National Recovery Plan for Buloke Woodlands of the Riverina and Murray Darling Depression Bioregions

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Australian Government

Government of South Australia

NSW Government Office of Environment & Heritage

State Government Victoria Department of Sustainability and Environment

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Authorized by the Victorian Government, 8 Nicholson Street, East Melbourne.

ISBN 978-1-74242-367-8 (online)

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This Recovery Plan has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

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Citation: Cheal, D., Lucas, A. and Macaulay, L. 2011. National Recovery Plan for Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions. Department of Sustainability and Environment, Melbourne.

Cover photographs: Buloke Woodland, Pine Plains, Wyperfeld National Park, Victoria

Contents

Summary

The 'Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions' ecological community (Buloke Woodlands) encompasses a number of closely-related woodland communities in which Buloke (*Allocasuarina luehmannii*) is usually the dominant or co-dominant tree. This community in the Riverina and Murray-Darling Depression Bioregions occurs from south-eastern South Australia through north-western and northern central Victoria into south central New South Wales. The Buloke Woodlands community has suffered a considerable reduction in distribution since European settlement, largely due to extensive clearing for agriculture and grazing by domestic stock, native and feral herbivores. Buloke Woodlands now exist as a patchy, highly fragmented, mostly highly degraded, community across much of its former range. Remnants persist on roadsides, private land and some public land including several parks and reserves. The Buloke Woodlands community is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. This national Recovery Plan for the 'Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions' ecological community is the first recovery plan for the community, and details its distribution, habitat, threats and recovery objectives, and actions necessary to ensure the long-term survival of the ecological community.

Community Information

Description

The 'Buloke Woodlands of the Riverina and Murray Darling Depression Bioregions' ecological community (herein referred to as Buloke Woodlands) encompasses a number of closely-related woodland communities in which Buloke (also known as Bull-Oak; *Allocasuarina luehmannii* (or *Casuarina luehmannii,* following Hwang 1992) is usually a dominant or co-dominant tree (DENR 2007). Other trees that may be prominent in Buloke Woodlands include:

- Slender Pine (*Callitris gracilis*) (also known as *Callitris preissii* following Farjon 2005) - a common codominant
- White/Murray Pine (*Callitris glaucophylla*) (also known as *Callitris columellaris* following Farjon 2005) - a common associate
- Black Box (*Eucalyptus largiflorens*) - a frequent dominant from adjoining communities
- Yellow/Blue Gum (*Eucalyptus leucoxylon* subsp. *pruinosa*) - a common codominant
- Grey Box (*Eucalyptus microcarpa*) - a common codominant

Buloke Woodlands includes vegetation where Buloke is a minor component or may even be absent (Sluiter *et al. 1997)*. The presence of Buloke is not necessarily a reliable indicator of Buloke Woodlands, and the lack of Buloke does not necessarily preclude a vegetation stand from being Buloke Woodland.

The method used to determine Buloke Woodlands is described in Appendix 1. The delimitation of 'Buloke Woodlands' is here based on the report of Sluiter *et al.* (1997) that classified Buloke and pine woodlands in Victoria and nearby regions into 10 groups. **Groups 1, 2, 3, 8, 9** and **10** fit the definition for inclusion in Buloke Woodlands (*sensu* DENR 1 2007). Together, these groups make up the bulk of the listed Buloke Woodlands community.

The Groups defined by Sluiter *et al.* (1997) are:

Group 1 Semi-arid Herbaceous Pine-Buloke Woodland

Group 2 Semi-arid Shrubby Pine-Buloke woodland

Group 3. Semi-arid Grassy Pine-Buloke Woodland

Group 8 Semi-arid Northwest Plains Buloke Grassy Woodland

Group 9 Buloke Grassy Woodland

Group 10 Grey Box Buloke Grassy Woodland

Within Buloke Woodland communities, these groups can be further classified as either Buloke Woodland (Loams) comprising Groups 8 and 10, or Buloke Woodland (Sands) comprising Groups 1, 2 and 3 . Buloke Woodland (Loams) occur on heavy loams or clay loams that are frequently waterlogged in winter and not closely associated with rivers or streams, while Buloke Woodland (Sands) occurs adjacent to freshwater river systems (such as the Wimmera and Murray Rivers) or in association with boinkas (groundwater discharge sites).

The following groups do not fit the definition of Buloke Woodlands and have been excluded from this Recovery Plan:

- **Group 4** (woodland dominated by *Callitris gracilis*) is best excluded as it is largely beyond the ecological and geographical range of Buloke. Group 4 represents highly degraded locations of related communities (such as the Pine Woodlands of Group 7 - see below) or marginal quadrats containing species more typical of distinctly different communities (such as riverine woodlands).
- **Groups 5** and **11** largely do not occur in either of the Riverina or the Murray-Darling Depression bioregions.
- **Group 6** appears to lack Buloke and other species of Casuarinaceae and is thus outside the scope of this Recovery Plan.
- **Group 7** comprises a large area of woodland lacking Buloke and dominated by Slender Pine in the region. Most of these woodlands are clearly excluded from 'Buloke Woodlands', but are included within the analysis by Sluiter *et al.* (1997) and form part of their Group 7 'Semi-arid sand dune hummock pine woodland'. Woodlands solely dominated by Slender Pine (i.e. lacking Buloke) are presumptively outside the scope of the EPBC Act listing. Stands of Sluiter's Group 7 containing Buloke are included within the current Recovery Plan, whilst stands of Group 7 lacking Buloke and solely dominated by Slender Pine are excluded.
- **Group 12** is the '*E. camaldulensis* and/or *E. leucoxylon* – *Allocasuarina luehmannii* sedge rich woodland' of Sluiter *et al.* (1997) that occurs near, and largely within, the southern margin of the Murray-Darling Depression Bioregion. The occurrence of Buloke within this (sub-) community is ecologically anomalous and few other plant species are shared with the (rest of) Buloke Woodlands. This community has been excluded from this Recovery Plan for Buloke Woodlands.

Further detail on the method and classification of groups is provided in Appendix 1.

A large number of rare and threatened species of both flora and fauna occurs in Buloke Woodlands. Many of these would benefit greatly from Buloke Woodlands restoration or protection. They are listed in Appendices 2 (vascular plants) and 3 (fauna).

Distribution

Buloke Woodlands were once widespread in the broad riverine plains of the Murray Darling Depression and Riverina Bioregions (Figures 1 & 2). Remnants of these once extensive woodlands occur from south-eastern South Australia through north-western Victoria to the eastern borders of the Riverina bioregion. More significantly, woodlands including Buloke as a (co-)dominant extend much farther north in New South Wales than the northern boundary of the Riverina Bioregion (Benson 2008). A similar community may extend well into south-eastern Queensland, as the distribution of Buloke extends well north of this northern boundary and most of the community's constituent species also occur well north of the northern boundary of the Riverina bioregion. There was a small, isolated occurrence of Buloke Woodlands in southern Victoria to the west of Melbourne, between Bacchus Marsh and Anakie, but this has been largely cleared and there are no remnants in reasonable condition. Further survey is likely to reveal that these woodlands are most reasonably included within Buloke Woodlands as defined in this Recovery Plan. It should be noted that the distribution of Buloke is much more extensive than of Buloke Woodlands, including within the Riverina and Murray-Darling Depression bioregions. This Recovery Plan is restricted to the occurrence of the Buloke Woodlands community within the noted bioregions.

In South Australia, Buloke Woodlands occur in the far south-east of the Murray-Darling Depression bioregion, near Bordertown. This landscape has been substantially cleared and only a very small area of Buloke Woodlands remains.

In Victoria, Buloke Woodlands occur throughout the Riverina bioregion, except for immediately adjacent to major rivers, including the Murray River intrusion of Riverina into the adjoining Murray-Darling Depression bioregion. In the Murray-Darling Depression bioregion, Buloke Woodlands are widespread and common in the south (and are a dominant feature of remnant native vegetation in the Wimmera) (Macaulay & Westbrooke 2003; Morcom 2000) but become increasingly rare to the north. In the north of the Murray-Darling Depression bioregion, Buloke Woodlands is restricted to near freshwater river systems (notably the Murray and Wimmera Rivers) or adjacent to sites of ground water discharge, such as Pink Lakes, the Raak Plain and Rocket Lake. The northernmost Victorian remnant is a highly-degraded stand on private land immediately west of Yarrara, some 30–40 km south of the Murray River.

The former and current extent of Buloke Woodlands in south-western New South Wales is uncertain, in large part due to extensive woodland degradation and clearing that has occurred in the region (Porteners 1993,

Westbrooke & Miller 1995). Also, other semi-arid, non-riverine and non-eucalypt woodland such as remnant shrubby woodlands dominated by *Casuarina pauper* or *Casuarina cristata* have been confused with former Buloke Woodlands. Analyses completed for this Recovery Plan did not detect substantial Buloke Woodlands stands anywhere in New South Wales, except in the far south. Recent summary reports by Benson (2008) have comprehensively discussed the vegetation types of the two subject bioregions and have identified former and current (degraded) occurrences in both the Murray-Darling Depression and the Riverina bioregions. In the Riverina bioregion, Buloke Woodlands are largely restricted to south of Deniliquin, in the zone mapped as 'Grey Box' (or similar) or adjacent to the Murray River, downstream to Euston.

The maps presented in Figures 1 & 2 are not maps of the total extent of Buloke Woodlands. They are maps of the currently recognized vegetation units that contain Buloke Woodlands (and also may contain related vegetation that is not Buloke Woodlands). Buloke Woodlands extend beyond the Riverina and Murray-Darling Depression Bioregions, but these occurrences are not included in this Recovery Plan.

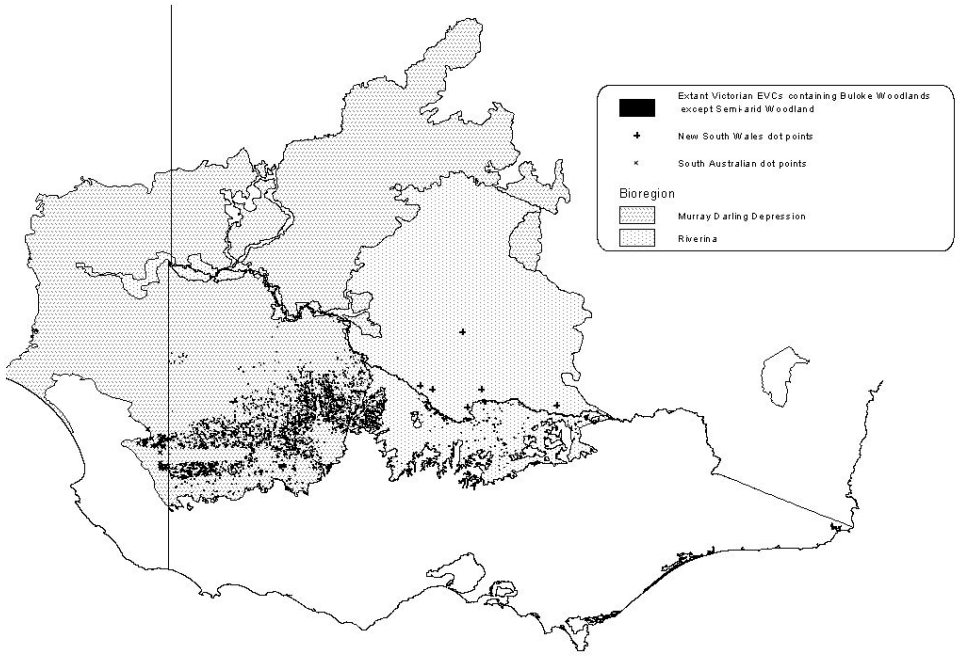

Figure 1 Distribution of extant stands of vegetation communities including Buloke Woodlands

(SA–pixels containing Buloke Woodland; NSW–point localities of Buloke Woodlands; Vic–Ecological Vegetation Class [EVC] polygons (1:100,000 scale) that include Buloke Woodlands (excluding Semi-arid Woodland [EVC with only small proportion of Buloke Woodland])

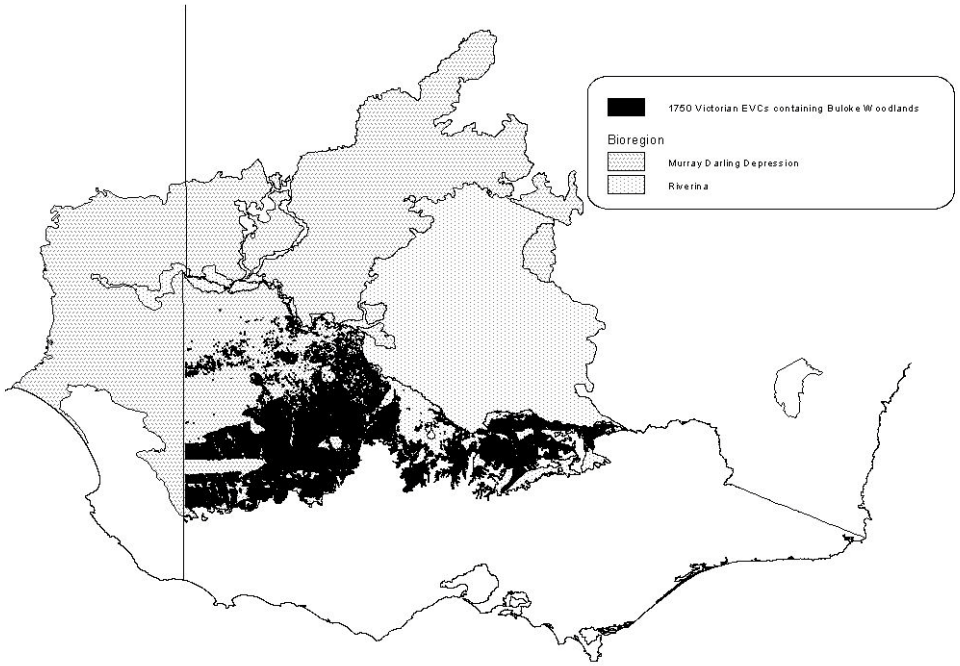

Figure 2 Extrapolated Victorian distribution of vegetation communities that contained Buloke Woodlands prior to European settlement

Habitat

Buloke Woodlands occurred in a mosaic pattern across the landscape, interspersed amongst grasslands and eucalypt woodlands. The boundaries and transitions between these adjoining communities were not fixed in space but varied as the fire regime varied. Other communities were also interspersed amongst the broad regional mosaic, but these were often reflective of local variations in other features such as soils (e.g. mallee vegetation on deeper sands) and moisture regimes (e.g. riverine forests on sites subject to periodic flooding).

