of the Bogan on the flats and very low hills in the eastern section of the Cobar peneplain. It is mainly confined to the geological unit known as the Honeybugle basic intrusion but can also be found on the very low rises of the peneplain around Quanda Nature Reserve where Ordovician sediments dominate. It typically forms dense, generally even height, Very Tall to Extremely Tall Mallee Forests, predominantly composed of *Eucalyptus socialis* and *Eucalyptus dumosa.* The understorey is typically composed of *Acacia* species, *Geijera parviflora* and *Eremophila mitchellii* in the upper shrub layer with the grass *Triodia scariosa* and few herbs being characteristic of the ground layer.

Note that this map unit is very similar to H7 Mallee Woodlands on Rolling Hills in floristic composition, but differs in its structure and its position in the landscape. Mallee Woodlands on the Plains are more diverse and may display a taller structure, with *E. leptophylla* (Narrow-leaved Red Mallee), *E. microcarpa* (Mallee Grey Box) and *E. sideroxylon* (Mugga Ironbark) occurring with *Eucalyptus dumosa* (Congoo) and *Eucalyptus socialis* (Pointed Mallee). *Eucalyptus viridis* is an occasional co-dominant on gravely soils. *Brachychiton populneus, Eucalyptus intertexta* and immature *Callitris glaucophylla* may also be found as isolated trees scattered within these remnants.

A good example of this taller, more diverse mallee occurs within Tollingo, Woggoon and Quanda Nature Reserves. Also of interest in Woggoon Nature Reserve is the occurrence of Mallee Pine (*Callitris preissii* subsp. *verrucosa*). Remnants of Mallee Woodlands line the roads in the peneplain.

NAME: P4East (Eastern Poplar Box Woodlands) 4234

SITES: 51 (503, 508, 509, 510, 515, 518, 519, 520, 521, 528, 530, 534, 536, 538, 561, 563, 565, 568, 571, 572, 573, 574, 577, 578, 579, 585, 589, 590, 592, 593, 600, 601, 614, 659, 660, 662, 664, 665, 666, 668, 670, 676, 678, 680, 683, 684, 685, 686, 687, 688, 932) 33 (706, 716, 717, 719, 721, 722, 725, 742, 751, 752, 753, 756, 757, 762, 763, 768, 769, 775, 776, 789, 799, 800, 801, 802,805, 836,845, 846,847,849, 866, 867, 754)

LANDFORMS: Flats and some open depressions of the backplains and floodplains.

SOILS: Red, red-brown and yellow earths and grey, brown and red clays.

GEOLOGY: Quaternary colluvial and alluvial derivation.

STRUCTURE: Mid-High to Tall Woodlands and Open Woodlands.

SPECIES: Trees *Eucalyptus populnea, Callitris glaucophylla, Allocasuarina leuhmanni;* Low Trees *Alectryon oleifolius, Atalaya hemiglauca, Capparis mitchellii,*

Acacia homalophylla; Tall Shrubs *Geijera parviflora, Eremophila mitchellii, Apophyllum anomalum, Hakea leucoptera;* Shrubs *Einadia nutans* subsp. *nutans, Rhagodia spinescens, Sclerolaena birchii, Sclerolaena muricata, Maireana aphylla, Maireana decalvans, Lycium ferocissimum, Myoporum montanum;* Herbs *Oxalis chnoodes, Calotis lappulacea, Solanum* subsp., *Marsilea drummondii, Tetragonia tetragonoides, Marrubium vulgare;* Grasses *Stipa scabra, Enteropogan acicularis, Chloris truncata.*

COMMENTS: Poplar Box Woodlands occur across the entire study area and have been separated into Eastern and Western map units. The distinction between these units is based on a slight difference in floristic composition and was difficult to consistently determine from objective analysis of site data or from examination of air photo patterns. (See Western Poplar Box Woodlands below.)

It should be noted that within Eastern Poplar Box Woodlands a number of different associations are recognised within this map unit and are described below, their subtle differences in structure and composition in the field made it impracticable to classify them as separate map units given the scale of the aerial photography interpreted, the limited amount of available site data, and the scale of the final map.

This map unit is the most commonly occurring and widespread remnant type of the study area. P4 Eastern Woodlands may, in its more altered state, occur as small isolated stands and narrow, linear corridors along road and property boundaries and as wind breaks. Where land use and management has had minimal impact, expansive Tall Woodlands and Tall Open Woodlands are found. Eastern Poplar Box Woodlands topographic range is from the slightly elevated flats and open depressions of the alluvial meander plains of the Bogan, Macquarie and Castlereagh River's, and on to the flats and low slopes of the Pilliga peneplain in the east.

A typical Eastern Poplar Box Woodland is dominated by *Eucalyptus populnea* in the overstorey with the relative dominance of associated overstorey and understorey species changing with the degree of impact of past and current land use practices and local variations in environmental conditions. The upper layer of the understorey is commonly composed of scattered low trees such as *Alectryon oleifolius, Capparis mitchellii* and *Atalaya hemiglauca* occurring with tall shrubs including *Geijera parviflora, Eremophila mitchellii* and *Apophyllum anomalum*. The lower shrub layer is typically dominated by chenopod shrubs and may include species such as *Einadia nutans* subsp. *nutans, Rhagodia spinescens, Sclerolaena birchii, Sclerolaena muricata* and *Maireana aphylla.* The ground layer may be particularly variable but is generally characterised by herb species such as *Oxalis chnoodes*, *Calotis lappulacea* and *Medicago polymorpha* and grasses including *Enteropogon acicularis* and *Stipa scabra.*

The following is a description of the range of associations from west to east that can be noted at the local level, but were unable to be separated systematically at mapping of this scale.

East of the Cobar peneplain, on the red earths of the slightly elevated flats of the Bogan River backplain, *Eucalyptus populnea* is associated with *Callitris glaucophylla, Casuarina cristata* and occasional *Eucalyptus intertexta*. On the low

flats and in the open depressions nearer to the main channel of the Bogan River, the red earths of the backplain grade into red-brown and grey clays. In these areas Mid-High Open Woodlands with *Eucalyptus populnea, Callitris glaucophylla* and *Eucalyptus largiflorens* occur often with a sparse understorey.

Moving further east across the major floodplains, the slightly elevated Bogan River backplains gently grade into the lower flats and depressions of the Macquarie River floodplain. Alluvial red and yellow earths and some grey clays support Tall Open Woodlands of *Eucalyptus populnea* with occasional *Casuarina cristata* and *Allocasuarina leuhmannii* (see Tullamore and Dandaloo 1: 100 000 sheets). The understorey of these woodlands is generally sparse in structure. The low tree *Acacia pendula* may be present at, or just within, the outer edges of these communities. In some areas (near Enerweena Creek, north-west of Warren, for example), where there are subtle changes in local sediments and the land is slightly depressed, occasional small stands of *Eucalyptus largiflorens* are interspersed. There are some locations where the duplex soil structure is such that the sediments are more freely draining in the upper horizons and less well drained in the lower horizons. Mid-High Open Woodlands of *Eucalyptus populnea* and *Eucalyptus camaldulensis* may occur at these locations with some *Eucalyptus largiflorens* occasionally present. It is interesting to note that field observations have shown that the *Eucalyptus camaldulensis* in these communities is generally of a more stunted and spreading form than the taller more graceful trees that occupy the banks along the main river channels..

As the landscape rises gently east of the Macquarie River, the slow draining red and yellow earths of the quaternary Carrabear geological formation support Tall Woodlands and Tall Open Woodlands of *Eucalyptus populnea* with *Callitris glaucophylla* and *Allocasuarina leuhmannii.* In the areas surrounding what is known as the Monkey Scrub, *Eucalyptus chloroclada* and *Callitris glaucophylla* may co-dominant with *Eucalyptus populnea,*, particularly in remnants adjacent to the P15 Woodlands. On the yellow earths of the raised flats nearer to the main channel of the Castlereagh River Mid-High or Tall Open Woodlands of *Eucalyptus populnea, Callitris glaucophylla* and *Eucalyptus camaldulensis* occur. This association continues to the south and east beyond the Castlereagh River to the edge of the Pilliga peneplain. It is here that the vegetation changes in composition, grading into the P12 Woodlands of the Pilliga peneplain. On the sandier, quartzose dominated soils common to these areas, components of the P12 Woodlands occasionally occur *Eucalyptus pilligaensis, Eucalyptus conica, Casuarina cristata* and *Eucalyptus melanophloia* have been observed as associated overstorey species in the field. These may include species such as *Eucalyptus chloroclada, Casuarina cristata* and occasional *Eucalyptus pilligaensis*

NAME: P4West (Western Poplar Box Woodlands) 4134

SITES: 18 (525, 537, 539, 543, 549, 552, 553, 555, 560, 619, 625, 626, 636, 641, 689, 693, 730, 735) 11 (556, 824, 832, 856, 874, 876, 909, 910, 911,912,960)

LANDFORMS: Flats and drainage depressions of the plains and rises of the Cobar peneplains.

SOILS: Red earths and occasional red clay soils

GEOLOGY: Quaternary colluvial and alluvial derivation over the Ordovician Girilambone Beds.

STRUCTURE: Mid-High to Tall Woodlands and Open Woodlands.