The occurrence of Buloke Woodlands is constrained within an environmental envelope identified by various environmental features, including climate (e.g. mean annual rainfall, mean minimum temperature, absolute minimum temperature) and soil (e.g. it does not occur on deep siliceous sands) (Clemens *et al.* 1983). Climatic features may be used to derive a maximal environmental envelope for the community, but the likelihood of Buloke Woodland's occurrence at any point within that envelope is also determined by soil and other environmental features. Buloke Woodlands is not (and was not) ubiquitous within the broad range defined by climate and soils. Many sites that support Buloke Woodland and are contained within this same environmental envelope, adjoin other sites lacking Buloke Woodland. The important distinction between sites supporting Buloke Woodlands and otherwise similar sites lacking Buloke Woodlands may reflect different land management histories. Buloke, and many of the other component species of Buloke Woodland, are curiously susceptible to high intensity fire. On the heavier loams of the riverine plains, Buloke was a common dominant and Buloke Woodlands was probably widespread when Europeans arrived and first settled. But, at the same time, large areas on the riverine plains also supported grasslands and woodlands dominated by eucalypts. It is difficult to understand the apportionment of sites and vegetation across the plains on the basis of climate and soil alone. It is likely that Aboriginal land management, and particularly the application of a managed fire regime, constrained the widespread occurrence of Buloke Woodlands (Macaulay & Westbrooke 2003; Morcom 2000). Sites with particularly 'heavy' soils (loamy clays, sometimes sodic) were dominated either by tussock grasslands or by Buloke Woodland. Relatively frequent fires of moderate local intensity may have favoured the maintenance of grasslands, at the expense of Buloke Woodlands. On sites with better-drained loams, eucalypts co-dominated and Buloke may have been reduced or eliminated as a result of frequent applied fires. A similar dynamic and unstable 'balance', dependent on fire regime, may explain the mixed dominance of *Callitris* species and eucalypts across the same plains (Harris 2002; Hunter 1998; Sluiter & Parsons 1995).

Historical changes in habitat condition

Buloke Woodland (Sands) is typically associated with either freshwater river systems or boinkas and occurs as narrow bands between other vegetation communities (Figures 3 and 4) and rarely occurs (or occurred) as extensive stands. Adjoining vegetation communities include (or included) -

- Riverine Grassy Chenopod Woodland[1] (lower in the catena, along freshwater river systems),
- Samphire Shrubland and Chenopod Mallee Woodland (lower in the catena, near boinkas),
- Sandplain Grassland[2] (lower in the catena[3], near boinkas[4]), and
- Pine Woodland[5] (higher in the catena).

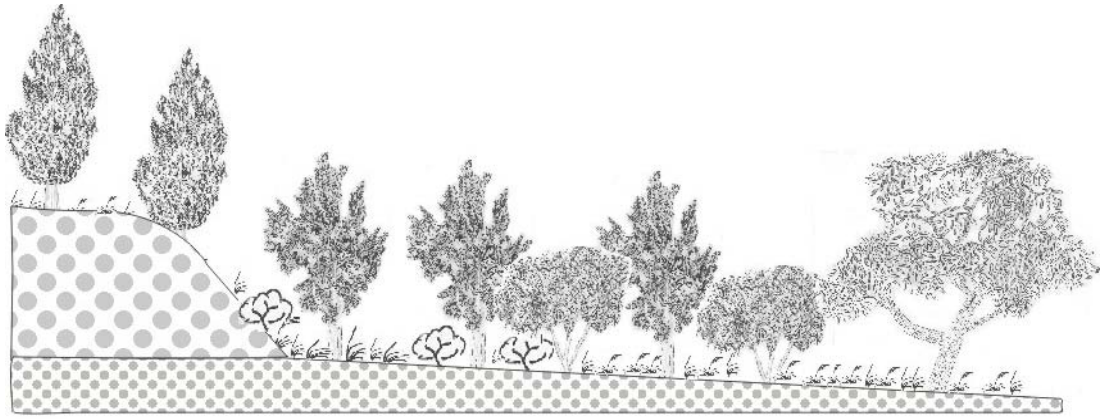

Figure 3 Profile Diagram of Buloke Woodland (Sands), pre-settlement

Pine Woodland on the deep aeolian sands (high in catena)

Buloke Woodlands on intervening zone (middle of catena), with scattered *Melaleuca lanceolata*

Riverine Grassy Chenopod Woodland on the adjoining floodplains (low in catena)

Extensive stock grazing characterized early settlement. This was maintained until after inclusion of parts of the landscape within national parks. Rabbits invaded and established in the 1870s (White *et al.* 2003) and the landscape along the inland rivers proved particularly suitable habitat for them. The fertile loams and clay loams of the riverine woodlands and lakebeds provided highly suitable forage and the nearby lunettes provided highly suitable sites for deep burrow construction, enabling the maintenance of dense populations of rabbits. Buloke Woodlands (Sands) often lay directly between these forage and burrow sites and hence suffered prolonged over-grazing (Anonymous 1996). This overgrazing extended to the pine-dominated lunettes, effectively preventing all regeneration of Bulokes and pines in the Buloke Woodlands and of pines on the adjoining deep-sand lunettes. Even once domestic stock had been removed, rabbit numbers stayed high and over-grazing continued (Anonymous 1996). As old trees died, they were not replaced by seedlings or suckers. Thus the high lunettes remobilized annually when the (newly-dominant) annual plants died, and subsequent wind erosion led to the deposition of their unconsolidated sands onto the heavier soil of nearby Buloke Woodlands.

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[1] Nomenclature of vegetation communities follows White *et al.* (2003) 'Vegetation Mapping North-West Victoria.' Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, East Melbourne., unless indicated otherwize.

[2] this vegetation community was not recognized by White *et al.* (2003), but is described in LCC (1987) 'Report on the Mallee Area Review.' (Land Conservation Council: Melbourne)

[3] 'catena' is a pedologiocal or geological term describing a series of soil types, derived from the same parent material, and in a topographic sequence

[4] 'boinka' is a geological term describing a complex set of landscapes associated with saline groundwater discharge

[5] a component of Semi-arid Woodland, *sensu* White *et al.* (2003) solely dominated by *Callitris gracilis* and typically occurring on the deep sand lunettes.

Although not particularly susceptible to fires, both Buloke Woodlands and the Pine-dominated woodland of the adjoining lunettes may burn in exceptional circumstances (Meredith 1981).

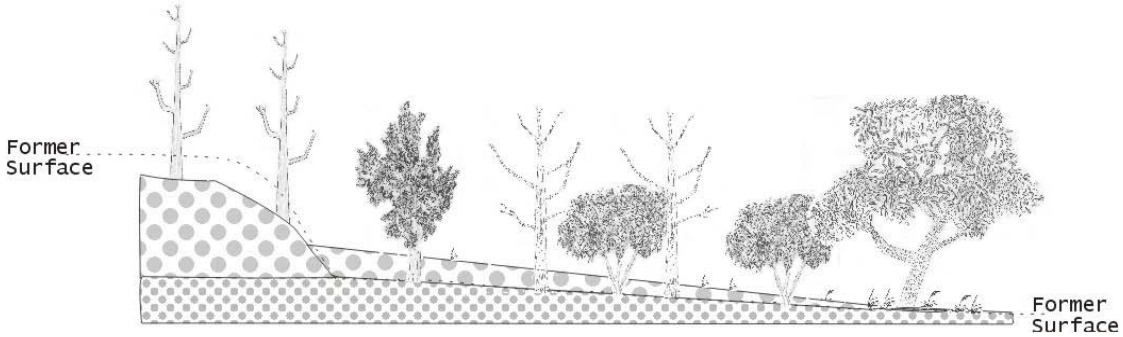

Figure 4 Profile Diagram of Buloke Woodlands (Sands), post-settlement

Callitris gracilis eliminated from the high dunes, eroded sands redeposited lower in the catena

Species typical of Buloke Woodlands largely eliminated (except for the few which sucker post-fire); sands deposited over the former surface of clay loams (middle of catena)

Riverine Grassy Chenopod Woodland dominated by *Eucalyptus largiflorens* on the adjoining floodplains

The major regional rivers, that formerly supported bands of Buloke Woodlands immediately above the riverine forests subject to occasional flooding, are the Murray and the Wimmera. Prior to European settlement, the Murray extensively flooded fairly frequently (once every 2-3 years) (Eldridge *et al.* 1993; Frood 2002). Floods along the lower Wimmera were much less frequent – every 20-22 years or so (Barnett and Ingamells 2002), but still allowed for a number of flooding events within each Buloke generation. Such extensive floods led to extended periods when the raised soil water table was at or above the surface (in the riverine woodlands dominated by *Eucalyptus camaldulensis* and/or *Eucalyptus largiflorens*) or very close to the surface (in the Buloke Woodlands zone – the next step in the catena, immediately above the riverine woodlands) (Figure 5).

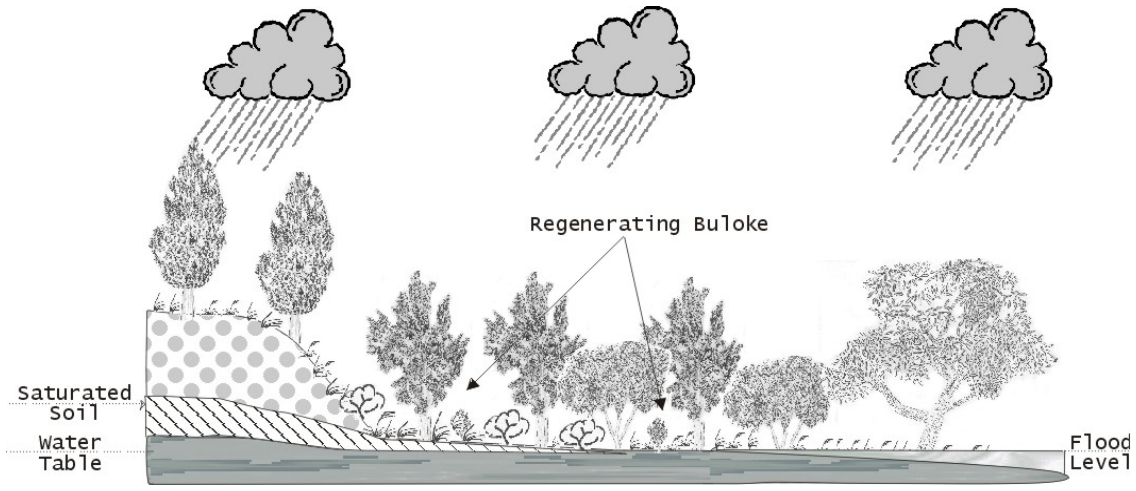

Figure 5 Profile Diagram of Buloke Woodland (Sands)

Flooding from the nearby river has extended throughout the riverine woodlands.

Local rainfall, additional to the river-borne floodwaters, can neither drain away nor move into the soil profile, thus temporarily saturating the surface soil of Buloke Woodlands – providing ideal conditions for Buloke regeneration.

It is suggested that, as these floods persisted or very slowly receded, even average local rainfall would have been unable to either drain away or soak into the deeper soil profile, thus saturating the surface soils in the Buloke Woodlands zone. This scenario would have produced extended periods of saturated soils enabling the seedling establishment of Buloke and other woody species.

Similar localized soil saturation would have occurred adjacent to boinkas, even without riverine flooding, as the regional (saline) groundwater rose in wetter winters. Localized rainfall, unable to drain away, would have produced occasional extended periods of saturated soils (freshwater-saturated soils lying over the saline regional groundwater table).

Population Information

Where the predominant cover of all recognizable major strata consists of native species believed to be constituents of Buloke Woodlands prior to European settlement, Buloke Woodlands is assumed to still occur at that site. Where some of these strata have been subject to substantial alteration in species composition (e.g. a more or less intact tree canopy over pasture grasses) the woodland may best be described as 'degraded Buloke Woodland' or 'extinct Buloke Woodland'. Where the pre-settlement physiognomy of the woodland no longer exists, but the constituent species of Buloke Woodlands may still be found, even though at greatly reduced density, that woodland may also be best described as 'degraded Buloke Woodland'. In situations where there have been complete loss (or almost so) of vegetation strata and of species formerly constituting Buloke Woodland, then Buloke Woodlands is considered extinct at that site.

Survival of the Buloke Woodlands community includes a consideration of long-term viability and degree of isolation of the remnant stand. Stands that are too small to support long-term viable populations of critical component species of Buloke Woodlands are less valuable than stands that support good populations of all critical component species. This applies even if those stands that are too small are described as being in 'good condition' currently. To help prioritise actions for the recovery of this ecological community, the most important extant stands of Buloke Woodlands have been identified based on criteria developed specifically for this plan (themselves based on standard criteria for conservation importance, Regan *et al.* 2000; Sattler & Williams 1999; Woodgate *et al.* 1996). These criteria are:

- **Size of Remnant**[6] – Recognizing that many component species have minimal areas essential for long-term local survival, the larger the area of the remnant, the better. Some fragments are too small to remain viable in the long term.
- **Shape of Remnant** – Many disturbances to community function impinge on Buloke Woodlands via the margins, e.g. weed invasion, inappropriate fires. A large perimeter to area ratio maximizes the impacts of these disturbances.
- **Connectivity** – Isolated stands have reduced capacity for reinvasion by component species if those species are locally eliminated. Nearby Buloke Woodlands patches facilitate invasion and re-establishment of species locally eliminated by fires, weeds or similar disturbances. Nearby native vegetation provides 'reserve' habitat for similar re-establishment of species shared with Buloke Woodlands. Many species have great difficulty crossing broad areas of alienated landscape.
- **Intactness** – Better quality stands are assumed to be those with fewer introduced plant and animal species, fewer environmental weeds (both in number of species and in overall biomass), minimal changes to flooding and fire regimes and reduced impact from nearby soil changes (e.g. less topsoil drift, less fertilizer drift). The history of grazing is an especially important determinant of quality with the few stands that have been rarely or only lightly grazed being of high conservation significance.
- **Structural Complexity** – Intact Buloke Woodlands are presumptively multi-layered, with an open canopy of trees, an open understorey of tall shrubs or small trees and a number of lower strata shrubs, including a more or less dense grassy field layer. Remnant stands that approximate this multi-strata condition are preferable to simplified vegetation (e.g. trees over pasture) (Watson 1994). The pre-settlement Buloke woodlands of the Wimmera were often open and grassy, with only scattered shrubs (Morcom and Westbrooke (1998). Remnants, in this region, that maintain an open structure with scattered shrubs are preferable to stands with dense tree and shrub regeneration (see the subsequent discussion under Threats – Fire), and these in turn are preferable to those with an understorey dominated by introduced species.
- **Redundancy** – Buloke Woodlands varies in composition across its range. The value of an individual remnant is dependent on the degree to which that same variant is already reserved or well-managed. A unique variant has higher value than a variant that is already well-reserved and managed in reserves.
- **Security of ecological conditions** – Security (i.e. likely long-term persistence of the conditions that have led to the Buloke Woodlands being maintained at that site) depends on both the environment and the socio-legal context. The local environmental component includes rainfall patterns (quantities,

[6] Large = > 120 ha, Medium = 20 – 120 ha, Small = < 20 ha

seasonality), soil fertility, fire regime, flooding regime and the grazing/browsing regime. The socio-legal context includes any formal reservation status, management strictures including planning overlays and clearance controls, and local attitudes to the values of Buloke trees and their plant and animal associates. Buloke Woodlands (Sands) may be dependent on local flooding from streams. With the current practice of diverting massive amounts of stream flow to other uses, such woodland stands are threatened in the short term and have little prospect of long-term maintenance. Similarly, rising saline water tables, increased fire frequency and unsatisfactorily-controlled grazing all adversely affect survival prospects for Buloke Woodlands. Individual private landholders may be strongly committed to conservative management of Buloke Woodlands on their land, but such ownership is readily transferable and any new owners may not have the same commitment. Buloke Woodlands along roadsides may be (intentionally or unintentionally) destroyed by replacement of services such as telephone lines or power lines.

The most important stands of remnant Buloke Woodlands are summarized in Table 1 (public land in the Murray-Darling Depression & Riverina bioregions) and Table 2 (private land in Victoria only) below.

Table 1. Localities of the most important stands of Buloke Woodlands on public land (a systematic survey is likely to reveal other small stands including those in good to excellent condition)[7]

Site Name	Quality	Area Buloke Woodlands	Total area native vegetation
South Australia			
Conkar Rd, Frances	Good	?	?
Frances Cemetery	Good	4 ha	4 ha
Pooginagoric-Teatrick Rd	Good	?	?
Wolseley – Mt Gambier Railway easement, Custon/Frances	Good	?	?
Wolseley Common Cons. Park	Good	~20 ha	~20 ha
Lockhardt Rd, Wolseley	Poor	?	?
Victoria			
Ailsa Road	Good	?	?
Angle Road, shire of Buloke	Moderate	24 ha	
Barham-Echuca Rd, Echuca (incl. adjoining private land)	Poor	~10 ha	~100 ha
Barrabool Flora & Fauna Reserve, Murtoa	Good	~60 ha	1,175 ha
Barrat Road	Moderate	?	?
Barrett Flora & Fauna Reserve, Warracknabeal	Excellent	~100 h	223 ha
Bell, Drapers, Winiam Hall Roads	Good	?	?
Big One Dam	Poor	?	?
Bill Middleton Roadside Reserve	Good	?	?
Birchip-Wycheproof Road	Moderate	24 ha	?
Boundary Rd, Culgoa	Good	10 ha	10 ha
Boyeo Flora Reserve, Nhill	Moderate	~20 ha	28 ha
Borung Highway, Areegra	Moderate	?	?
Boundary and Kennedys Road	Good	?	?
Butts Road	Excellent	?	?
Cannie Flora Reserve, Quambatook	Moderate	15 ha	16 ha
Charlton to Thalia Road	Moderate	35 ha	?
Cocamba Bushland Reserve	Good	20 ha	?
Corack East Bushland Reserve	Moderate	~70 ha	129 ha
Corack East Roadside	Good	10 ha	?
Dahlenbergs B. R.	Excellent	25 ha	?

[7] many of these patches of native vegetation include Buloke Woodlands with other vegetation types, while some patches are only Buloke Woodlands. The column titled 'Area Buloke Woodlands' provides data on the area of Buloke Woodlands, while the column titled 'Total area native vegetation' provides data on the total area of native vegetation (including Buloke Woodlands) at the nominated site.

D. Allens Road	Moderate	30 ha	?
Dering Flora & Fauna Reserve, Patchewollock	Poor (small patches good)	?	356 ha
Diapur / Lawloit Road	Moderate	10 ha	?
Dimboola-Minyip Rd (scattered)	Moderate	~100 ha	~100 ha
Dunmunckle Creek	Good	?	?
East Kiata Bushland Reserve	Excellent	?	?
Dinyarrak	Good	14 ha	?
Eureka Bushland Reserve	Good	?	?
G. Dahlenbergs Road	Excellent	?	?
Gerang Gerung - Glenlee road	Good	?	?
Gerang Gerung North Flora Reserve	Moderate	~30 ha	93 ha
Gerang Gerung South Flora Reserve	Moderate	~40 ha	57 ha
Glenlee Flora & Fauna Reserve	Excellent	~400 ha	560 ha
Glenlee – Lorquon Road	Moderate	?	?
Green Lakes Recreation Park	Poor	?	307 ha
Glenlee –Nhill Road	Good	?	?
Green Swamp	Moderate	?	?
Hattah-Kulkyne National Park, Hattah	Poor	~200 ha	48,000 ha
Hinnebergs Road	Excellent	?	?
Hogans Bushland Reserve	Good	?	?
Jordans Road	Excellent	?	?
Katyil Bushland Reserve	Excellent	?	?
Kellers Road	Good	?	?
Kiata Flora and Fauna Reserve	Excellent	?	?
Kiata Glenlee Road	Moderate	?	?
Lake Albacutya Park, Yaapeet	Poor	<20 ha	8,300 ha
Lianiduck Flora & Fauna Reserve, Sealake	Good	<10 ha	290 ha
Lake Lawloit	Moderate	40 ha	?
Leeor Bushland Reserve	Moderate	?	?
Lillimur South	Good	20 ha	?
Lillimur Three Chain Road	Moderate	?	?
Lil Lil Dam Conservation Reserve	Moderate	?	?
LCC (Wimmera) L11	Good	?	?
LCC (Wimmera) L12	Good	?	?
Lorquon Palms Road	Good	?	?
Miram	Good	20 ha	?
Nhill- Yanac -road	Good	?	?
Peakes Three Chain Road	Good	?	?
Prestons Bushland Reserve	Excellent	?	?
uncommitted crown land, Minyip	Poor	<25 ha	~100 ha
Mirampiram Bushland Reserve (part)	Excellent	?	?
Murray-Sunset National Park (Central Sunset)	Poor	~500 ha (many small patches)	633,000 ha
Murray-Sunset National Park (Pink Lakes)	Poor	~120 ha (± continuous)	633,000 ha
Murray-Sunset National Park (Rocket Lake)	Poor	~50 ha (± continuous)	633,000 ha
Murtoa South Recreation Reserve & crown land	Poor	<20 ha	<100 ha
Natimuk-Frances Rd (Vic & SA) (discontinuous on roadsides)	Poor	~50 ha	<1,000 ha
Nhill-Glenlee Rd, Nhill	Moderate	~50 ha	<1,000 ha
Ni Ni Bushland Reserve	Good	18 ha	?
Nicholls Road, Carron	Excellent	2.5 ha	?
Nurrabiel Cemetery		?	?

Nurrabiel Roadsides and Railway	Moderate	?	?
Old Minyip Road	Good	?	?
Patchewallock Racecourse Flora and Fauna Reserve South	Good	10 ha	166 ha
Quambatook Flora & Fauna Reserve	Moderate	?	71 ha
Lubeck State Forest, Rupanyup	Moderate	<100 ha	~500 ha
Pound Paddock Donald	Good	5 ha	?
Roadsides around Warmur	Excellent	?	?
Schmidts Road – Bpundary Road	Moderate	?	?
Sheep Hills / Bangerang Recreation Reserve	Poor	~20 ha	<100 ha
Salisbury Bushland Reserve	Good	13 ha	?
Swan Hill Road, Shire of Buloke	Moderate	28 ha	?
South Lillimur Road	Moderate	?	?
Terrapee Public Reserve	Good	6 ha	14 ha
Timberoo Flora & Fauna Reserve Walpeup	Poor	~50 ha	1,228 ha
Turners Tank Road	Moderate	28 ha	?
Tyrell Creek, 27km north of Wycheproof	Excellent	80 ha	?
Wail-Dimboola back road	Excellent	?	?
Wail Bushland reserve	Poor (revegetated)	?	?
Watchem Bushland Reserve.	Moderate	?	?
Watchem -Roadsides	Excellent	?	?
Weddings Bushland Reserve South Section	Good	100 ha	?
West Wail Flora and Fauna Reserve	Excellent	?	?
Winiam East	Good	20 ha	?
Woorack Church Road	Good	?	?
Wyperfeld National Park (Pine Plains)	Poor	~700 ha	356,800 ha
Wyperfeld National Park (south)	Poor	~200 ha	356,800 ha
New South Wales			
Moama-Deniliquin Rd (scattered)	Good	~100 ha	~250 ha
Lake Urana Road, Urana	Moderate	~40 ha	~200 ha
Yarrein Creek, Moulamein	Poor (small area Moderate)	~700 ha	~2,000 ha
Pitarpunga Lake	Poor	?	?
Merran Creek, Dilpurra	Poor	?	?
Euston-Pringle Rd, Euston	Poor	?	?

The information relating to occurrences of Buloke Woodlands on private land has been drawn from a variety of sources, including a series of studies completed for *Trust for Nature* (Victoria) (Marriott and Marriott 1996; Marriott and Marriott 1997; Marriott and Marriott 1999), Diez and Orr 1999; Foreman and Bailey 1996) and DSE (Victoria) staff. These sources cover the centre of the distribution of Buloke Woodlands, but there is scant information for occurrences elsewhere, particularly on private land in South Australia and New South Wales. Furthermore, there has been scant systematic survey for Buloke Woodlands on private land. Further systematic survey would likely identify other important sites.

Table 2. Localities of important stands of Buloke Woodlands on private land in Victoria[8]

Locality	Quality	Area of native vegetation	Covenant

[8] There is no reliable estimate of the area that Buloke Woodlands comprises of the total area of native vegetation on private land.