SPECIES: Trees *Eucalyptus populnea, Callitris glaucophylla, Eucalyptus intertexta;* Low Trees *Alectryon oleifolius;* Tall Shrubs *Geijera parviflora, Eremophila mitchellii, Acacia deanei;* Shrubs *Einadia nutans* subsp. *nutans, Sclerolaena muricata, Dodonaea viscosa, Maireana microphylla;* Herbs *Oxalis chnoodes, Calotis lappulacea, Cheilanthes austrotenuifolia;* Grasses *Enteropogan acicularis, Aristida* subsp.

COMMENTS: Poplar Box Woodlands occur across the entire study area and have been separated into Eastern and Western map units. The distinction between these units is based on a slight difference in floristic composition and was difficult to consistently determine from objective analysis of site data or from examination of air photo patterns. (See Eastern Poplar Box Woodlands above.)

This map unit is very similar to P4 Eastern Poplar Box Woodlands the distinction between these woodlands is based on the relative simplicity of the Western woodlands. Western Poplar Box Woodlands are dominated by *Eucalyptus populnea* and *Callitris glaucophylla.* They are characterised by a grassy understorey and a patchy, open shrub layer.

P4 Western Poplar Box Woodlands topographic range is from the low slopes, broad drainage lines and low undulations of the Cobar peneplain in the west, to the slightly elevated flats and open depressions of the alluvial meander plains of the Bogan River in the east. The shape and size of the remnants have the same variation as Eastern Poplar Box Woodland and can occur as small isolated stands and narrow, linear corridors along road and property boundaries and as wind breaks or as expansive Tall Woodlands and Tall Open Woodlands where land use and management has had minimal impact.

The following is a description of the variation that can be found within the Western Poplar Box Woodlands. On the flats and low gentle rises of the Cobar peneplain, Mid-High to Tall Open Woodlands of *Eucalyptus populnea* and *Callitris glaucophylla* occur on the Quaternary red earths overlying Ordovician sediments. Associated overstorey species include *Eucalyptus intertexta* and *Brachychiton populneus,* with the former often occurring as a co-dominant on the slopes of the more gentle rises. The understorey within these woodlands vary relative to the level of disturbance caused by both grazing and seasonal influences. On the lower flats and in drainage depressions, the communities are denser Mid-High Woodlands of *Eucalyptus populnea* and *Callitris glaucophylla*. In the drainage lines *Casuarina cristata* (Belah) may dominate. While *E. microcarpa* (Grey Box) may occur on the gentle, gravellier crests. In the Western Poplar Box Woodlands *E. largiflorens* (Black Box) occurs occasionally with Poplar Box, particularly in the alluvial outwash areas near Fountain Dale on the Nymagee 1:250,000.

Western Poplar Box Woodlands are characterised by a grassy understorey and a patchy, open shrub layer. The most dominant grasses include *Enteropogon acicularis, Aristida jerichoensis, Panicum subxerophilum* and various species of *Stipa* and

Danthonia and small-localised occurrences of *Themeda australis.* Small trees and shrubs in the lower stratum of the woodland include *Einadia nutans, Geijera parviflora* and *Sclerolaena bicornis.*

NAME: P6 (White Cypress Pine Woodlands) 4036

SITES: 7 (511, 512, 513, 582, 583, 584, 663) 10 (718, 773, 774, 793, 794, 795, 808, 823, 833, 834)

LANDFORMS: Flats, low rises and aeolian dunes of the alluvial plain. Low slopes and flats of the peneplains.

SOILS: Sandy red and yellow earths

GEOLOGY: Quaternary alluvials and residuals.

STRUCTURE: Tall Open Woodland and Tall Woodland. Minor Mid-High Open Woodland.

SPECIES: Trees *Callitris glaucophylla, Eucalyptus populnea, Eucalyptus microcarpa, Allocasuarina luehmannii, Eucalyptus melliodora;* Low Trees *Alectryon oleifolius, Acacia doratoxylon, Alstonia constricta;* Tall shrubs *Geijera parviflora;* Shrubs *Dodonaea viscosa*, *Einadia nutans* subsp. *nutans, Rhagodia spinescens, Parsonsia eucalytophylla;* Herbs *Oxalis chnoodes, Sida corrugata, Malva parvflora, Lepidium pseudohyssopifolium, Cheilanthes austrotenuifolia;* Grasses *Enteropogon acicularis, Stipa scabra, Stipa verticillata, Lomandra glauca, Thyridolepis mitchelliana, Danthonia linkii, Panicum subxerophilum.*

COMMENTS: This map unit occurs on the red earths of the Cobar peneplain, alluvial plain and the sandy red and yellow earths of the Pilliga peneplain. White Cypress Pine Woodlands are characterised by a predominance of mature *Callitris glaucophylla* in the tallest stratum, or by a dense, uniform, regrowth layer of *Callitris glaucophylla* in the mid stratum. It typically occurs in State Forests as large stands of Tall Open Woodlands or Tall Woodlands. White Cypress Pine Woodlands may contain elements of other plains communities, with Eucalypt species occurring as isolated emergent trees. They are generally characterised by a sparse understorey with scattered low trees such as *Acacia doratoxylon* and *Alectryon oleifolius*, few shrubs, and a bare or patchy ground layer.

On the low slopes and flats of the Cobar peneplain, P6 Woodlands may have the overstorey species *Eucalyptus populnea* and *Eucalyptus intertexta* interspersed. Further east, in the plains area and on the gently undulating rises of the Pilliga peneplain, species such as *Eucalyptus populnea, Allocasuarina luehmannii, Eucalyptus pilligaensis* and *Eucalyptus melliodora* may be locally abundant.

NAME: P7 (Belah, Poplar Box and Pine Woodlands) 4037

SITES: 4 (575, 580, 622, 661) 12 (741, 744, 745, 746, 755, 758, 759, 765, 766, 767, 826, 843)

LANDFORMS: Flats and depressions of the floodplains.

SOILS: Red Earth, grey and brown clays.

GEOLOGY: Quaternary alluvium.

STRUCTURE: Mid – High Open Woodlands

SPECIES: Trees *Casuarina cristata, Allocasuarina leuhmannii, Eucalyptus populnea, Callitris glaucophylla;* Low Trees *Santalum acuminatum;* Tall shrubs *Geijera parviflora, Eremophila mitchellii, Exopcarpus aphyllus, Apophyllum anomalum;* Shrubs *Muelenbeckia florulenta; Rhagodia spinescens, Sclerolaena birchii, S. muricata, Einadia nutans* subsp. *nutans;* Herbs *Oxalis chnoodes, Calotis lappulacea, Marsilea drummondii, Dichondra repens;* Grasses *Stipa scabra, Enteropogon acicularis, Paspalidium gracile.*

COMMENTS: This map unit varies in size and composition across the study area and occurs on a range of topographical sequences. It occurs on the banks of intermittent and perennial creeks, on the flats and depressions of the alluvial plains and backplains of the major river systems. In favourable situations it may occur beyond the backplains in the zone of transition between the floodplain and peneplain.

This map unit is typically a Tall Woodland to Tall Open Woodland with Belah (*Casuarina cristata*) commonly the dominant canopy species. *Eucalyptus populnea* frequently occurs with *Casuarina cristata* on the red and brown earths and sandy clays of the flats of the alluvial plains and in depressions that may be subject to periodic inundation. Away from the main channels towards the backplains where fine, sandy, yellow and red earths occur, *Casuarina cristata* declines in dominance and species such as *Allocasuarina leuhmannii, Eucalyptus populnea* and *Callitris glaucophylla* become more common with the relative diversity and abundance of species being related to local variations in soil type, soil moisture and microtopography.

Geijera parviflora is a common understorey species in these remnants. Scattered *Alectryon oleifolius* also occurs, often as a result of having been left as fodder trees following thinning or clearing of the surrounding vegetation. The lower shrub layer and ground cover varies between remnants but usually consists of unpalatable chenopods and grasses. Lignum is common in the understorey on the Dandaloo and Tottenham 1:100,000 sheets.

Surrounding of the Bay of Biscay Swamp, between the Bogan River and the township of Narromine, Belah and Grey Box *(E. microcarpa*) occur on Red Brown Earths. Belah with both Grey Box and Poplar Box are less restricted, occurring throughout the flats of the Bogan River on Yellow, Red and Red Brown Earths, as well as the Grey and Brown Clays closer to Dandaloo. Localised pure stands of Belah are usually associated with intermittent drainage lines. Belah, Poplar Box and Pine Woodlands grade into Myall Woodlands (R5) and Black Box Woodlands (R3).

NAME: P11 (Leopardwood Open Shrublands) 4011

SITES: 1 (541)

LANDFORMS: Flats on alluvial plains.

SOILS: Red and grey clays

GEOLOGY: Quaternary alluvium.

STRUCTURE: Mid-High Sparse Shrublands to Low Open Woodlands.