Areegra	Moderate	44 ha	-
Ashens (1), Murtoa	Excellent	10 ha	-
Ashens (2), Murtoa	Excellent	50 ha	Yes
Aubrey	Good	24 ha	-
Avoca Plains (15)	Good	75 ha	-
Avoca Plains (24)	Good	42 ha	-
Bangerang	Good	30 ha	-
Banyena Road	Moderate	?	?
Barrabool	Good	9 ha	-
Blackheath	Good	24 ha	-
Boolite	Excellent	?	?
Corack Rd, Birchip	Moderate	40 ha	-
Crymelon, Warracknabeal	Moderate	18 ha	-
Culgoa	Excellent	200 ha	-
Dadswells Bridge (1)	Excellent Good???	80 ha	Yes
Dadswells Bridge (2)	Poor	60 ha	-
Dadswells Bridge (3)	Good	50 ha	?
Dimboola	Excellent	48 ha	?
Fieldings Road, Shire of Buloke	Good	30	?
Flora MacDonald Covenant	Moderate	?	?
Gilberts, Jefcott	Good	?	?
Gerang Gerung 1	Good	?	?
Gredgwin, Lake Marmal Cluster	Good	40 ha	-
Harris Road Donald	Good	12	?
Jephcott North, Donald	Good	11 ha	-
Kalkee, Dimboola	Moderate	4 ha	-
Kellalac	Moderate	16 ha	-
Kinimakatka	Excellent	8 ha	-
Lah (1)	Good	28 ha	-
Lah (2)	Poor	30 ha	-
Lah (3)	Moderate	20 ha	-
Lake Buloke (1)	Good	130 ha	-
Lake Buloke (2)	Good	200 ha	?
Lallat	Excellent	?	?
Lawler/Boolite	Moderate	6 ha	-
Longeronong (1)	Excellent	8 ha	Yes
Longeronong (2)	Good	18 ha	-
Minyip (4 sites)	Moderate	?	?
Minyip Township	Good	10 ha	?
Mitre	Moderate	8 ha	-
Netherby/Lorquon (1)	Moderate	8 ha	-
Netherby/Lorquon (2)	Moderate	10 ha	-
Nullawil, 9km SE	Moderate	40 ha	?
Pimpinio	Poor	?	?
Lower Norton	Excellent	15 ha	Yes
Ninyeunook, Quambatook	Excellent	120 ha	-
Quambatook	Excellent	70 ha	-
Rupanyup North	Moderate	20 ha	Yes

Sheep Hills	Good	?	?
Towaninny, 6km north	Moderate	60 ha	?
Trollops, Jeffcott	Good	?	?
Upper Regions 1 & 2	Moderate	?	?
Vectis Quarry Road	Good	?	?
Wail	Good	4 ha	-
Warmur	Excellent	10 ha	-
Warracknabeal (1)	Moderate	16 ha	-
Warracknabeal (2)	Excellent	11 ha	-
Winiam (1 & 2)	Moderate	?	?
Wycheproof, 3km SE	Good	40 ha	

The 170 sites identified in Tables 1 and 2 can be grouped according to their current conditions. Only those sites which have reliable condition and area statements are discussed here. The groups are:

- **Public Land - Large (> 120 ha), Insecure Ecologically, Secure Legally, Highly Degraded** (7 of the 170) – The largest stands of (former and moribund) Buloke Woodlands can be found in the larger national parks in Victoria, notably Albacutya, Hattah-Kulkyne, Murray-Sunset and Wyperfeld parks. Throughout these parks, the Buloke Woodlands stands have been eliminated or are highly degraded, with further degradation to extinction likely.
- **Public Land - Medium to Small (< 120 ha), Secure (both Ecologically and Legally) , Good Condition** (30 of the 170) – Many of the smaller reserves that include Buloke Woodlands have a history of only occasional or low intensity stock grazing and concerted control over pests and kangaroos. In addition, those south of Lake Albacutya [i.e. Buloke Woodlands (Loams)], are not dependent on riverine flooding to establish suitable conditions for germination and establishment. Until the 1970s or so, their value was largely overlooked. But, following regional surveys, e.g. LCC (1974), LCC (1987) and Stokes (1996), this value has often now been recognized and these medium to small stands (>20 ha) are usually now reserved for conservation purposes. Fire and pest control remain a priority for adjoining landholders. Notable examples of these smaller, but well-managed, reserves containing Buloke Woodlands in good condition, include Barrabool, Barrett, Boyeo, Cocamba, Corack East, Culgoa, Dering, Frances Cemetery, Gerang Gerung North, Gerang Gerung South, Glenlee, Hogans, Katyll, Kiata, Lianiduck, Lubeck, Mirampiram, Ni Ni, Patchewollock Racecourse, Prestons, Quambatook, Rupanyup South, Sheep Hills/Bangerang, Salisbury, Terrapee, Timberoo, Watchem, West Wail, Winiam East and Wolseley Common.
- **Public Land - Small to Medium (< 120 ha), Insecure (both Ecologically and Legally), Good Condition** (51 of the 170) – The Buloke Woodlands remnants found along roadsides have also benefited from occasional grazing, low pests and kangaroo numbers, weed control and low fire frequencies. Sometimes, these stands, although highly fragmented and discontinuous, are particularly valuable, for example, along the Moama-Deniliquin Road. Notable examples include along the Barnham Rd, Corac-Godwins Rd, Corack Rd, Dimboola-Minyip Rd, Euston-Pringle Rd, Moama-Deniliquin Rd, Natimuk-Frances Rd, Nhill-Glenlee Rd, Pooginagoric-Teatrick Rd and Wolseley-Mt Gambier railway easement.
- **Public Land – Small (< 20 ha), Insecure Ecologically, Poor Condition** (21 of the 170) **–** Small stands of Buloke Woodlands on public land that is either unreserved or reserved for purposes other than conservation are insecure and likely to continue to slowly degrade, unless management priorities change. Notable examples include Cannie, Green Lakes, Lake Urana Rd, Lockhardt Rd, Merran Creek, Minyip, Murtoa South, Pitarpunga Lake, Sheep Hills and Yarrein Creek.
- **Private Land - Small, Insecure Legally, Excellent to Moderate Condition** (61 of the 170) **–** The Buloke Woodlands stands identified in Table 2 (i.e. on private land) have been managed in such a way as to maintain their conservation values (whether this was intentional or not). Some of them are now subject to conservation covenants which confer moderate security against being cleared or otherwise degraded. The isolation has conferred some protection such as from frequent fires. However, all such stands may be degraded if management changes or if weeds are not controlled.

Decline and Threats

Since European settlement, the Riverina and Murray-Darling Depression bioregions have been subject to extensive clearing (Benson 2008; Connor 1966; Scott 1992) and remnants of the former native vegetation communities are now scattered in a landscape dominated by cropping and grazing lands. Temperate woodlands including Buloke Woodlands were amongst the first to be used for grazing by domestic livestock in southern Australia, and have been subject to extensive clearing (Whalley and Lodge 1987). Most Buloke Woodlands remnants are small (less than 200 ha) and isolated from other stands of the community by broad-scale cropland and grazed pasture. Even the few large national parks of the bioregions support little area of Buloke Woodlands. All the national parks were reserved many decades after initial selection and clearing. Selectors early realized that the soils of Buloke Woodlands were particularly suitable for agricultural production and, consequently, Buloke Woodlands was preferentially selected and cleared (Anonymous 2001; Connor 1966; Lunt 2002; Sluiter *et al.* 1997).

Most of the former extent of Buloke Woodlands has been eliminated and only highly degraded remnants of its former occurrence remain. Buloke is a widespread roadside tree throughout much of the region and still occasionally occurs as isolated paddock trees. However, individual trees (or even groups of trees) do not necessarily indicate the persistence of Buloke Woodland. The associated flora is usually dominated by introduced species and few of the vascular plant species typical of Buloke Woodlands still co-occur with the Bulokes themselves. Buloke Woodlands are almost everywhere eliminated. All the remnant stands listed in Tables 1 and 2 are either greatly degraded or small in area (when compared with the former extent of the community).

The largest contiguous areas of remnant Buloke Woodlands (or some semblance of it) can be found in three national parks, i.e. Hattah-Kulkyne, Murray-Sunset and Wyperfeld, all in north-western Victoria. Although these areas have avoided broad scale clearing, the Buloke Woodlands therein are greatly disturbed and highly degraded, for reasons which will be discussed later. Most of the former extent of Buloke Woodlands in these national parks no longer supports that community, but is now dominated by perennial native grasses or introduced Mediterranean annuals. It could be argued that all the stands listed in Table 1 from the national parks are so degraded as to no longer be reasonably included within 'Buloke Woodlands', although they retain some elements of Buloke Woodlands (including the canopy trees) and are candidates for restoration.

In the Wimmera region, the formerly extensive Buloke Woodlands are now represented by many scattered small remnants partly linked by the extensive, largely uncleared road network. The vegetation on the three and five chain roads forms especially important links. The Plains Savanna vegetation community, which includes Buloke Woodlands, has over 21000 ha extant in the Wimmera, of which 19900 ha is found on private land (DSE data) not including the road reserves. Buloke Woodlands contained within other Wimmera vegetation communities are additional to these figures.

Even where some semblance of the original Buloke Woodlands remains, regeneration of most of the component species (including Buloke itself) has been lacking for many decades (Raymond 1990; Benson 2008; Watts no date; Williams *et al.* 2004a, 2004b). In addition, effectively irreversible soil and ground water changes have eliminated the former environmental conditions that supported development of Buloke Woodlands (see subsequent discussion). The decline in both area and quality of Buloke woodlands is still occurring. A study of Buloke on roadsides and in paddocks in the Moolort Plains in Victoria found a 15% decrease in the number of individual Buloke trees during the period 1993 to 2000 (Cheers 2000).

As a result, even when not directly cleared, most former Buloke Woodlands is highly degraded, with little indication of its former presence except for occasional Buloke trees or scattered occurrences of long-lived shrubs formerly part of Buloke Woodland. The field layer is currently dominated by introduced species or native species not previously common in Buloke Woodlands, but now abundant there owing to aeolian deposition of sands from nearby dunes or other siliceous soils. Consequently, it is very difficult to discuss the distribution of remnant Buloke Woodlands without also considering the degree of degradation of each stand. No stand of Buloke Woodlands is free of introduced species. No stand of Buloke Woodlands has the same grazing regime as prior to European settlement, nor the prior fire regime. Everywhere there has been nutrient accretion (following fertilization of adjoining or nearby agricultural land), a change in ground water (through increasing salinity and nitrification, as well as regionally higher water tables) and altered flooding regimes. All these changes have affected processes within all Buloke Woodlands and the species composition has changed, and continues to change. Species have disappeared, others have been introduced and species proportions and growth habits have altered.

Four closely-related communities that may be found within the broad context of Buloke Woodlands have been listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988*. These four communities are: the Grey-Box-Buloke Grassy Woodland Community, the Semi-arid Herbaceous Pine-Buloke Woodland Community, the Semi-arid North-west Plains Buloke Grassy Woodlands Community and the Semi-arid shrubby Pine-Buloke Woodland Community. The community Semi-arid shrubby Buloke – Slender Cypress Pine woodland, far south-western NSW, a constituent community of Buloke Woodlands, is listed under the New South Wales *Threatened Species Conservation Act 1995*.

There are many threats to the persistence and further development of Buloke Woodlands. Some of the most significant threats are discussed below, but there are many other threats, and some of these may be particularly important at particular sites. Threats not discussed here include exotic invertebrates, fertilizer drift from nearby agriculture, incremental clearing through firewood collection, inappropriate revegetation programs and excessive drainage. The following discussion is restricted to the most pervasive threats.

Inappropriate Grazing Pressure

Changes to both the structure and the composition of Buloke Woodlands have been fully or partially attributed to changes in mammalian grazing pressure in Buloke Woodlands following European settlement (Castle 1989; Lange and Purdie 1976; Lunt 1991; Lunt 1995; Macaulay and Westbrooke 2003; Morcom and Westbrooke 1998; Sandell *et al.* 2002; Sluiter *et al.* 1997; Watson *et al.* 2000).

In an undisturbed condition, the various vegetation strata within Buloke Woodlands are dominated by perennial species (although this simple statement is somewhat conjectural and inferential as Buloke Woodlands in original condition no longer exist). Most of these perennial species are palatable to grazing animals (Benson 2008; Cheal 1993; Morcom and Westbrooke 1998; Wilson *et al.* 1976) and under moderate to high grazing pressure are either locally eliminated (if the plants are within reach of the grazing animals) or regeneration is prevented (as suckers or seedlings are within reach of the grazing animals). On initial introduction of stock (or rabbits) to a formerly-ungrazed woodland stand, the abundance of perennial palatable forage often led to high stocking rates which impacted particularly severely on this perennial component of the woodland. As these decreased, they were (ecologically) replaced by introduced annuals, the establishment of which exacerbated the grazing pressure on the remnant perennials in following summers (when the introduced annuals had died). Further reduction in perennial abundance led to increased abundance in annuals, further disadvantaging the perennials - a positive feedback leading to the loss of all palatable perennials, a ground layer dominated by annuals and a tree layer gradually opening out as deaths are not replaced. The endpoint of continuous inappropriate grazing pressure (whether by stock or rabbits or kangaroos) is a community lacking in non-eucalypt woody dominants, i.e. lacking Buloke, Slender Cypress pine and most other trees, no shrub or sub-shrub layer and a ground cover consisting of exotic annual grasses (Benson 2008; Castle 1989; Lange and Purdie 1976; Wilson *et al.* 1976). This is the typical condition of Buloke Woodlands in all large reserved stands, including in national parks. Recent impacts of RCD (Rabbit Calicivirus Disease) have led to an increase in the native perennial grasses in remnant Buloke Woodlands in large reserves (including national parks), but there has been (as yet) scant response from other perennial components of Buloke Woodlands. The most encouraging signs of perennial species recovery, including Buloke itself, in large reserves, have been in Hattah-Kulkyne National Park in Victoria. This park has been subject to over a decade of carefully-controlled grazing reduction, including a concerted campaign to reduce the grazing impacts of rabbits and kangaroos (Sandell *et al.* 2002).