SPECIES: Low Trees *Flindersia maculosa;* Tall Shrubs *Apohyllum anomalum, Atalaya hemiglauca Geijera parviflora, Capparis mitchellii;* Shrubs *Rhagodia*

spinescens, Scleolaena muricata, Einadia nutans subsp. *nutans, Lysiana subfalcata, Lasiopetalum baueri.*

COMMENTS: Low Open Woodlands and Mid-High Sparse Shrublands dominated by scattered *Flindersia maculosa* occur in small areas on red and grey clays of the flats of the alluvial plains. Associated species include scattered tall shrubs *Geijera parviflora* and *Apophyllum anomalum*. A sparse shrub layer being characteristic of this unit. The stem parasite *Lysiana subfalcata* may also be found growing on the overstorey species. Beadle (1948) notes that on the red soils of slightly elevated areas, a low scrub of the perennial saltbushes *Atriplex numularium* and *Atriplex vesicarium* was once supported and surrounded by a zone of *Flindersia maculosa*. Given the present degraded nature of this remnant, it is possible that some of the larger trees have been removed in the past and grazing pressure has produced the current vegetation cover mapped today.

Remnants of this map unit are not common in the study area and are often difficult to distinguish on the high level aerial photography. Note that more extensive areas of P11 have been mapped further north on the Bourke and Walgett 1:250,000 vegetation sheets.

NAME: P12 (Jurassic Sandstone Woodlands) 4042

SITES: 15 (506, 507, 648, 650, 651, 652, 653, 655, 656, 657, 664, 672, 673, 674, 675) 12 (724, 860, 861, 862, 863, 896, 897, 898, 899, 900, 901, 902)

LANDFORMS: Flats, broad drainage lines and gently undulating rises of the Pilliga Peneplain.

SOILS: Sandy and sandy loam red earths

GEOLOGY: Jurassic Pilliga Sandstone.

STRUCTURE: Mid-High to Tall Open Woodlands and Mid-High to Tall Woodlands.

SPECIES: Trees *Eucalyptus pilligaensis, Eucalyptus chloroclada, Eucalyptus conica, Eucalyptus crebra, Eucalyptus microcarpa, Eucalyptus populnea, Callitris glaucophylla, Allocasuarina luehmannii, Angophora floribunda;* Low Trees *Acacia doratoxylon, Pittosporum phylliraeoides, Alectryon oleifolius;* Tall Shrubs *Acacia ixiophylla, Acacia deanei, Eremophila mitchellii, Geijera parviflora;* Shrubs *Dillwynia juniperina, Melichrus urceolatus, Micromyrtus subsp. Einadia nutans* subsp. *nutans, Desmodium varians;* Herbs *Alternanthera denticulata, Cheilanthes austrotenuifolia, Oxalis chnoodes, Trifolium subterraneum, Lomandra longifolia;* Grasses *Aristida muricata, Aristida ramosa, Bothriochloa biloba, Chloris gayana, Elymus scaber, Enteropogan acicularis, Eragrostis* subsp., *Leptochloa digitata, Paspalidium jubiflorum, Stipa scabra, Themeda australis.*

COMMENTS: This map unit occurs on the low undulating hills and the flats and broad drainage lines of the Pilliga peneplain in the east and south-east of the study area. In some areas the map unit may extend to the apron of colluvial material eroded from the Pilliga sandstone, located immediately west of the outcropping peneplain. It occurs as a diverse complex of vegetation varying spatially in structure and floristic composition. It is often found in roadside corridors and reserves but may also occur in large isolated stands on sandy red and yellow earths.

Diverse associations of a variety of Eucalypt and other tree species form complex Mid-High to Tall Open Woodlands and Mid-High to Tall Woodlands. In the western extents of the outcropping peneplain on the Bundemar 1:100 000 map sheet, *E. chloroclada, E. pilligaensis, E. sideroxlyon, Callitris glaucophylla* and *Allocasuarina leuhmannii* are some of the more dominant overstorey species with dense *Acacia ixiophylla* occurring below the canopy in some woodlands. Further to the east on the main extent of the Pilliga peneplain, Grey Box (*E. pilligaensis, E. microcarpa, E. conica*), Ironbarks *(E. melanophloia, E. sideroxylon, E. crebra, E. nubila,)* Red Gum *(E. chloroclada,* and hybrids) and Pine (*Callitris glaucophylla)* dominate the overstorey. The understorey is equally diverse, with a large Acacia component: *A. hakeoides, A. havilandiorum, A. lineata* and *A. tindaleae* are the most frequent, although *A. cardiophylla, A. spectabilis, A. triptera* and *A. excelsa* also occur. Genera common to coastal communities are also a feature of the P12 woodlands; including *Dillwynia juniperina, Hibbertia sericea* and *H. obtusifolia, Micromyrtus sessilis* and *M. ciliata, Melaleuca uncinata* and *M. densispicata* and *Melichrus urceolatus*. The ground layer of P12 Woodlands is characterised by a diverse layer of grass species.

Of note in this map unit is an area on the Bundemar 1:100 000 map sheet to the west of the peneplain proper near Ferndale Stud Park (GR 598500, 6484400). Here, on the raised flats surrounding a large cowal, is an occurrence of a diverse stand of vegetation that closely resembles that which commonly occurs to the east on the Jurassic peneplain sediments. Also on the Bundemar 1: 100 000 map sheet is a small homogeneous stand of *Acacia harpophylla* near the Pine View property (GR 624500, 6466300). The only other occurrence of this species noted in the study area is in the very north of the Gulargambone 1:100 000 map sheet near Fairfield property (GR 622000, 6569600), some distance from the Pilliga sediments. Also occurring in the Coolbaggie Creek system is *Angophora floribunda*, which, with *E. conica*, occurs in the streams of the P12 woodland remnants.

NAME: P13 (Grey Box, Poplar Box and Pine Woodlands) 4043

SITES: 21 (778, 779, 781, 783, 796, 811, 813, 819, 821, 822, 825, 837, 839, 889, 903, 904, 905, 913, 914, 916, 921)

LANDFORMS: Slopes and low rises of the hills and rolling country of the peneplain. Relief to 15m

SOILS: Red Earths.

GEOLOGY: Quaternary eluvial sediments

STRUCTURE: Mid High to Tall Open Woodlands

SPECIES: Trees *Eucalyptus microcarpa, E. populnea, Callitris glaucophylla*; Tall shrubs *Apophyllum anomalum, Acacia deanei, Eremophila mitchellii, Geijera parviflora*; Shrubs *Sclerolaena* subsp., *Dodonaea viscosa sens lat, Einadia nutans* subsp. *nutans*

Herbs and Grasses *Enteropogon acicularis, Stipa scabra, Panicum subxerophilum, Thyridolepis mitchelliana, Parsonia eucalyptophlla.*

COMMENTS: Woodlands of Grey Box, Poplar Box and White Cypress Pine occur in the west of the study area. They are found on the rolling country of the Nymagee 1:250,000 sheet; and on footslopes and rolling country of the Narromine 1:250,000 sheet (Boona Mount, Tottenham and Tullamore 1:100 000 sheets). Grey Box and

Poplar Box are the dominant canopy species. The understory has a diverse range of shrubs and a grassy ground layer is generally present, with *Danthonia linkii*, *Enteropogon acicularis*, *Panicum subxerophilum* and *Stipa scabra* commonly occurring. The vine *Parsonsia eucalyptophylla* frequently occurs scrambling through the ground layer.

Grey Box, Poplar Box and Pine Woodlands are present on Quaternary eluvial sediments that overlay many different geological substrates. These substrates often outcrop through the eluvial layer to produce crests and rocky outcrops. Where these crest and outcrops occur, the Grey Box, Poplar Box and Pine Woodlands give way to other plant communities. Common to the crests and shallow, gravelly soils are Green Mallee Crests (H2) or Dwyers's Red Gum, Ironbark and Green Mallee Woodlands (H1). This pattern, of rolling Grey Box, Poplar Box and Pine woodlands interspersed with crest of Green Mallee and hills with Dwyers's Red Gum, Ironbark and Green Mallee Woodlands, is characteristic of the western half of the Narromine 1:250,000 sheet and parts of the northern half of the Nymagee 1:250,000 sheet.

The rolling woodlands have natural grades of density existing throughout them due to local changes is physical conditions, but they may also have a localised and distinct "patchwork" pattern resulting from land use. In these areas, White Cypress Pine regeneration is common.

NAME: P14 (Red Box, Poplar Box and Pine Woodlands) 4044

SITES: 24 (544, 545, 546, 559, 627, 628, 629, 631,632, 633, 638, 643, 690, 691, 692, 695, 696, 697, 702, 729, 732, 733, 734, 736) 9 (857, 858, 875, 877, 878, 881, 882, 886, 895)

LANDFORMS: Undulating rises, slopes, flats and open depressions of the Cobar peneplain. Relief to 15m.

SOILS: Red earths and quartzose

GEOLOGY: Coarse grained quaternary colluvial and alluvial deposits overlying Ordovician sedimentary bedding and some Devonian volcanics.

STRUCTURE: Tall Woodlands to Tall Open Woodlands. Minor Very Tall Mallee Woodlands.

SPECIES: Trees *Eucalyptus intertexta, Eucalyptus populnea, Callitris glaucophylla;* Tall Shrubs *Eremophila mitchellii, Geijera parviflora;* Shrubs *Dodonaea viscosa, Dodonaea lobulata, Acacia decora, Senna artemisioides* subsp. f*ilifolia, Sclerolaena bicornis, Sclerolaena birchii;* Herbs *Cheilanthes austrotenuifolia, Oxalis pes-caprae, Solanum eremophilum;* Grasses *Aristida muricata, Enteropogon acicularis.*

COMMENTS: Woodlands of Red Box , Poplar Box, and Pine characterise the slopes of the far north-west of the study area. P14 Woodlands extend to where the intergrade between the undulating rises of the peneplain and the flats of the Bogan River occur.