Buloke Woodlands in smaller reserves, particularly if immersed in a predominantly agricultural landscape, are in much better condition. As these small reserves have been surrounded by high value agricultural land, adjoining landholders have not permitted the numbers of kangaroos and rabbits to increase unchecked. These reserves may have been grazed by domestic stock for many years (this grazing pressure is now largely eliminated), but these 'woodland' or 'timber' reserves were rarely intentionally cleared. As a result, their Buloke Woodlands are in much better condition than is the case in the larger national parks (contrast Frances Cemetery or Glenlee Flora and Fauna Reserve, both containing Buloke Woodlands in relatively good condition, with decrepit stands in Wyperfeld National Park).

Where eucalypts were not initially a component of the canopy, overgrazing has led to the conversion of woodlands into grasslands dominated by annual herbs (Cheal 1986; Cheal 1993; Sandell *et al.* 2002). Grazing animals can promote these changes by directly eating seeds or seedlings, or indirectly by changing soil structure and chemical properties or by otherwise changing the environmental conditions that are required for particular species' regeneration, for example, removing shading by loss of the shrub layers (Cheal 1993).

The overall grazing pressure has changed since European settlement, even in land that has not been intentionally cleared for agriculture. For example, small to medium-sized native grazers have become

depleted or extinct through the former range of Buloke Woodlands (Christensen 1980; Robinson 1975; Wakefield 1966a; Wakefield 1966b) and introduced cattle, sheep, rabbits, hares, goats and mice are now widespread. The abundance of some native animals may have increased. For example, kangaroo numbers are believed to have increased in (at least parts of) the Mallee since European settlement (Cheal 1986; Coulson 1988). Grazing pressure varies across the landscape (Pringle and Landsberg 2004) resulting in variation in the localized intensities of degradation. In addition, there are different management objectives for native grazers such as kangaroos (*viz*. maintain at a low density) compared with introduced pests such as rabbits and goats (*viz.* local elimination).

The impact of grazing on a vegetation community depends upon:

The type of grazers present. Different species of grazers have different dietary preferences leading to selective grazing. For example rabbits tend to graze grasses and herbs whereas goats, being preferentially browsers, are more likely to concentrate on shrubs (Sandell *et al.* 2002; Williams 1969; Wilson 1979). Grazing in woodland vegetation, including Pine-Buloke Woodland, by domestic stock, resulted in an increase in exotic annuals and a decrease in long-lived perennials, particularly chenopods (Cheal 1993). Grazers can also modify the physical environment. In the case of kangaroos, their mode of resting by exposing soil during the formation of hip holes may provide an area of localized relatively high nutrient and water concentration aiding in the preparation of seedbeds for shrub regeneration (Eldridge and Rath 2002). However, such impacts are highly localized and affect only a very small proportion of the landscape. Rabbit warrens may have much greater impacts on vegetation. A study in semi-arid New South Wales found that rabbit mounds are likely to be nutrient-poor with a soil surface dominated by lag gravel, which appeared to promote a sparse covering of typically low quality Mediterranean weeds (Eldridge and Myers 1999).

Stocking rates. While it has long been known that high stocking rates will cause degradation, there has been concern about the impact of even low numbers of rabbits. A 92% reduction in *Acacia* seedlings occurred during trials in an arid zone woodland when rabbits were at only 0.5 ha^{-1} (Lange and Graham 1983). The presence of even low numbers of rabbits in the landscape has prevented almost all regeneration in *Acacia melvillei* (Batty and Parsons 1992).

Environmental conditions. Grazing is likely to have a more severe impact where it directly affects particular germination requirements of plant species.

In semi-arid environments the infiltration efficiency of rainfall (ability of the soil profile to incorporate water from rainfall) may also be limited by the loss of perennial grasses (Anderson and Hodgkinson 1997). Perennial grasses upslope of *Acacia aneura* effectively captured overland flow (of both water and nutrients) in areas less-impacted by grazing, which then became available for use by *A. aneura*. These local resource increases then provided a natural recruitment bed for both perennial grasses and *A. aneura* seedlings. The importance of the maintenance of such phytogenic heterogeneity in Buloke Woodlands is unknown.

Sources of water. Grazing pressure is likely to be heavier near water points (Fisher 2002; Florian *et al.* 1997; Hacker 1986). This varies with the species of grazers. For instance, rabbits are not usually dependent on surface water for survival and have a more widespread impact on the environment whereas goats, sheep and cattle are dependent on water in summer and areas closer to water are more heavily grazed (Fisher 2002).

Land management. The increased frequency and duration of mice plagues has been linked to changes in farming practices (Stratford *et al.* 1996). Mice are more likely to be common where there has been an increase in the number of farms using techniques that cause minimal disturbance to the ground layer or when there has been an increased intensity and diversity of cropping. Buloke Woodlands adjacent to, or dispersed in, agricultural land (the typical landscape occurrence of Buloke Woodlands) are more likely to be subject to mice plagues than Buloke Woodlands remote from agricultural land. There has been no research on the impact of mouse plagues in remnant Buloke Woodlands.

Buloke itself has not regenerated in Buloke Woodlands (Sands) following removal of domestic stock[9] (Castle 1989; Morrison and Harvey 1997; Raymond 1990). Unlike *Casuarina cristata* (Belah), which regenerates readily by root suckering, Buloke only rarely suckers (although there is anecdotal evidence that root suckering may be promoted by damaging the roots and hence may be frequent on roadsides, where

[9] Recent inspection of former Buloke Woodland (Sands) in Hattah-Kulkyne National Park revealed the first signs of some (very limited) vegetative regeneration of Buloke, after more than 10 years of stock removal and heavy control of browsing by rabbits and kangaroos.

firebreak construction or utility installation and maintenance often involves disk ploughing, Cheers 2000). Most other dominants in Buloke Woodland, notably the eucalypts and pines, all regenerate solely from seed.

Weeds

All stands of Buloke Woodlands contain weeds (introduced plant species) and the field layer of most stands is typically dominated by weeds (Benson 2008; Macaulay and Westbrooke 2003; Marriott and Marriott 1999; Sluiter *et al.* 1997; Specht 2000). All quadrats reanalyzed as part of this Recovery Plan contained weeds, notably *Avena* species, *Brachypodium distachyon, Bromus* species, *Lolium* species, *Medicago* species, *Poa bulbosa* and *Trifolium* species. There has been little research on the direct, competitive effects of this abundance of weeds, but it is reasonable to suppose that they supplant native plant species, particularly in the ground layer. The abundance of introduced herbaceous legumes (e.g. species of *Medicago*, *Melilotus* and *Trifolium*) and the concomitant rarity of native herbaceous legumes (e.g. species of *Cullen*, *Lotus* and *Swainsona*) may be directly related. The spread of *Lolium rigidum* in the 1950s was associated with a rapid decline in the distribution of *Swainsona* species (Morcom and Westbrooke 1998).

The current abundance of introduced annuals in most stands of Buloke Woodlands is probably an outcome of the current and immediate-past grazing regimes. It is likely that these annuals substantially interfere with regeneration in native species (by introduced annuals pre-empting space in the community) and thus change the foraging habitats for the dependent fauna (Macaulay 2006). Furthermore, there is a smaller number of introduced perennial environmental weed species, which may change growing conditions within Buloke Woodlands to the extent that ecological function within Buloke Woodlands stands is substantially altered (= 'degraded'). Most Buloke woodland stands are relatively free of such perennial environmental weeds, but the invasive potential is high (particularly in the higher rainfall parts of the range of Buloke Woodlands and particularly in linear remnants, such as Buloke Woodlands on roadsides).

As discussed elsewhere in this recovery plan, many Buloke Woodlands stands now support native plant species that were not a typical constituent of these woodlands prior to European settlement. These native plant species could be considered as 'weeds', but it is suggested that expansion of their ranges into Buloke Woodlands is the result of changed environmental conditions (notably the accretion of aeolian deposits overlying the former loamy soils, the lack of flooding in adjacent riverine woodlands and intense grazing from decades of high rabbit numbers and the presence of domestic stock). In this situation, these native species are unlikely to hamper regeneration of the native species typical of Buloke Woodlands.

Fire

In the higher rainfall parts of its range, Buloke Woodlands often adjoins (or adjoined) either open-forest and woodlands dominated by *Eucalyptus* species, or grasslands. Both these communities are more flammable (and more fire tolerant) than is Buloke Woodlands and fire may have been one of the major determinants of Buloke Woodlands occurrence prior to European settlement. Fire in small reserves, as now characterize most of the range of Buloke Woodlands, is now rare. Nevertheless, it has been suggested that fires of very low intensity may have been important in maintaining the open nature and the grassiness of Buloke Woodlands prior to European settlement (Macaulay and Westbrooke 2003).

There is a serious threat of severe wildfire in the few large reserves that support some (highly modified) remnants of Buloke Woodland, notably in the large national parks in the Mallee of north-western Victoria. Large wildfires burnt a substantial part of remnant Buloke Woodlands in Wyperfeld National Park in 1981 (Anonymous 1996; Meredith 1981). Notwithstanding the fire's low intensity in these Buloke Woodlands (due to discontinuous fuels and low fuel quantities), many trees were burnt and subsequently died. There has been no tree regeneration following the fire (Castle 1989; Raymond 1990; Williams *et al.* 2004a) and substantial areas were converted to very open woodland or annual grassland or shrubland now-dominated by the short-lived *Acacia ligulata*.

Intense fires in these large stands of Buloke Woodlands were formerly very rare, due to heavy grazing by rabbits, domestic stock and kangaroos which removed the grassy field layer by early summer. Control of grazing pressure has resulted in the field layer in these disturbed Buloke Woodlands being now dominated by perennial grasses. For the first time in many decades (and probably a century or more) there is adequate dry fuel to carry a low intensity fire into and through these Buloke Woodlands. As a result, occasional fires now burn these Buloke Woodlands and tree death has accelerated (Anonymous 1996).

In the Wimmera prior to settlement, fire is presumed to have been an important periodic ecological process in Buloke Woodlands and was essential to maintaining the open structure of these woodlands (Macaulay and Westbrooke 2003). Since settlement, fire has been generally excluded from these woodlands, and where stock grazing has been absent for an extended period, prolific Buloke regeneration has sometimes occurred. It is suspected that lack of fire, in association with removal of grazing, has led to increased woody species in the lower strata of otherwise good quality remnants on public land.

In the Wimmera mature Buloke in Buloke Woodlands generally survives low severity fire, either wildfire, small experimental burns or stubble burns. Young stems are burnt to the ground but generally resprout. Repeated stubble burns, especially where the stems of individual old Buloke are already damaged, is a cause of accelerated decline to individual paddock Buloke trees.

Restoration of fire as an ecological process could assist in maintaining appropriate woodland structure, open spaces in which native lower strata species flourish and assist in weed control, in some stands of Buloke Woodlands.

Preliminary work on two small experimental burns (Macaulay 2006) found that rabbit and hare grazing after fire had negative impacts on the lower strata. Introduction of fire without associated effective rabbit and hare control is problematic. Both Buloke and cypress-pines are susceptible to fires and regeneration is mainly from seed (Castle 1989; Cheal *et al.* 1979; Cochrane and McDonald 1966; Raymond 1990; Zimmer 1942). Any regenerant seedlings are prone to being browsed by rabbits, stock or other mammalian herbivores, particularly during the ensuing dry summer to autumn periods. As a result, a single wildfire may lead to a catastrophic change from woodland of pine &/or Buloke to herbland. Continuing overgrazing leads to a landscape dominance by annual species, with a few fire-resistant shrubs.

Increasing soil salinity

It is difficult to determine the exact threat to remnant Buloke Woodlands from increasing salinity, due to the lack of knowledge of exact distribution of Buloke Woodlands, particularly in NSW, the lack of information about salinity tolerances of the various plants that comprise Buloke Woodlands and the limitations of existing salinity modelling. Buloke appears to be relatively susceptible to increasing soil salinity, and Buloke deaths immediately surrounding Yatpool Basin appears to be associated with increased soil salinity (Sluiter 1996). Increased groundwater discharge that has resulted from the removal of deep-rooted perennial vegetation (and hence a reduction in evapotranspiration) or from excess irrigation water may affect communities that occur lower in the landscape. Loss of flooding, leading to a reduction of salt flushing (leaching) from the soil may affect communities that occur closer to watercourses. Susceptible species are affected by increasing soil salinity well before saline groundwater reaches the surface. Existing modelling has indicated that the regional groundwater system underlying Buloke Woodlands in northern Victorian and the local and regional groundwater systems in south-western New South Wales are likely to be highly saline (Anonymous 1999). Groundwater salinity levels appear to be at least 14 000 mg/L in much of the region (Anonymous 2003) - seawater is around 35 000 mg/L.

The following areas are of concern:

New South Wales: Potential high water levels (<2m depth) have been predicted within the Murray Irrigation area, an area where Buloke Woodlands remnants may occur (Anonymous 2000). A salinity outbreak map is currently being prepared for the Murray region and may help to elucidate areas of concern (Basin Salinity Management Strategy 2001–2002, see http://www.environment.nsw.gov.au/salinity/government/basin.htm).