Tall Woodlands to Tall Open Woodlands of *Eucalyptus populnea* and *Callitris glaucophylla* occur on the deeper red earths of the flats and open depressions. Further upslope from the flats, on the more gravely rises and low crests, *Eucalyptus intertexta* becomes a major component of these woodlands. On some of the coarser grained quartzose dominated soils at the crests of the undulations, localised stands of

Eucalyptus viridis have been observed in the field. As with F5 Woodlands, *Geijera parviflora* and *Eremophila mitchellii* form an open understorey that is occasionally dense particularly where nutrients and moisture accumulate on the flats and in open depressions. *Dodonaea viscosa, Dodonaea lobulata, Acacia decora, Sclerolaena birchii,* and *Senna artemisioides* subsp. *filifolia* form the lower shrub layer. Herbs including *Cheilanthes austrotenuifolia, Oxalis pes-caprae, Solanum eremophilum* and grasses such as *Aristida muricata* and *Enteropogon acicularis,* are commonly present in the ground layer.

This map unit is similar to F5 and P13 Woodlands. It differs from F5 in that it occurs slightly lower in the landscape and extends further east on the undulating rises and open depressions of the Cobar peneplain. Red Box, Poplar Box, and Pine Woodlands are associated with the gentler more undulating landforms than the steeper more abrupt rises of P13. It also differs from F5 and P13 in that *Eucalyptus intertexta* is one of the major canopy species especially on the more gravelly rises, rockier drainage lines.

NAME: P15 (Dirty Red Gum, Pine and Poplar Box Woodlands) 4045

SITES: 5 (392, 566, 567, 569, 570)

LANDFORMS: Flats and gently undulating belts and sandy lenses of the meander plain and flats to low gentle rises of the western apron of the Pilliga peneplain.

SOILS: Light Red to Yellow Earths and Sandy Loams

GEOLOGY: Quaternary meander plain facies of Carrabear Formation and some Jurassic Pilliga Sandstone.

STRUCTURE: Mid-High to Tall Woodlands and Open Forests.

SPECIES: Trees *Eucalyptus chloroclada, Callitris glaucophylla, Eucalyptus populnea, Allocasuarina luehmannii, Casuarina cristata, Brachychiton populneus;* Low Trees *Alectryon olefolius, Atalaya hemiglauca;* Tall Shrubs *Acacia deanei, Hakea leucoptera, Apophyllum anomalum, Geijera parviflora;* Shrubs *Dodonaea viscosa, Einadia nutans* subsp. *nutans;* Herbs *Calotis lappulacea, Calotis cunefolia, Oxalis chnoodes;* Grasses *Enteropogon acicularis, Stipa scabra, Paspalidium gracile, Aristida calycina.*

COMMENTS: This map unit generally comprises the lateral sandy lenses of the alluvial meander plain that form what is known as The Monkey Scrub. Another smaller occurrence of these woodlands can be found further south on the sandy red earths of the western apron of the Pilliga peneplain on the Bundemar 1:100000 map sheet. *Eucalyptus chloroclada* and *Callitris glaucophylla* are usually co-dominant within the communities. Other species such as *Eucalyptus populnea, Allocasuarina luehmannii* and *Casuarina cristata* are commonly associated at the periphery. Scattered *Brachychiton populneus* has been observed in Warrie State Forest at the south-eastern extent of The Monkey Scrub and *Eucalyptus sideroxylon* has also been observed in the communities situated within the Pilliga. The low trees *Alstonia constricta* and *Atalaya hemiglauca* are commonly scattered throughout this community with tall shrubs such as *Geijera parviflora, Hakea leucoptera* and *Acacia deanii* forming the upper shrub layer of the understorey. In the communities of the Pilliga, *Acacia ixiophylla* is common in the understorey with dense monospecific

stands of this species having been observed on the adjacent low slopes nearby. The lower shrub layer in these woodlands and forests is often absent and scattered herbs and grasses can be found in the ground layer.

REMNANTS ON UNDULATING RISES

NAME: U1 (Red Box, Poplar Box, Pine and Green Mallee Woodlands) 4065

SITES: 2 (631, 694, 734)

LANDFORMS: Low crests and slopes of rounded ridges of the Cobar peneplain. Relief to 30m.

SOILS: Red to red-brown earths and gravely quartzites

GEOLOGY: Ordovician sedimentaries and Devonian sedimentary beds and volcanics.

STRUCTURE: Mid-High to Tall Open Woodlands and Very Tall to Extremely Tall Mallee Woodlands

SPECIES: Trees *Eucalyptus intertexta, Eucalyptus populnea, Eucalyptus viridis, Callitris glaucophylla;* Tall Shrubs *Eremophila mitchellii, Geijera parviflora;* Shrubs *Dodonaea viscosa* subsp. *angustissima, Acacia decora, Capparis mitchellii, Senna sp;* Grasses *Themeda australis.*

COMMENTS: This map unit is predominantly associated with the rolling hills and lower crests of the Cobar peneplain west of the township of Girilambone and extends into the Western Division. The mallee species *Eucalyptus viridis* is most commonly found on low crests where shallow gravely quartzites and light red earths occur. On the upper and mid-slopes where deeper red and red-brown earths occur, *Eucalyptus intertexta* dominates in Mid-High to Tall Open Woodlands. *Eucalyptus populnea* and *Callitris glaucophylla* are often scattered within these woodlands and may be co-dominant in some areas. *Eremophila mitchellii* and *Geijera parviflora* commonly form an open understorey with the lower shrub layer consisting of *Acacia decora, Capparis mitchellii* and *Senna sp. Themeda australis* forms good grass cover where grazing has been minimal and/or seasonal conditions have been favourable. Lower in the landscape on the mid and lower slopes, deep colluvial and eluvial red earths are dominated by Tall Woodlands of *Eucalyptus populnea* with occasional *Eucalyptus intertexta* and *Callitris glaucophylla*. The understorey is similar to that of the mid and upper slopes but may be locally dense in minor depressions where nutrients and moisture accumulate, and where thinning of the vegetation has been kept to a minimum.

NAME U2: Red Box, Poplar Box and Pine Woodlands on Granite Hillslopes 4066.

SITES: 3 (854, 855, 883).

LANDFORMS: Slopes and lows of rolling granite country west of Black Range.

SOILS: Red Earths on Quaternary eluvial sediments.

GEOLOGY: Silurian grey granite.

STRUCTURE: Low Open woodlands

SPECIES: Trees *Eucalyptus intertexta, E. populnea, Callitris glaucophylla, Brachychiton populneus*; Tall shrubs *Eremophila mitchellii, Acacia homalophylla*; Low shrubs *Sclerolaena bicornis*; Herbs/grasses *Enteropogon acicularis*.

COMMENTS: Open woodlands of Poplar Box, Pine and Red Box occur on the rolling granite country in the far west of the study area. Rolling crests and slopes are characteristic of the granite on the Western Division Boundary. They form part of a much larger granite belt, extending beyond the study area boundary, west and south from the property of Balowra and Nangerybone State Forest, down to form the Tarran Hills and the hilly country to the west of them. The rolling country of the granite is sharper than the rolling country of the nearby peneplain, with relief up to 30m, and the open woodlands are characterised by a very sparse understorey. Scattered shrubs may include *Sclerolaena bicornis* and *Acacia homalophylla*, while small trees of *Eremophila mitchellii* also occur. Scattered patches of *Enteropogon acicularis* occur on the ground.

NAME: U3 (Dwyer's Red Gum, Low Open Woodland on Granite Crests) 4067

SITES: 1 (884)

LANDFORMS: Upper slopes and crests of the rolling granite country west of Black Range.

SOILS: Lithosols

GEOLOGY: Silurian grey granite

STRUCTURE: Low open woodlands

SPECIES: Trees *Eucalyptus dwyeri, Callitris glaucophylla, Brachychiton populneus;* Shrubs *Acacia decora* ; herbs/grasses *Cheilanthes austrotenuifolia, Enteropogon acicularis, Goodenia cycloptera.*

COMMENTS: Low Open Woodlands of Dwyer's Red Gum and Pine occur on the exposed granite outcrops of the granite country described in U2. The vegetation of the granite crests has a barren character about it, accentuated by bare slabs of granite with lone Dwyer's Red Gums growing in their crevices. The understorey is equally sparse, with low occurrences of species such as *Acacia decora, Goodenia cycloptera, Enteropogon acicularis* and *Cheilanthes austrotenuifolia*. The soils on this substarate are fragile and prone to erosion.

HILL AND RIDGE REMNANTS

NAME: H1 (Dwyer's Red Gum, Ironbark and Green Mallee Woodlands) 4076

SITES: 54 (712, 713, 714, 715, 747, 749, 780, 782, 784, 785, 787, 790, 791, 797, 798, 803, 806, 807, 809, 810, 812, 814, 815, 816, 817, 818, 820, 830, 838, 840, 841, 842, 859, 868, 869, 870, 871, 872, 879, 880, 887, 888, 890, 891, 893, 907, 908, 915, 917, 918, 919, 921, 922, 956)

LANDFORMS: Slopes, ridges and crests of Hills and Low Rises.

SOILS: Predominantly gravelly to sandy Red Earths, with Red-Brown Earths and Yellow Earths, and Lithosols.

GEOLOGY: Occurs on Ordovician sediments, Silurian conglomerate, sandstone, volcanics, chert and limestone, Devonian sediments, granite and volcanics and a small patch of Tertiary basalt.

STRUCTURE: Mid High Woodlands to Open Woodlands

SPECIES: Trees *Eucalyptus dwyeri, E. sideroxylon, E. viridis, Callitris glaucophylla;* Shrubs *Acacia doratoxylon, A. deanei, A. decora, A. hakeoides, A. pravifolia, A. lineata, A. triptera, Dodonaea heteromorpha, D. viscosa, Santalum acuminatum, Einadia nutans, Geijera parviflora, Leptospermum divaricatum, Kunzea ambigua, Melichrus urceolatus;* Herbs and Grasses: *Aristida jerichoensis, Enteropogon acicularis, Eragrostis* subsp., *Calotis cuneifolia, Cheilanthes austrotenuifolia*.

COMMENTS: (from series 5) Dwyer's Red Gum, Ironbark and Green Mallee Woodlands occur high up off the plains (usually greater than 250m ASL), on the gravelly and rocky soils of the hills, ridges and slopes. As the landform and soils associated with this map unit are unfavourable for agriculture they make up some of the largest remnants of study area.

In the far west of the study area, the woodlands of the hills are a simple association of Dwyer's Red Gum and Pine. Proceeding eastwards, these simple woodlands become more diverse, with Mugga Ironbark on the slopes and Green Mallee occurring with the Red Gum and Pine on the crests.

Given that this community has a large geographic range, occurring right across the study area, other tree species may be locally common. On the ridges and slopes of hills in the central-eastern part of the study area (Tullamore 1:100,000 sheet), *E. intertexta* (Red Box) is scattered over the low, rocky and gravelly rises. *E. microcarpa* (Grey Box) and *E. populnea* (Poplar Box) may occur on the lower slopes where the soils are slightly loamier. In the far east, *Allocasuarina luehmannii* sometimes occurs on the sandier soils. On an outcrop of Jurassic conglomerate and fine sandstone, just east of the Boona Mountains, occurs a tall woodland of Mugga Ironbark over a dense thicket of *Kunzea*, atypical of the understorey for woodlands on the hills. It also has, in its small tree layer, Native Cherry (*Exocarpos cupressiformis*) and Black Cypress Pine (*Callitris endlicheri*), which are also less common across the study area.

The understorey of the H1 woodlands has a strong representation of Acacias. *Acacia doratoxylon* is the most dominant species, although *A. deanei, A. decora, A. hakeoides, A. pravifolia, A. lineata* and *A. triptera* are also common. Other shrub species occurring include *Dodonaea heteromorpha* and *D. viscosa*, *Santalum acuminatum, Einadia nutans, Geijera parviflora, Leptospermum divaricatum, Kunzea ambigua* and *Melichrus urceolatus*. The ground layer is open, with the grasses and herbs.

NAME: H2 (Green Mallee Woodlands) 4077

SITES: 7 (748, 777, 786, 828, 844, 894, 906)

LANDFORMS: Crests and gentle hillslopes

SOILS: Gravelly Red and Yellow Earths and Lithosols

GEOLOGY: Ordovician sediments and Silurian conglomerate and sandstone.

STRUCTURE: Mid High Open Mallee Woodlands

SPECIES: Trees *Eucalyptus viridis, E. sideroxylon, Callitris glaucophylla*, Tall Shrubs *Acacia doratoxylon, A. deanei, A. amblygona, Cassinia* subsp*., Dodonaea* subsp*., Platysace lanceolata, Melichrus erubescens, Calytrix tetragona*

Herbs and Grasses *Cheilanthes austrotenuifolia, Enteropogon acicularis*. *Aristida jerichoensis, Panicum subxerophilum*.

COMMENTS: Green Mallee Woodlands with White Cypress Pine are characteristic of crests and hilltops in the western half of the study area (on the Gindoono, Bobadah, Tottenham and Boona Mount 1:100,000 sheets). Dwyer's Red Gum is commonly scattered throughout the Green Mallee Woodlands, becoming more frequent towards the eastern part of the distribution of this mapunit (on the Tottenham and Boona Mount sheets). In the far south-west, *E. intertexta* (Red Box) occurs on saddles between crests .

A mosaic of Green Mallee Woodlands on the crests and Grey Box, Poplar Box and Pine Woodlands on the slopes and flats of the rolling country is a feature of the mapunit. This pattern is a result of the underlying geology and the soils. Green Mallee Woodlands occur on the shallow, gravelly soils of the outcropping Ordovician and Silurian sediments. The surrounding rolling country is covered by Red Earths derived from Quaternary eluvial sediments on which (P13) Grey Box, Poplar Box and Pine Woodlands occur.

NAME: H6 (Open Grey Mallee, Box and Pine Woodlands) 4081

SITES: 4 (635, 700, 701, 704)

LANDFORMS: High steep hills and outcropping linear ridges of the Cobar peneplain. Relief to 100m.

SOILS: Shallow stony and sandy lithosols becoming deeper, better developed gravely red earths downslope

GEOLOGY: The Whinfell Chert and massive white quartzites of the Ordovician Girilambone Group and the early Devonian volcanics of the Kopyje Group.

STRUCTURE: Tall to Very Tall Open Mallee Woodland and Mid-High Open Woodland.

SPECIES: Trees *Eucalyptus morrisii, Eucalyptus viridis, Eucalyptus intertexta, Eucalyptus socialis, Callitris glaucophylla;* Low Trees *Acacia aneura, Acacia burrowii, Acacia doratoxylon, Alectryon oleifolius;* Tall Shrubs *Eremophila mitchellii;* Shrubs *Acacia deanei, Acacia decora, Acacia hakeoides, Beyeria viscosa, Cassinia laevis, Prostanthera ringens;* Herbs *Cheilanthes sieberi* subsp. *sieberi,* Grasses *Themeda australis*

COMMENTS: Tall to Very Tall Open Grey Mallee Woodlands grow on the lithosols and skeletal soils of the Ordovician geologies on the crests of the high, steep, hills and ridgelines of the Cobar peneplain. *Eucalyptus morrisii* is common in the overstorey in these areas with *Eucalyptus viridis* an occasional co-dominant. Scattered low trees and a patchy shrub layer with a variety of Acacia species are characteristic of the understorey of these woodlands.

Down slope from the high hill crests and ridgelines, the lithosols and skeletal soils grade into the more developed gravely eluvial red earths formed by the Ordovician sedimentaries and Devonian volcanics. The vegetation here changes from the Tall to

Very Tall Open Grey Mallee Woodlands to Mid-High Open Woodlands of *Eucalyptus intertexta, Eucalyptus populnea* and *Callitris glaucophylla* with mallee species occasionally interspersed. These woodlands reflect the intergrade that exists with the F5 (Red Box, Poplar Box and Pine on Open Woodlands on Granite Hillslopes) mapunit which occurs lower in the landscape. Similar to F5 Woodlands, the understorey of this map unit is generally open with scattered *Alectryon oleifolius* and *Eremophila mitchellii* in the upper layer and shrubs such as *Einadia nutans* subsp. *nutans, Dodaonea viscosa* and *Cassinia laevis* in the lower layer. The ground layer is patchy. With few herbaceous or grass species recorded in the sites.

Open Grey Mallee, Box and Pine Woodlands are confined to the west of the study area on the Gindoono, Bobadah, Canbelego 1:100,000 map sheets. Small occurrences can be found on the outcrops known as "Trig Hill" and "The Brothers" just west of the township of Girilambone on the Coolabah 1:100,000 map sheet.

NAME: H7 (Mallee Woodlands on Rolling Hills) 4082

SITES: 8 (558, 630, 637, 639, 640, 697, 698, 703, 737) 6 (739, 740, 829, 831, 873, 892)

LANDFORMS: Rolling hills, ridges and crests of the Cobar peneplain. Relief to 50m.

SOILS: Red Earths, Red-Brown Earths and minor gravely Red Earths

GEOLOGY: Ordovician metasediments and some Devonian volcanics. Includes the Whinfell cherts along ridges in the west of the study area.

STRUCTURE: Very Tall to Extremely Tall Open to Closed Mallee Forest.

SPECIES: Trees *Eucalyptus dumosa, Eucalyptus socialis, Eucalyptus viridis;* Low Trees *Alectryon oleifolius;* Tall Shrubs *Acacia colletioides, Eremophila mitchellii, Geijera parviflora;* Shrubs *Acacia hakeoides, Bertya cunninghamii, Bossiaea walkeri, Dodonaea viscosa* subsp. *cuneata, Einadia nutans* subsp. *nutans , Eremophila glabra, Olearia pimeleoides, Senna artemisioides* subsp. f*ilifolia;* Herbs *Oxalis chnoodes, Solanum* subsp., Grasses *Stipa scabra, Panicum subxerophilum.*

COMMENTS: This map unit occurs mainly on the slopes, ridges and hill crests of the Cobar peneplain. *Eucalyptus socialis* and *Eucalyptus dumosa* dominate on the deeper red earths with *Eucalyptus viridis* becoming more prevalent as the soils become more gravely at the crests of the hills. It is typically dense Mallee Forest, generally being more variable in height than that which occurs further east on the flats of the peneplain in P1 Woodlands. The understorey is variable between remnants and often reflects the density of the overstorey and past management practices. *Triodia scariosa* is noticably absent from the understorey.