Victoria: 36% of the cleared land south of the Mallee is expected to have water table levels within 2 m of the land surface by 2050 (Anonymous 1999). Saline discharge is greatest in the Avoca catchment.

Mallee (New South Wales, South Australia, Victoria): It has been tentatively estimated that an additional 200 000 ha in the Mallee may become salt affected before groundwater equilibrium is reached (Anonymous 2003). At present, the increase in recharge is only starting to become apparent and increased saline discharge may not occur for 100 years (Anonymous 1999). The areas of Buloke Woodlands that are most at risk are Pink Lakes, the Raak Plains, the Lake Tyrrell region and the lower reaches of the Wimmera.

Irrigation areas: The Murray Darling Basin Commission has predicted that all irrigation regions within the southern Basin will have water table levels within 2 m of the surface by the year 2010 (Anonymous 1999), well within the root zone of the dominant trees and larger shrubs.

In South Australia, remnant Buloke Woodlands occurs in areas that currently show little risk of salinization.

Landscape Resorting

Landscape resorting refers to the movement and deposition of surface material from one part of the landscape to another. Removal of historic overgrazing has not led to reinstatement of the typical field layer of pre-settlement Buloke Woodland. The field layer now includes many introduced species, such as the annuals *Bromus rubens* (Red Brome)*, Medicago* species (Medics), *Pentaschistis airoides* (False Hair-grass), *Silene* species (Catchflies), *Trifolium* species (Clovers) and *Vulpia* species (Fescues), plus native species not previously typical of Buloke Woodland, but more characteristic of the adjoining sandy lunettes, including *Calotis erinacea* (Tangled Burr-daisy)*, Isolepis marginata, Wahlenbergia gracilenta* (Annual Bluebell) and *Zygophyllum ammophilum* (Sand Twinleaf). It is possible that the major sub-community 'Buloke Woodlands (Sands) is an artefact deriving from deposition of sands onto the clay loams of Buloke Woodland. The original soil profile cannot be reinstated without removal of hundreds of thousands of tonnes of resorted surface sands.

Freshwater Flooding

Buloke Woodlands (Loams) occur on alluvial soils and often on soils that are waterlogged for varying periods during winter and spring, particularly where Buloke is the principal or sole dominant. Depending on local drainage works, these situations still experience local waterlogging and occasionally periods of extended soil moisture following late summer- early autumn storms (although only rarely), thus seed regeneration of Buloke trees (and associated plant species) is still evident on the plains. However, regeneration from seed is uncommon and dependent on an unusual combination of local climatic factors, notably heavy rainfall at seed drop and a relatively moist succeeding summer (Macaulay and Westbrooke 2003). As a result, most regeneration of Buloke (trees) in Buloke Woodlands (Loams) is derived from (underground) suckers.

Farther north, Buloke Woodland (Sands) is restricted to close association with either freshwater river systems or with boinkas. The broad alluvial plains support other vegetation communities (Cheal and Parkes 1989; White *et al.* 2003). Preliminary research has demonstrated that soil water supply is rarely adequate to enable Buloke germination and establishment (Raymond 1990; Watts; Williams *et al.* 2004a; Williams *et al.* 2004b), even within (degraded) Buloke Woodlands. A feature of the degraded Buloke Woodlands from the large Mallee national parks has been the absence of any Buloke regeneration for many decades and continuing decline in Buloke trees and associated woody species. Williams *et al.* (2004a) suggested that seedling establishment of Buloke is restricted to extremely rare climatic events involving high summer rainfall and preferably over two succeeding summers. However, such a climatic pattern is rare to non-existent in the Mallee. How could the dominant component species of Buloke Woodland (Sands) have established from seed when local rainfall was both inadequate and restricted to seasons that did not enable such regeneration?

The Wimmera River has been subject to extraction of water and allocation to domestic, horticultural, agricultural and mining use and has not flooded extensively since the 1920s. There is little prospect of even moderate flooding again being a feature of this system. The Murray is now subject to more water diversion than any other Australian river (Anonymous 1999; Eldridge *et al.* 1993) and floods extensive enough to affect the Buloke zone are a thing of the past. As such, the extensive stands of heavily–degraded Buloke Woodland (Sands) along these rivers, and particularly in the large national parks, are destined to disappear.

A more optimistic assessment of the likelihood of successful regeneration of Buloke Woodland (Sands) around boinkas may be justified, as these woodland stands are not dependent on occasional river floods.

Fragmentation

Fragmentation, along with weed invasion, is a major threat to Buloke Woodlands. The existing road network, notably including the travelling stock reserves, has important conservation values including stands of Buloke Woodlands in good condition. An important associated issue is the appropriate management of the remnant grassland patches that occur in mosaic with woodlands.

Climate Change

Climate change poses a threat to Buloke Woodlands. Buloke may require high autumn rainfall for mass regeneration (Macaulay and Westbrooke 2003). Reduction in autumn rainfall has been the most significant aspect of the past 12 years of low average annual rainfall across the region. Buloke has suffered severe canopy decline across the region over this time. The stress of the continuing dry conditions led to a dramatic decline in old trees and associated habitat across Buloke Woodlands. The Buloke Woodlands towards the south of their range (with their higher mean annual rainfall) are probably less vulnerable than elsewhere.

Buloke Woodlands (Sands) are presumptively reliant on water that falls many kilometres away and is (or was) delivered by now-moribund river systems. The reliance of these ecosystems on ground water or extreme flood events along the Wimmera River makes them especially vulnerable to climate change.

Identification of threats

Tables 1 and 2 identify 170 important sites for Buloke Woodland, categorized into five groups:

a. Large blocks of public land, insecure ecologically, secure legally, highly degraded (mostly national parks)
b. Small to medium blocks of public land, secure, good condition (many specifically reserved for conservation purposes)
c. Small to medium blocks of public land, insecure, good condition (mostly roadsides)
d. Small blocks of public land, insecure, poor condition (recreation reserves, uncommitted public land etc.)
e. Small blocks of private land, insecure, moderate to good condition (including blocks with conservation covenants)

The major threats for each group are categorized below in Table 3, while some significant Buloke woodland sites in each group are provided in Table 4.

Table 3. Known and potential threats to Buloke Woodlands.

Current threats/perceived risk					
Over-grazing	**Weeds**	**Fire**	**Salinity**	**Landscape resorting**	**Lack of flooding**
Group a (by rabbits, hares, goats, kangaroos) **Group e** (by domestic stock, plus **Group a** in NSW leasehold grazing)	**Groups a, c & d** (environmental weeds) **Group e** (agricultural weeds) **Lesser threat to Group b** (environmental weeds)	**Group a** (mostly wildfires, but breaks established for prescribed burns are also foci for weed infestation)	**Group a** (particularly Buloke Woodlands adjoining boinkas)	**Group a** (from aeolian erosion of adjoining dunes **Group e (**from ground disturbance associated with nearby cropping)	**Group a** (particularly Buloke Woodlands associated with rivers)

Potential threats/perceived risk		
Grazing absence	**Clearing**	**Interplanting**
Groups b & d (dependent on role of grazing in maintaining the herbaceous field layer and preventing shrub encroachment)	**Groups c, d & e** (particularly roadsides and private land that is not covenanted or otherwise protected)	**Group c** (particularly roadsides, where revegetation and 'corridor' works are focused

Table 4. Some Significant Buloke Woodlands sites under threat
Sites are categorized according to vegetation condition and land status

Group a (Large, Insecure ecologically, Reserved, Degraded)	Group b (Small – Medium, Secure, Good condition)	Group c (Small-Medium, Insecure, Good condition)	Group d (Small, Insecure, Degraded)	Group e (Small, Insecure, Private land)
Albacutya Hattah-Kulkyne Murray-Sunset Wyperfeld	Barrabool Barrett Boyeo Corack East Culgoa Dering Frances Gerang Gerung Nth Gerang Gerung Sth Glenlee Lianiduck Quambatook South Rupanyup South Terrapee Timberoo Wolseley Common	Corac-Godwins Rd Dimboola-Minyip Rd Euston-Pringle Rd Lk Urana Rd Moama-Deniliquin Rd Natimuk-Frances Rd Nhill-Glenlee Rd	Cannie Green Lakes Lake Urana Merran Ck Minyip Murtoa South Pitarpunga Lake Sheep Hills Yarrein Ck	All private land blocks identified in Table 2.

Areas and populations under threat

Areas and stands under threat are discussed in the context of the grouping of sites and stands presented in Tables 3 and 4.

Group a – All large stands of Buloke Woodlands (>100 ha) are securely reserved and managed by Parks Victoria. However, secure reservation status has not been adequate to maintain nor restore vegetation quality. All remnant stands are degraded and many areas that formerly supported Buloke Woodlands within these national parks no longer do so. The condition of all remnant stands in national and similar parks is continuing to decline. Vegetation mapping has proved unreliable as it maps former occurrences of Buloke Woodlands as extant, even though many of these stands are often so degraded as to be most reasonably considered 'extinct'.

Remnant stands in large reserves are currently threatened by the following.:

Major Threats

Over-grazing – notably from rabbits, hares, goats and kangaroos, preventing regeneration and encouraging continued landscape resorting.

Fire – following the advent of RCD (Rabbit Calicivirus Disease), fires have become a notable threat to the peculiarly-susceptible flora of Buloke Woodlands, notably including Buloke trees. Wildfires have eliminated a large number of scattered Buloke trees from northern Wyperfeld.

Landscape Resorting – a feature of Buloke Woodland (Sands), particularly when associated with rivers, notably the Murray and the Wimmera. Continued deposition of aeolian sands is an irreversible change to Buloke Woodlands.

Lack of Flooding – a feature of Buloke Woodland (Sands), notably when associated with rivers (the Murray and Wimmera). As regeneration of Buloke Woodlands depended on the highest and most extensive floods, which have become extremely rare, there is little to no prospect of restoring these Buloke Woodlands.

Lesser Threats

Salinity – some Buloke Woodlands, particularly those remote from rivers, are affected by the regional saline water table. It is uncertain what impacts changes in regional saline water tables will have on remnants.

Weeds – most weeds in degraded Buloke Woodlands are primarily a response to degraded land condition, rather than a cause of that degradation. A small number of weed species may further degrade woodland condition by competing with, and impeding regeneration of, native species.

Group b – Buloke Woodlands in group b include all the most valuable and least-disturbed stands. Perhaps the most significant site is Glenlee in Victoria, but other highly significant stands include Barrabool, Barrett, Frances Cemetery, Quambatook, Rupanyup South and Wolseley Common. These sites have maintained Buloke Woodlands in good to excellent condition as they have not been subject to clearing, nor wildfires, and because nearby landholders have prevented build up of rabbits and kangaroos. In these reserves, 'benign neglect' has hitherto been a successful management approach. However, benign neglect may have also excluded the relatively frequent, and low intensity, fires that maintained the grassy nature of these woodlands. There appear to have been increases in lower shrub densities in these woodlands over the last few decades. Whether this on-going change is desirable or negative cannot be assessed, in the absence of a definitive statement of desired woodland condition (the 'management goal').

Lesser Threats

Weeds – weeds are not a feature of Buloke Woodlands in the better condition small reserves, but a 'watching brief' should be maintained to prevent establishment and spread of invasive environmental weeds, such as *Ehrharta calycina* and *Lycium ferocissimum.* Elsewhere, on private land, in the larger parks and in many insecure stands on public land weeds are one of the major threats to Buloke Woodlands. A floristic survey and analysis by Macaulay (2006) in the 1990s found that introduced grasses, particularly *Avena barbata, Lolium rigidum* and *Bromus diandrus* have replaced, or compete with, native field layers in most remnants.

Fire – High intensity (wild-) fires may adversely affect Buloke Woodlands by killing trees, understorey and lower strata shrubs. However, in good condition (without a high component of introduced Mediterranean weeds), this vegetation community is not notably flammable and is somewhat resistant to high intensity fires. In contrast, low intensity, patchy fires may have had a major role in maintaining the pre-European condition of open grassy patches interspersed amongst tree copses. The lack of low intensity fires may be leading to increasing shrub encroachment in the lower strata and the loss of native grasses in the field layer.

Grazing absence - The absence of heavy grazing has ensured maintenance of these Buloke Woodlands, but many sites are now effectively ungrazed. Former low intensity grazing by moderate densities of kangaroos and other native herbivores, in association with the planned application of low severity fires, may have been critical in maintaining the grassy field layer and preventing shrub encroachment. Native shrubs (such as *Eutaxia microphylla, Olearia pimeleoides* and *Rhagodia spinescens*) are coming to dominate the field layer of formerly grassy Buloke Woodlands in Glenlee and elsewhere.

Group c – Most Buloke Woodlands in group c occur on roadsides. Generally speaking, the broader the roadside, the less-disturbed the Buloke Woodland. The most valuable roadside stands are those on (former) travelling stock routes in New South Wales, e.g. the Moama-Deniliquin Road. However, habitat conservation is only one of the many functions of roadsides.

Major Threats

Weeds – the relatively high intensity of continuing soil disturbance on roadsides ensures that invasion and establishment of environmental weeds remains a major threat to remnant Buloke Woodlands.

Fertilizer and Pesticide Drift – The adjoining agricultural landscapes are usually high value crop lands, incorporating repeated fertilizer and weedicide application. Application of these chemicals inevitably leads to them also affecting the nearby roadsides, directly killing perennial natives and exacerbating invasibility by weeds.