NAME: H8 (Tumbled Down Red Gum Woodlands on Basalt Hills) 4083

SITES: 2 (514, 962)

LANDFORMS: Outcropping hills in the east of the study area. Relief to around 100m.

SOILS: Basaltic Clay Lithosols with some outcropping

GEOLOGY: Tertiary Basaltic lava derived from volcanic centres in the Warrumbungle Ranges further to the east.

STRUCTURE: Low to Mid-High Open Woodland.

SPECIES: Trees *Eucalyptus dealbata, Casuarina cristata* Low Trees *Atalaya hemiglauca, Alectryon oleifolius, Alstonia constricta;* Tall Shrubs *Geijera parviflora;* Shrubs *Lycium ferocissimum;* Herbs *Malva parviflora, Medicago trunculata, Oxalis chnoodes, Canthium oleifolium;* Grasses *Eleusine indica.*

COMMENTS: This map unit occurs on the outcropping basaltic hills in the east of the study area. The structure of the vegetation varies across the hillslopes with aspect, landuse and grazing pressure. The low trees *Atalaya hemiglauca, Alectryon oleifolius, Alstonia constricta* and *Owenia acidula* are commonly associated on the lower and upper slopes, with *Eucalyptus dealbata* and mature *Casuarina cristata* having been observed on the north-east facing slopes of Tenandra and Magometon Hill's, respectively. As with the granite hills further west, the lower shrub and ground layers may be dominated by a diverse mix of woody weeds, grasses and herbs, the density of which is governed by factors such as grazing, herbicide spraying and the degree of outcropping.

NAME: H9 (Dwyer's Red Gum Open Woodland on Granite Hills) 8084

SITES: 4 (602, 603, 604, 605)

LANDFORMS: Rounded outcropping hills on the Macquarie River floodplain. Relief to around 80m.

SOILS: Lithosols with some outcropping

GEOLOGY: Part of the early Devonian intrusives of the Lachlan Fold Belt. Known as the Mt Foster Monzonite.

STRUCTURE: Low to Mid-High Open Woodland.

SPECIES: Trees *Eucalyptus dwyeri, Eucalyptus populnea, Brachychiton populneus;* Low Trees *Alstonia constricta, Alectryon oleifolius;* Shrubs *Sclerolaena birchii, Lycium ferocissimum, Pandorea pandorana;* Herbs *Cheilanthes sieberi* subsp. *sieberi, Calostemma purpureum, Calotis lappulacea, Chrysocephalum apiculatum, Goodenia fascicularis, Isotoma axillaris, Lepidium pseudohyssopifolium, Mimulus prostratus, Oxalis chnoodes, Pelargonium australe, Portulaca oleracea, Solanum esuriale, Trachymene incisa* subsp. *corrugata, Wahlenbergia communis,* Grasses *Eriachne mucronata, Stipa scabra, Themeda australis.*

COMMENTS: This map unit is located on the granitic intrusives of Mt Foster and Mt Harris on the Mt Harris 1:100 000 map sheet. It is typically very open, low woodland with scattered occurrences of *Eucalyptus dwyeri* (in both tree and mallee form), *Eucalyptus populnea, Brachychiton populneus* and the low trees *Alstonia constricta, Atalaya hemiglauca* and *Alectryon oleifolius* extending from the lower slopes to the crests of the hills. Shrubs are generally scattered, isolated woody weeds with the ground layer a diverse array of herbs and grasses.

AREAS NOT MAPPED AS WOODY VEGETATION

NAME: Null (Non-Woody Vegetation) 9999

The area identified as Null on the map consists of four categories;

a) exotic vegetation, b) highly modified native vegetation, c) no vegetation and d) native vegetation difficult to be accurately identified on high level aerial photography.

The categories are defined in the following way;

exotic vegetation is land that is highly modified, under crop production and areas where current land management activity will not allow vegetation to revert to a natural state, for example plantations, crops, orchards.

highly modified native vegetation occurs where native species composition and density is low. The area is usually dominated by exotic species, this is often as a result of intensive thinning, tilling and grazing. The area was not under cultivation at the time of the survey or ground truthing.

areas where no vegetation is present due to natural or management induced physical conditions, for example; barrens, scars, scalds, tilled or ploughed earth and off river storage.

d) native vegetation difficult to be accurately identified on high level aerial photography are patches of native vegetation less than 10 ha in size and vegetation types such as Lignum, Myall, Chenopod Shrublands, wetlands and naturally treeless plains (grasslands) that are difficult to discern on photographs of a scale of less than 1:50 000. 1:50 000 is the highest resolution photographs used in the wheatbelt mapping.

Grasslands are present in the area and exist under Open Woodlands. Pure grassland is not mapped because of the difficulty in distinguishing grassland from improved pasture and some chenopod shrublands. Grasslands need to be mapped at a larger scale with landuse information indicating the extent of pasture improvement and time since last tilling.

REMNANT DESCRIPTIONS FOR
THE FORBES AND CARGELLIGO 1:250 000 VEGETATION SHEETS
(BAND E)

THE MAPPING UNITS

The following map unit descriptions summarise the landforms, soils, vegetation structures and species occurring in each unit. These remnants are not homogeneous with respect to all of these factors, hence, the descriptions deal with the most common and characteristic features. Variations will be discussed in the 'comments' section.

Each mapping unit will be described in the following terms:

Name: Map Unit Code (Characteristic Vegetation Type) Unit Number.

Sites: The number of formal sites described in the mapping unit.

Landforms: Most frequently occurring Morphological Terrain Types.

Soils: Main soil types encountered. This typing of soils is based on field observations (as previously described) and, where available, mapped information; they should not be interpreted as resulting from formal profile descriptions.

Structure: Main vegetation structural types, following Walker and Hopkins (1984).

Species: Dominant and most frequently occurring species in each stratum are listed. For convenience the strata are labelled 'Trees', 'Low Trees', 'Tall Shrubs', 'Shrubs', 'Herbs' and 'Grasses'. Where one or more of these strata do not commonly occur they will be omitted.

Comments: This section is devoted to general descriptions of the unit and descriptions of the range of variation expected.

Table 1 – Details of Aerial Photography Interpreted

1:250 000 Map sheet	Scale	Date(s) Flown
Forbes	1:50 000	1989
Cargelligo	1:85 000	1980

RIPARIAN AND FLOODPLAIN REMNANTS

Name: R1. (River Red Gum Forests) 1001

Sites: 23.

Landforms: Banks, channels and backplains.

Soils: Grey cracking clay and polygenetic alluvial soils.

Structure: Tall Open Forest.

Species:

Trees *Eucalyptus camaldulensis*; Low Trees *Acacia stenophylla, Acacia saligna*; Shrubs *Muehlenbeckia florulenta*; Herbs *Pratia concolor, Rumex brownii, Echium plantagineum, Sonchus oleraceus, Onopordum acanthium* subsp. *acanthium, Oxalis corniculata, Centipeda cunninghamii*; Grasses *Cynodon dactylon, Paspalidium jubiflorum, Lolium rigidum*.

Comments: This remnant type is characteristic of streamline and river margins. The dominant community most commonly comprises two strata; the canopy and a herbaceous understorey, usually dominated by exotics. The shrub stratum is patchy in occurrence and is frequently absent.

Name: R2. (Floodplain Mosaic) 1002

Sites: 7.

Landforms: Backplains, floodplains and banks.

Soils: Grey cracking soils.

Structure: Tall Open Forests and Closed Grassland.

Species:

Trees *Eucalyptus largiflorens, Eucalyptus camaldulensis;* Low Trees *Acacia salicina* and *Acacia stenophylla;* Shrubs *Muehlenbeckia florulenta;* Herbs *Carex inversa, Centipeda cunninghamii, Marrubium vulgare, Echium plantagineum*; Grasses *Lolium rigidum, Hordium leporinum, Phalaris paradoxa, Agrostis avenacea*.

Comments: This remnant type comprises a mosaic of R1, R3 and Grasslands where the individual elements are too small to map separately. It is mainly associated with backplain and floodplain areas of the Lachlan and other major rivers and characteristically contains a network of minor stream channels.

Name: R3. (Black Box Woodlands)

Sites: 23.

Landforms: Floodplains, closed depressions and very gentle rises.

Soils: Mainly grey cracking clays with some red earths and brown clays.

Structure: Mid-High Open Forests, Mid-High Woodlands and Mid-High Open Woodlands.

Species:

Trees *Eucalyptus largiflorens, Eucalyptus camaldulensis, Eucalyptus populnea* subsp. *bimbil*; Low Trees *Acacia salicina, Acacia pendula*; Shrubs *Muehlenbeckia florulenta*; Herbs *Einadia nutans, Sclerolaena muricata, Rhodanthe corymbiflora,*

Oxalis corniculata; Grasses *Danthonia setacea, Lolium rigidum, Hordium leporinum, Phalaris paradoxa*.