Lesser Threats

Clearing – remains a threat on roadsides. Crop firebreaks are sometimes constructed by nearby landholders on public land on roadsides, rather than on adjoining private land. Other clearing threats include vegetation removal preparatory to establishment of roadside avenues of trees, dumping of gravel and other materials used in road making, strip clearance for provision of utilities, such as electricity and water, and road-widening.

Interplanting – habitat restoration is becoming a feature in landscapes substantially cleared of trees (e.g. the Upper South-east in South Australia and the Wimmera in Victoria). Revegetation works may degrade Buloke Woodlands by interplanting inappropriate species (e.g. Western Australian eucalypts) or, more commonly, planting locally indigenous species in inappropriate sites (e.g. local

mallee eucalypts in heavy loams, low in the catena). The soil disturbance associated with interplanting may also exacerbate weed invasions.

Fire – roadside stands are often burnt to remove a perceived hazard from the build up of dry fuels. Such prescribed burns eliminate regeneration of Bulokes and other species, many of which are susceptible to fire, and further remove important habitat components, such as fallen logs.

Group d – Buloke Woodlands in group d are all those stands which persist on public land for which habitat conservation is not a prime management aim. The sites are either unreserved or are managed for other purposes, such as recreation or timber yield.

Major Threats

Weeds - the relatively high intensity of continuing soil and vegetation disturbance on most of these small patches of land (e.g. by mowing, fuel reduction and rubbish dumping) ensures that invasion and establishment of environmental weeds remains a major threat to the remnant Buloke Woodlands.

Clearing – remains a threat, including vegetation removal for fuel reduction or for site 'grooming'. These sites are also frequently used as storage sites for road-making materials or for other utilities or municipal works. The prime purpose of land management of these sites does not usually include habitat conservation and hence clearance for provision of recreation facilities remains a threat to the small, degraded patches of remnant Buloke Woodland.

Grazing absence – the absence of heavy grazing has enabled persistence of these Buloke Woodlands, but often sites are now effectively ungrazed. Former low intensity grazing by moderate densities of kangaroos and other native herbivores, in association with the planned application of low severity fires, may have been critical in maintaining the grassy field layer and preventing shrub encroachment

Lesser Threats

Interplanting – habitat restoration is becoming a feature in landscapes substantially cleared of trees (e.g. the Upper South-east in South Australia and the Wimmera in Victoria). Revegetation works may degrade Buloke Woodlands by interplanting inappropriate species (e.g. Western Australian eucalypts) or, more commonly, planting locally indigenous species in inappropriate sites (e.g. local mallee eucalypts in heavy loams, low in the catena).

Group e – More than half the remnant stands, and a notable proportion of the good quality remnant stands, occur on private land. A small proportion is covered by conservation covenants which restrict future management options and offer some security against future adverse management. By far, most private land occurrences have no such restrictions and the security of the Buloke Woodlands is tenuous.

Major Threats

Weeds - the relatively high intensity of continuing soil and vegetation disturbance on most of these small patches of land, including fertilizer and pesticide drift from nearby agricultural land, ensure that continued weed establishment is the most significant threat. Many patches are grazed by domestic stock, enhancing establishment of weed species not commonly an overwhelming problem on reserved land (e.g. *Agrostis* and *Lolium* species). A carefully managed grazing regime may help in controlling or reducing weed invasion, although stock may also exacerbate weed invasion by importing weed seeds from improved pastures.

Clearing - despite legislation which aims to restrict clearing, clearing remains a problem. Clearing may be insidious, through continued heavy grazing (hence no replacement of the woody dominants) or by fertilizer application. Small sites may also be overtly cleared, utilizing exemptions for local domestic purposes (such as the establishment of house gardens).

Over-grazing – notably from domestic stock, but also from rabbits and hares, may selectively remove the palatable native species and prevent regeneration of the woody dominants. Over-grazing encourages the establishment and dominance of introduced annuals and other less palatable introduced species, including shrubs.

Lesser Threats

Landscape Resorting – a feature of Buloke Woodlands remnants adjoining cropping land, particularly in the lighter soils of the more arid stands, is aeolian drift of surface soils from the nearby land being worked.

Fragmentation – Private land Buloke Woodlands remnants are threatened by limited connectivity. However existing remnant vegetation on roadsides forms a basis for (re-)connection of otherwise isolated remnants. Degraded patches along the wider roadsides can be revegetated. Of paramount importance however, is to avoid planting trees and shrubs into the remnant grasslands that still occur on some roadsides in a mosaic pattern amongst the woodlands. In many cases these former grassland patches are now cropped. Unused road reserves could also be revegetated.

Existing Conservation Measures

Management practices generally follow the groupings indicated in Table 4. Specific conservation measures for Buloke Woodlands are being introduced on public land, but are, as yet, far from ubiquitous and are largely focused on the small reserves. Nevertheless, it may be possible to reconstitute Buloke Woodlands, even in the larger parks, from either degraded remnants or by intervention in ecologically-related communities. Degraded Buloke Woodlands may be managed so as to gradually restore the previous Buloke Woodlands status. Eucalypt-dominated woodlands on alluvial soils may be managed (through in-planting and fire exclusion) so as to develop towards Buloke Woodland. Existing conservation measures include:

Group a – Rabbit control has been undertaken with moderate success throughout, but has been highly successful where intensive and planned (notably in Hattah-Kulkyne). The establishment and spread of RCD has resulted in dramatic recent decreases in rabbit populations, although recent recoveries in rabbit populations are now evident. Goat control is ineffective. Kangaroo control is practised in some reserves, notably parts of Hattah-Kulkyne and parts of Wyperfeld. Weed control is focused on preventing the establishment or spread of major (new) environmental weeds, but with limited success (note the recent spread and dominance of *Carrichtera annua*; Cheal 2009). Firebreak construction is the most effective action undertaken to reduce the likelihood of damaging wildfires in Buloke Woodlands. Firebreak construction may also be a notable soil disturbance encouraging weed establishment. Reservation has largely eliminated overt clearing.

Group b – There is little active management in many of these small reserves, but the Buloke Woodlands stands have benefited from past 'benign neglect'. Nearby landholders have assisted in maintaining low grazing pressure (whether from rabbits, hares, goats or kangaroos). Rubbish removal and targeted removal of novel environmental weed infestations have assisted in maintenance of Buloke Woodlands condition. Reservation has largely eliminated overt clearing and has prioritized active efforts at weed control and investigation, and trialling, of practicable restoration and management techniques.

Group c – There are few (effective) conservation measures in place for roadsides. Weed control is often attempted, but is often a source of degradation of woodland condition (through the use of relatively non-selective herbicides and as a result of the associated ground disturbance). Fire control measures are usually a source of further degradation, through the removal of fallen timber, destruction of seedlings and species susceptible to fires and the provision of sites for weed establishment (in ploughed breaks).

Group d – There are few active conservation measures in place on unreserved public land, although native vegetation clearance controls offer some protection to remnant Buloke Woodlands.

Group e – Conservation measures on private land vary enormously, dependent on landholder attitudes. Those properties with conservation covenants often have a variety of landholder-applied conservation measures, including grazing control or reduction, interplanting with former woody species, weed control and even reinstatement of coarse woody debris to the field layer (Harvey 2000). The conservation covenant itself usually includes protection against overt clearing. In stands on private land without conservation covenants,

management varies from intensive and conservation-oriented through to neglect. Some private land stands are subject to antithetical management (e.g. maintenance of high levels of stock grazing).

Region-wide - The Wimmera Catchment Management Authority (CMA) has led an awareness campaign around the significance of Buloke Woodlands, including two biodiversity seminars (1998 and 2008) focusing on Buloke Woodlands. They have commenced a tender scheme to provide payments to private land owners to manage Buloke Woodlands for conservation outcomes (K. Lawton, pers. comm.).

Ballarat University, with support from the (former) *Natural Heritage Trust* and the *Department of Sustainability and Environment (Victoria)*, has completed a series of management-focused research and survey projects on Buloke Woodlands. These were on reptiles (Hadden and Westbrooke 1993), bats (Adler and Westbrooke, no date), insects (Douglas, no date), floristic composition and ecology (Macaulay 2006) and pre-settlement vegetation (Morcom and Westbrooke 1998). A booklet, summarizing these studies, *Guidelines for the Management and Rehabilitation of the Wimmera Buloke Woodlands of western Victoria* has been published (Macaulay and Westbrooke 2003).

Survey of significant remnants includes a roadside survey of the Shire of Lowan (Westbrooke, 1989) and assessments of remnant vegetation in the Shire of Buloke (Foreman and Bailey 1996; Diez and Orr 1999).

The Habitat 141 Program and the Yarrilinks Program (both at http://www.victorianaturally.org.au/), co-ordinated by *Greening Australia,* both have replanting components relating to Buloke Woodlands.

The state-based conservation agencies of the three states (NSW, SA and Victoria) all support Buloke Woodlands conservation through weed and feral pest control programs, fire management and the reservation system. These agencies also implement and monitor recovery actions for some of the individual threatened flora and fauna species that are components of Buloke Woodlands (e.g. programs for *Pimelea spinescens* subsp. *pubiflora*, *Acacia enterocarpa*, *Acacia glandulicarpa* and Golden Sun Moth). In Victoria, Action Statements (under the Victorian *Flora and Fauna* Guarantee legislation) have been prepared for various threatened flora and fauna species.

Callister (2002) has researched and recommended on land management within semi-arid woodlands (including Buloke Woodlands) in north-western Victoria.

Recovery Information

Recovery Objectives

The **overall recovery objective** is to increase the probability of important stands becoming self-sustaining by minimizing threats and to protect remnant stands to prevent the extinction of Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregion community in the wild. Within the life span of this Recovery Plan (5 years), the **specific objectives** of recovery for 'Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregion' community are to:

1. Clarify distribution and condition of stands
2. Improve ecological understanding
3. Ensure that all stands and their habitat are protected and managed appropriately
4. Manage threats to stands
5. Promote regeneration and rehabilitate degraded stands
6. Build community support for conservation

Program Implementation and Evaluation

This Recovery Plan guides recovery actions for the Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregion community and will be implemented and managed by the relevant nature conservation agency in each state, supported by other agencies, educational institutions, regional natural resource management authorities and community groups as appropriate. Technical, scientific, habitat management or education components of the Recovery Plan will be referred to specialist groups on research, *in situ* management, community education and cultivation as required. Contact will be maintained between the

state agencies on recovery issues concerning the Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregion community. The Recovery Plan will run for five years from the date of its adoption under the EPBC Act, and will be reviewed by State agencies and revised within five years of the date of its adoption.

Recovery Actions and Performance Criteria

Action	Description	Performance Criteria
Specific Objective 1: Clarify distribution and condition of stands		
1.1	Establish the locations, internal variation and condition of remnant Buloke Woodlands in NSW **Responsibility: OEH, RBG**	• Completed investigations (published reports) establishing the distribution and locations of remnant Buloke Woodlands in NSW. Reports to include information on the internal variation of Buloke Woodlands and the condition state of each significant stand.
1.2	Accurately map Buloke Woodland in northern and north-eastern Victoria and in New South Wales east of the Moama-Deniliquin Road. **Responsibility: DSE, OEH, RBG**	• Accurate vegetation maps of Buloke Woodlands indicating condition status.
1.3	Reassess the polygons mapped as Buloke Woodland in Hattah-Kulkyne, Murray-Sunset and Wyperfeld National Parks and in Albacutya Park, categorize the condition status of all mapped stands and remap Buloke Woodlands, excluding grossly degraded stands and indicating the condition status of the remnant stands **Responsibility: DSE, PV**	• Completed investigations, including targeted vegetation maps, establishing the condition status of each remnant stand in the 3 National Parks. • Accurate vegetation maps of Buloke Woodlands (indicating condition status).
1.4	Curate all existing floristic quadrat data from NSW, SA & Victoria and re-analyze to characterize constituent communities, thus providing rehabilitation goals and measures. **Responsibility: DSE , OEH, DENR**	• Published stable classification of Buloke Woodland, including distinction from adjoining communities. • Published floristic and structural summary statements of constituent communities.
Specific Objective 2: Improve ecological understanding		
2.1	Establish the regeneration requirements of the woody species characteristic of Buloke Woodland **Responsibility: DSE, OEH, DENR**	• Established projects investigating the regeneration requirements of the component woody species of Buloke Woodlands. • Published accounts of the regeneration requirements of the component species of Buloke Woodlands.
2.3	Determine salinity tolerances of all major perennial species of Buloke Woodland **Responsibility: OEH, DENR, DSE**	• Published accounts of the salinity tolerances of the major perennial/woody species of Buloke Woodlands. • Adjusted priorities for salinity works (e.g. increased efforts in areas affecting high priority Buloke Woodlands stands, or reduced efforts where these would have negligible impact on priority Buloke Woodlands stands).
Specific Objective 3: Ensure that all stands and their habitat are protected and managed appropriately		
3.1	Include in secure reserves (i.e. with conservation management as a principal objective) notable occurrences, including Frances Cemetery (SA), Rupanyup-South and Corack East (Victoria), Lake Urana Rd and Yarrein Ck (NSW) **Responsibility: DENR, DSE, OEH**	• All named stands included in a suitable reserve or land management priorities changed to reflect the importance of the Buloke Woodlands stands. May include purchase of adjoining or nearby land to enable more conservation-oriented management of the existing Buloke Woodlands stands.
3.2	Incorporate conservation management into management of strategic roadsides, especially Dimboola-Minyip Rd, Moama-Deniliquin Rd, Natimuk-Frances Rd and Nhill-Glenlee Rd	• Inclusion of Buloke Woodlands on roadsides in nominated conservation-oriented reserves. • Those responsible for roads maintenance trained