Comments: Associated with broad floodplain areas and isolated closed depressions which often pond water for several days following rain. *E. camaldulensis* tends to replace *E. largiflorens* in about the eastern third of the study area. Minor areas of *E. populnea* subsp. *bimbil* and *Casuarina cristata,* forming a mosaic pattern, occur on higher ground within this unit in the west. Typical Black Box (*Eucalyptus largiflorens*) communities in this area contain either a scattered Lignum (*Muehlenbeckia florulenta*) shrub layer or the shrub layer is absent. The ground cover may vary considerably from site to site and tends to be less dominated by exotics than is the case with river frontage remnants (R1 and R2).

Name: R4. (Lignum Shrublands) 1004

Sites: 1.

Landforms: Flats and Closed Depressions.

Soils: Brown clay.

Structure:Tall Shrublands.

Species:

Shrubs *Muehlenbeckia florulenta*; Grasses *Stipa aristiglumis, Enteropogon acicularis, Phyla nodiflora, Lolium perenn*e.

Comments: Remnant type of limited extent; associated with the Lachlan River and Lakes.

Name: R5. (Myall Woodlands) 1005

Sites: 1.

Landforms: Gilgaied flats.

Soils: Grey clay.

Structure: Mid-High Woodland to Mid-High Open Forest.

Species:

Trees *Acacia pendula*; Shrubs *Einadia nutans*; Herbs *Ixiolaena tomentosa*, *Marsilea hirsuta (Amyema quandang)*; Grasses *Danthonia setacea, Lolium rigidum*.

Comments: This remnant type is difficult to distinguish from grassed land on the 1: 85,000 aerial photography used in this project and hence, may be more common than indicated on the map. However, whilst it is possible to see scattered Myall (*Acacia pendula*) throughout the area, very few sizeable remnants were observed. The mistletoe (*Amyema quandang*) is a characteristic stem parasite of Myall.

Name: R6. (Yellow Box/River Red Gum Forests) 1006

Sites: 4.

Landforms: Flats, floodplains.

Soils: Brown earthy soils and clays.

Structure: Tall Open Forest to Tall Woodland.

Species:

Trees *Eucalyptus melliodora, Eucalyptus camaldulensis*; Low Trees *Acacia stenophylla;* Shrubs *Muehlenbeckia florulenta;* Herbs *Onopordium acanthium* subsp. *acanthium.* Grasses *Lolium perenne, Lolium rigidum, Avena ludoviciana.*

Comments: This remnant is characterised by the presence of Yellow Box (*Eucalyptus melliodora*), usually in combination with River Red Gum (*Eucalyptus camaldulensis*), and has many features in common with remnant type R1. However, it is does not occur on banks and tends to be confined to low-lying areas on the floodplains. The shrub layer tends to be both patchy and sparse and the ground cover is dominated by exotic species.

UNDULATING PENEPLAINS REMNANTS

Name: P1. (Mallee Woodlands) 1011

Sites: 11.

Landforms: Flats and very gentle rises.

Soils: Sandy red earths.

Structure: Low to Mid-High Mallee Woodlands.

Species:

Trees *Eucalyptus socialis, Eucalyptus gracilis, Eucalyptus dumosa, Callitris glaucophylla*; Shrubs *Melaleuca uncinata, Olearia pimeleoides, Eremophila glabra, Acacia* spp., *Halgania cyanea*; Herbs *Chrysocephalum apiculatum, Hyalospermum semisterile, Stackhousia viminea, Lomandra effusa, Dianella revoluta, Daucus glochidiatus*; Grasses *Triodia scariosa* subsp. *scariosa, Stipa elegantissima*.

Comments: This remnant type is characterised by Mallee Woodlands on red sands. These communities support diverse and variable shrub and herbaceous understoreys. Small areas of *Callitris* open woodlands occur on hard-setting red earth soils within the mallee.

Name: P2. (Open Mallee Woodlands) 1012

Sites: 8.

Landforms: Flats and gentle rises.

Soils: Sandy red earths.

Structure: Low Mallee Woodlands and Mid-High Woodlands.

Species:

Trees *Callitris glaucophylla, Casuarina cristata*; Low Trees *Eucalyptus socialis, Eucalyptus dumosa, Eucalyptus oleosa, Eucalyptus leptophylla*; Shrubs *Olearia pimeleoides, Geijera parviflora, Acacia* spp., *Hakea tephrosperma, Pittosporum phylliraeoides*; Herbs *Chrysocephalum apiculatum, Dianella revoluta, Vittadinia pterocheata, Daucus glochidiatus, Echium plantagineum, Hyalosperma semisterile, Hypochaeris radicata*; Grasses *Bromus rubens, Stipa scabra* var *scabra, Vulpia myuros, Stipa elegantissima*.

Comments: In this remnant type the vegetation communities are structurally diverse. The Mallee communities are frequently more open than in P1 as a result of past clearing and grazing, and are interspersed patches of White Cypress Pine (*Callitris glaucophylla*) and Belah (*Casuarina cristata*) dominated communities.

Where the shrub and grass layers have been removed and disturbed by grazing, exotic species dominate the understorey.

Name: P3. (Open Box Woodlands) 1013

Sites: 27.

Landforms: Flats and gentle slopes <2 degrees.

Soils: Loamy red earths, minor sandy red earths and brown earths.

Structure: Mid-high Open Woodland, Tall Open Woodlands, Tall Woodlands and Tall Grassland

Species:

Trees *Callitris glaucophylla, E. populnea* subsp. *bimbil, Eucalyptus intertexta, Eucalyptus microcarpa, Allocasuarina luehmannii*; Low Trees *Geijera parviflora, Acacia oswaldii*; Tall Shrubs *Dodonaea viscosa, Eremophila mitchellii*; Shrubs *Maireana enchylaenoides, Einadia nutans*; Herbs *Sida corrugata, Echium plantagineum*; Grasses *Danthonia setacea, Enteropogon acicularis, Stipa scabra* var *scabra, Vulpia myuros, Elymus scaber* var. *scaber, Lolium rigidum.*

Comments: A generally open pattern with scattered denser areas on the aerial photographs. Site descriptions suggest previous clearing and moderate to heavy grazing patterns.

Name: P4. (Box Woodlands) 1014

Sites: 52.

Landforms: Flats, very gentle slopes and minor drainage lines.

Soils: Loamy red earth soils, minor occurrences of sandy and clayey red and brown earths.

Structure: Tall Woodland to Tall Open Woodland and Mid-High Woodland.

Species:

Trees *E. populnea* subsp. *bimbil, Callitris glaucophylla, Eucalyptus microcarpa, Eucalyptus conica, Eucalyptus intertexta,* and *Allocasuarina luehmannii*; Tall Shrubs *Dodonaea viscosa, Pittosporum phylliraeoides, Acacia deanei, Senna artemisioides* and *Santalum acuminatum*; Shrubs *Einadia nutans, Maireana enchylaenoides*; Herbs *Calotis cuneifolia, Dichondra repens, Sida corrugata, Vittadinia dissecta, Oxalis corniculata,*; Grasses *Danthonia setacea, Stipa scabra* var *scabra, Lolium rigidum, Enteropogon acicularis, Vulpia myuros, Elymus scaber* var. *scaber*.

Comments: Very similar to P3 in composition but differing in having a consistently denser and more even canopy. Possibly not thinned as P3 has been. Varying

dominance of the main Eucalypt species; frequently with *Callitris glaucophylla* co-dominant.

Name: P5. (Mallee/White Cypress Pine intergrade) 1015

Sites: 5.

Landforms: Flats.

Soils: Sandy and loamy red earths.

Structure: Mid-High Mallee Woodland or Tall Woodland to Mid-High Woodland.

Species:

Trees *Callitris glaucophylla*; Low Trees *Eucalyptus socialis, Eucalyptus dumosa*; Tall Shrubs *Eremophila glabra, Pittosporum phylliraeoides, Melaleuca uncinata*; Shrubs *Maireana enchylaenoides*; Herbs *Dianella revoluta, Hyalosperma semisterile, Hypochaeris adicata*; Grasses *Danthonia setacea, Triodia scariosa* subsp. *scariosa, Vulpia myuros*.

Comments: Intergrade remnant between White Cypress Pine and Mallee remnants with cypress pine and mallee in discrete communities forming a mosaic, the individual units of which are too small to map separately.

Name: P6. (White Cypress Pine Woodlands) 1016

Sites: 48.

Landforms: Flats and gentle rises.

Soils: Loamy red earth soils.

Structure: Tall Open Woodland, minor Mid-High Open Woodland and Tall Woodland.

Species:

Trees *Callitris glaucophylla*, (minor *E. populnea* subsp. *bimbil, Eucalyptus microcarpa, Eucalyptus intertexta, Brachychiton populneus* and *Allocasuarina luehmannii)*; Tall Shrubs *Acacia deanei, Dodonaea viscosa, Geijera parviflora, Senna artemisioides*; Shrubs *Einadia nutans, Maireana enchylaenoides*; Herbs *Cheilanthes austrotenuifolia, Calotis cuneifolia, Oxalis corniculata, Sida corrugata, Hypochaeris radicata, Stackhousia viminea, Bracteantha bracteata*; Grasses *Stipa scabra* var *scabra, Vulpia myuros, Danthonia setacea, Elymus scaber* var. *scaber, Pentaschistis airoides*.

Comments: White Cypress Pine woodlands and forests dominate but contain elements of other plains communities. Eucalypts may be locally dominant or co-dominant and thus this type overlaps with P4. This remnant type often comprises a dense stratum of regrowth pine with Eucalypts as isolated emergents.

Name: P7. (Bull Oak/Belah Woodlands) 1017

Sites: 10.

Landforms: Flats, shallow depressions and minor drainage lines.

Soils: Gilgaied clays and red earths.

Structure: Tall Woodlands (minor Tall Open Woodland and Mid-high Open Woodland).

Species:

Trees *Allocasuarina luehmannii, Callitris glaucophylla, Casuarina cristata, Acacia homalophylla*; Low Trees *Myoporum montanum, Acacia deanei*; Shrubs *Einadia nutans, Enchylaena tomentosa*; Herbs *Sida corrugata, Vittadinia dissecta*; Grasses *Danthonia setacea, Lolium rigidum, Vulpia myuros, Stipa wakoolica, Enteropogon acicularis, Elymus scaber* var. *scaber*.

Comments: Confined to the eastern third of the study area, this remnant occupies a zone of transition between the floodplain and peneplain remnants.

FOOTSLOPE REMNANTS

Name: F1. (Grasslands) 1021

Sites: Nil

Landforms: lopes, low crests and flats.

Soils: Lithosols and colluvial soils.

Structure: Tall Grassland, (minor Mid-High Open Woodland).

Species:

Trees *Callitris glaucophylla, E. populnea* subsp. *bimbil*; Grasses *Stipa scabra* var *scabra, Danthonia setacea*.

Comments: No access was available for formal sites in this remnant type. However, it appears from the API to be mainly cleared and consists of grasslands with clumps of trees remaining; it is otherwise similar to F2.

Name: F2. (Open Pine and Box Woodlands) 1022

Sites: 18.

Landforms: Footslopes and flats.

Soils: Colluvial red earths.

Structure: Tall Open Woodland, Tall Woodland and Mid-High Open Woodland.

Species:

Trees *Callitris glaucophylla, E. populnea* subsp. *bimbil, Eucalyptus intertexta, Eucalyptus dwyeri, Eucalyptus sideroxylon, Brachychiton populneus*; Low Trees *Acacia doratoxylon, Acacia deanei, Myoporum montanum, Pittosporum phylliraeoides, Leptospermum divaricatum*; Shrubs *Chenopodium desertorum, Dodonaea viscosa, Cassinia laevis Maireana enchylaenoides, Einadia nutans*; Herbs *Calotis cuneifolia, Hypochaeris radicata, Sida corrugata, Cheilanthes austrotenuifolia*; Grasses *Vulpia myuros, Danthonia setacea, Stipa scabra* var *scabra, Bromus rubens*.

Comments: White Cypress Pine dominates over most of this remnant type. It displays elements of both hill and plains remnants as is to be expected with an interzone.

Name: F3. (Pine and Box Woodlands) 1023

Sites: 8.

Landforms: Footslopes and flats.

Soils: Red and brown earths.

Structure: Tall Woodland.

Species:

Trees*Callitris glaucophylla, Eucalyptus microcarpa, Eucalyptus populnea* subsp. *bimbil*; Tall Shrubs *Acacia deanei, Hakea tephrosperma, Eremophila mitchellii*; Shrubs *Senna artemisioides, Einadia nutans*; Herbs *Oxalis corniculata, Cheilanthes austrotenuifolia, Sida corrugata*; Grasses *Danthonia setacea, Stipa scabra* var *scabra, Vulpia myuros,Pentaschistis airoides*.

Comments: A denser version of F2 with White Cypress Pine dominating overall, although any of the main tree species may be locally dominant.

HILL AND RIDGE REMNANTS
SEDIMENTARY AND METAMORPHIC GEOLOGIES

Name: H1. (Dwyers Red Gum and Pine Woodlands) 1031

Sites: 30.

Landforms: Upper and mid slopes, crests and ridges.

Soils: Lithosols and shallow brown earths.

Structure: Mid-High Woodland, Mid-high Open Woodland, (minor Tall Open Woodland and Low Open Woodland).

Species:

Trees *Callitris glaucophylla, Eucalyptus dwyeri, Callitris endlicheri, Eucalyptus sideroxylon, Brachychiton populneus, Acacia doratoxylon, Allocasuarina verticillata*; Tall Shrubs *Leptospermum divaricatum, Cassinia laevis, Dodonaea viscosa, Calytrix tetragona*; Shrubs *Grevillea floribunda, Hibbertia obtusifolia, Melichrus urceolatus, Platysace lanceolata*; Herbs *Gonocarpus elatus, Cheilanthes austrotenuifolia, Wahlenbergia queenslandica*; Grasses *Vulpia myuros, Danthonia setacea, Pentaschistis airoides, Stipa scabra* var *scabra*.

Comments: Three main associations are represented: *E. dwyeri/Callitris glaucophylla, E. dwyeri/Callitris endlicheri* and *Callitris glaucophylla/E. sideroxylon.*

In some areas *Acacia doratoxylon* or *Allocasuarina verticillata* may form the canopy layer but usually form a dense understorey where they occur.

Name: H2. (Green Mallee Woodlands) 1032

Sites: 9.

Landforms: Low crests, gentle hillslopes and flats.

Soils: Lithosols and shallow brown earths.

Structure: Mid-High Mallee Woodland (structurally diverse, varying from Low to Tall formations).

Species:

Trees *Eucalyptus viridis, Eucalyptus sideroxylon, Callitris endlicheri, Eucalyptus dumosa, Eucalyptus gracilis, Eucalyptus polybractea, Eucalyptus dwyeri*; Low Trees *Melaleuca uncinata, Acacia doratoxylon, Acacia cultriformis, Santalum acuminatum*; Tall Shrubs *Cassinia laevis, Olearia floribunda, Pultenaea largiflorens, Cassinia uncata, Dodonaea viscosa*; Shrubs *Melichrus urceolatus, Platysace lanceolata*; Herbs *Dianella revoluta, Cassytha melantha, Helichrysum viscosum, Helichrysum obcordatum, Calotis cuneifolia*; Grasses *Danthonia setacea, Vulpia myuros, Stipa scabra* var *scabra*.

Comments: Mallee on hills, often associated with *E. dwyeri* and Cypress Pine.

VOLCANIC GEOLOGIES

Name: H3 (Pine and Poplar Box Open Woodlands) 1033

Sites: 6.

Landforms: Hillslopes, ridges and crests on granites and volcanics.

Soils: Lithosols and shallow brown earths.

Structure: Mid-High Open Woodland.

Species:

Trees *Callitris glaucophylla, E. populnea* subsp. *bimbil, Eucalyptus dwyeri, Brachychiton populneus*; Low Trees *Acacia doratoxylon, Allocasuarina verticillata*; Shrubs *Prostanthera nivea, Grevillea floribunda, Hibbertia riparia*; Herbs *Cheilanthes austrotenuifolia, Hypochaeris radicata, Oxalis corniculata*; Grasses *Stipa scabra* var *scabra, Pentaschistis airoides, Danthonia setacea, Vulpia myuros*.

Comments: Similar in many instances to H1 but differing in that *E. populnea* subsp. *bimbil or E. intertexta* may dominate or be co-dominant with White Cypress Pine in the canopy. This may reflect the fact that these geologies often display gentler slopes and lower hills than the steeply dipping sedimentaries.

Name: H4 (Cypress Pine Woodlands) 1034

Sites: Nil.

Landforms: Low crests and hillslopes on basalts.

Soils: Basalt derived clays.

Structure: Mid-High Open Woodland and Grasslands.

Species:

Trees *Callitris glaucophylla, Eucalyptus dwyeri*; Grasses *Stipa scabra* var *scabra, Danthonia setacea*.

Comments: There are very few basalt hills in the study area and most of these have been cleared. What vegetation remains appears similar to that of H1 on the aerial photographs. There was no access to this remnant for formal sites.

NAME: Null (Non-Woody Vegetation) 9999

The area identified as Null on the map consists of four categories; a) exotic vegetation, b) highly modified native vegetation, c) no vegetation and d) native vegetation difficult to be accurately identified on high level aerial photography.

The categories are defined in the following way;

exotic vegetation is land that is highly modified, under crop production and areas where current land management activity will not allow vegetation to revert to a natural state, for example plantations, crops, orchards.

highly modified native vegetation occurs where native species composition and density is low. The area is usually dominated by exotic species, this is often as a result of intensive thinning, tilling and grazing. The area was not under cultivation at the time of the survey or ground truthing.

areas where no vegetation is present due to natural or management induced physical conditions, for example; scars, scalds, tilled or ploughed earth and off river storage.

d) native vegetation difficult to be accurately identified on high level aerial photography are patches of native vegetation less than 10 ha in size and vegetation types such as Lignum, Myall, Chenopod Shrublands, wetlands and naturally treeless plains (grasslands) that are difficult to discern on photographs of a scale of less than 1:50 000. 1:50 000 is the highest resolution photographs used in the wheatbelt mapping.

Grasslands are present in the area and exist under Open Woodlands. Pure grassland is not mapped because of the difficulty in distinguishing grassland from improved pasture and some chenopod shrublands. Grasslands need to be mapped at a larger scale with landuse information indicating the extent of pasture improvement and time since last tilling.