	Responsibility: DSE, OEH	and committed to appropriate management. • Signage erected indicating roadsides now managed for conservation objectives.
3.3	Achieve conservation management of significant stands on private land **Responsibility: TfN, DENR, DSE, OEH, CMAs, LG**	• Coverage of all significant stands by conservation covenants. • Implementation of a scheme (or schemes) encouraging conservation management on private lands, including rate and land tax reduction. • Continuing implementation of existing Conservation Assistance Schemes for private land holders and implementation of such programs where not currently in place.
3.4	Purchase of significant stands for inclusion within the reserves system **Responsibility: DENR, DSE, OEH, DENR**	• Land purchase and gazettal
Specific Objective 4: Manage threats to stands		
4.1	Greatly reduce browsing impact from goats in Murray-Sunset National Park. Monitor outcome **Responsibility: PV, OEH**	• Reduction of goat damage from browse, particularly around Pink Lakes and Rocket Lake. • Reduction in presence of goats as determined by faecal counts (or other survey techniques).
4.2	Greatly reduce grazing impacts from rabbits in large parks (Albacutya, Hattah-Kulkyne, Murray-Sunset, Wyperfeld) in Victoria and at Lake Urana Rd & Yarrein Creek in NSW. Monitor outcome. **Responsibility: PV, OEH**	• Replacement of introduced annual spp in the field layer with perennial tussock native grasses and the native annuals typical of Buloke Woodlands. • Successful regeneration of associated woody species, notably *Hakea* spp, shrubby chenopods.
4.3	In-plant appropriate woody species into Buloke Woodland (Sands) in Albacutya, Hattah-Kulkyne, Murray-Sunset and Wyperfeld Parks, and in Buloke woodland remnants elsewhere in the bioregions, including along significant roadsides where appropriate. **Responsibility: PV**	• Re-incorporation of woody species typical of Buloke Woodlands into remnant stands. • Second generation regeneration of woody species in Buloke Woodland. • Consistent presence of woodland-dependent fauna (e.g. White-browed Treecreeper), as determined by survey.
4.4	As far as possible, restore flows along the Wimmera River to maximize the potential for floodwaters to flood the terminal lakes after exceptional sustained rainfall. Restore significant environmental flows to the Wimmera River, downstream of Lake Albacutya. **Responsibility: Wimmera CMA, DSE**	• Flooding extending to Wirrengren Plain.
4.5	Manage populations of kangaroos to levels below which they will not significantly adversely affect regeneration of and in Buloke Woodlands. **Responsibility: PV, OEH**	• Kangaroo population management strategies developed and implemented. • Successful regeneration of woody species within Buloke Woodlands.
4.6	Establish buffers of dense, locally-indigenous shrubs around all small reserves, to reduce aeolian soil and fertilizer drift. **Responsibility: OEH, DENR, PV**	• Marginal buffers established (where appropriate) within reserves or on adjoining private land (where it is not possible to establish such buffers without further disturbing Buloke Woodlands stands) where such buffers can be established on disturbed land that is not within Buloke Woodlands.
4.7	Develop and implement management plans for all reserves containing Buloke Woodland **Responsibility: OEH, DENR, DSE, PV**	• Management Plans published for all reserves containing Buloke Woodland and their effectiveness monitored regularly.
4.8	Implement effective weed control of weed species which are likely to change the ecological function of Buloke Woodlands. **Responsibility: OEH, DENR, DSE, PV**	• Lists of potential major impact weeds eliminated from Buloke Woodlands stands or reserves. • Increased regeneration of native woody species when compared with untreated stands and reserves.
4.9	Reintroduce keystone species to Buloke Woodlands	• Lists of species successfully re-established (as

	stands which now lack these species. **Responsibility: OEH, DENR, DSE, PV, TfN, CMAs (various)**	defined by 2nd generation regeneration) within Buloke Woodlands stands.
4.10	Long-term monitoring sites and projects established in a variety of Buloke Woodlands sites, in all three states, in a variety of initial condition states and in a variety of land status categories. **Responsibility: OEH, DENR, DSE, PV, CMAs (various)**	• Mapped monitoring sites established. • First monitoring event completed. • Database and data curation/responsibility established and accepted.
Specific Objective 5: Promote regeneration and rehabilitate degraded stands		
5.1	Describe the species composition (including proportions) of the various regional variants of Buloke Woodlands **Responsibility: DSE, OEH**	• Publication of a guide outlining the species composition and idealized structure of the various regional variants of Buloke Woodland.
5.2	Establish regeneration approaches for rehabilitation of Buloke Woodlands on both public and private land, including options for direct seeding and mechanism for successful in-planting **Responsibility: GA (principally Vic, also NSW)**	• Established strategies/projects investigating rehabilitation approaches in Buloke Woodland. • Publication of guidelines for rehabilitation of degraded Buloke Woodlands.
5.3	Develop, implement and monitor rehabilitation plans for Buloke Woodlands in groups c and d (above) **Responsibility: CMAs, OEH, DENR, DSE**	• Successful regeneration of Buloke Woodland on roadsides and in disturbed public land. • Re-routing of new utilities and services (e.g. gravel pits, telephone lines, power lines) around stands of Buloke Woodland on roadsides/unreserved public land.
Specific Objective 6: Build community support for conservation		
6.1	Identify opportunities for community involvement in the conservation of Buloke Woodlands. **Responsibility: DSE, DENR, OEH, CMAs**	• Community/Landcare groups actively involved in Buloke woodland conservation.
6.2	Identify and advertise opportunities for private land covenanting to preserve stands of Buloke Woodlands on private land **Responsibility: TfN, CMAs (various)**	• Increased area of private land covered by conservation-oriented covenants within the 2 bioregions

Abbreviations: CMA – Catchment Management Authority; OEH – Office of Environment and Heritage (NSW); DENR – Department of Environment and Natural Resources (SA); DSE – Department of Sustainability and Environment (Vic); GA – Greening Australia; PV – Parks Victoria; LG – Local Government; RBG – Royal Botanic Gardens, Sydney; TfN – Trust for Nature; CMA – Catchment Management Authority

Estimated Cost of Recovery Program

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Totals	**$675,000**	**$1,175,000**	**$930,000**	**$650,000**	**$345,000**	**$3,775,000**

(see Appendix 5 for more detail)

Role and Interests of Indigenous People

Indigenous communities on whose traditional lands the Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregion community occurs have been advised, through the relevant regional Indigenous facilitator, of the preparation of this Recovery Plan and will be invited to provide comments and be involved in the implementation of the plan.

Management Practices

The strategy for recovery of Buloke Woodlands is habitat conservation, restoration, reconnection and management based on an understanding of the ecological and biological requirements of Buloke Woodlands

of the Riverina and Murray-Darling Depression Community. The emphasis is on using knowledge to better implement *in situ* management techniques that protect populations and promote regeneration and recruitment. To achieve this, recovery actions are primarily structured to (i) acquire baseline data, (ii) assess habitat condition including ecological and biological function, (iii) protect stands to maintain or improve species composition and structure of the community and (iv) to engage the community in recovery actions. On-ground site management will aim to mitigate threatening processes and thereby insure against extinction or further degradation. Major threats requiring management include changed local environmental conditions (notably changed nearby flooding regimes and aeolian deposition of soils and fertilizers), grazing by pest animals, intentional clearing, competition from pest plants and inappropriate fire regimes. A range of strategies will be necessary to alleviate these threats including weed control, fire management, fencing and control of pest animals.

Broad scale protection measures applicable to all populations include legal protection of sites, habitat retention and liaison with land managers including private landholders. In addition, searches of known and potential habitat should continue to better define the distributions, quality and size of remnant stands. The Recovery Plan advocates strategies to fill some of the major gaps in our current knowledge. These include an understanding of the mechanisms underlying recruitment and regeneration. Successful *in situ* management will be founded on understanding the relationships between the component species of Buloke Woodlands, the associated fauna, and their responses to environmental stresses. These are all directly linked to environmental function and are thus vital to recovery. Monitored management actions ('Adaptive Environmental Management') is the best approach to both implement urgent recovery actions and ensure that future management is based on real-time outcomes and efficiently targeted.

In addition to the above, *ex situ* conservation measures may be feasible and worthwhile. Such activities include seed storage and plant cultivation. Cultivating *ex situ* populations will also aim to increase the amount of seed available for reintroduction to sites. Translocation of cultivated plants could be considered as there is a high chance of success and secure site(s) exist. *Ex situ* conservation measures cannot be budgeted at this stage, as their priority is dependent on completion of some of the activities recommended for this Recovery Plan, specifically items 2.1, 5.1, 5.2 and 5.3. Implementation of items 4.3, 4.6 and 4.9 can be seen as 'dry runs' for a subsequently-developed restoration program involving volunteer and private input. Community participation in many of these recovery actions will be sought, particularly in regard to recovery team membership and implementation of on-ground works.

Affected Interests

Buloke Woodlands lie within the jurisdictions of DIPNR and OEH (NSW), DENR (SA), Department of Sustainability and Environment (Victoria) and Parks Victoria. Buloke Woodlands are also found in areas administered by the local government areas of Berrigan, Carrathool, Conargo, Deniliquin, Griffith, Hay, Jerilderie, Leeton, Murray, Murrumbidgee, Wakool and Windooran (New South Wales); Lucindale, Naracoorte and Tatiara District (South Australia); Benalla, Buloke, Campaspe, Gannawarra, Greater Bendigo, Greater Shepparton, Hindmarsh, Horsham, Loddon, Mildura, Moira, Northern Grampians, Swan Hill, West Wimmera, and Yarriambiack in Victoria.

Catchment Management Areas which include Buloke Woodlands include Lachlan, Lower Murray, Murray and Murrumbidgee (New South Wales) and Goulburn-Broken, Mallee, North Central, North East and Wimmera (Victoria).

All these local governments have been contacted and their input sought and welcomed. Some private landholders and a number of landholder organizations and other interested parties have been contacted and their input sought (and freely provided – notably in a small number of open group meetings early in formulation of this recovery plan). Some private landholders have been contacted where management actions are proposed. Other private landholders and interested parties will be contacted upon implementation of this plan.

Biodiversity Benefits

Implementation of the Recovery Plan provides for a number of potential biodiversity benefits for many other regionally and nationally threatened species also occurring in Buloke Woodlands (see Appendices 2 and 3).

Social and Economic Impacts

The implementation of this Recovery Plan is unlikely to cause significant adverse social and economic impacts, with one exception.

Complete restoration of Wimmera River flows, such that the system again flooded occasionally (roughly every 20 years) through to Wirrengren Plain, would mean a major diversion of water resources, a large proportion of which is currently committed to agricultural and domestic uses. The biological imperatives and directions are presented in this Recovery Plan. Whether such a significant redirection of priorities can be implemented depends on many other (social and other) inputs than the solely biological. In the likelihood that flows and water use in the Wimmera River system are not redirected to achieve system-wide floods, it will be incumbent on the relevant land management agencies to reorder their land and habitat restoration priorities, including those deriving from this plan, to reflect these 'new realities'. The lack of system-wide floods means that it will not be possible to restore Buloke Woodlands in all their former occurrences. In this scenario, either a highly managed novel vegetation community on former Buloke Woodlands will be fostered or a novel natural vegetation community which reflects the new ecological constraints will develop. Either way, it must be accepted that fully functioning Buloke Woodlands cannot be restored and the community is now extinct, in these locations.

Otherwise, important populations on public land are usually in land management units for which conservation is a major objective. Important remnants on private land can be maintained with minimal adverse impact on those private landholders (and such remnants have usually persisted to date because of conservative management by those landholders).

Acknowledgments

The authors would like to acknowledge the valuable contributions made by the following people to this Recovery Plan: Geoffrey Allen, James Fitzsimons, Rolf Weber, Justine Wait and Matt White (Department of Sustainability and Environment Vic); Gary Aitken and Dean Robertson (Wimmera Catchment Management Authority); John Brickhill, Matt Cameron and Colin Killick (Office of Environment and Heritage NSW); Dave Barber, Bob Denholm, Keith Emery and Tim Hudspith (Department of Primary Industries NSW); John Benson, Gary Chappel and Barbara Wiecek (Royal Botanic Gardens Sydney); Noel Heyward (Mallee Catchment Management Authority); Martine Maron (University of Southern Queensland); Fiona Murdoch (University of Ballarat); Kathryn Williams (University of Melbourne); Ian Sluiter (Ogyris Pty Ltd); Rick Webster (Ecosurveys Pty Ltd); Bryan Haywood and Randall Johnson (Department of Environment and Natural Resources SA); Nick Myer, Ross Peacock, Sofie Powery and Deanne Stevens (Department of Lands NSW); Suzanne Johnstone, Rebecca Heard, Alex Sislov and Lance Williams (Department of Primary Industries Vic); Phil Murdoch (Parks Victoria); Sandra Keane (Department of Water, Land and Biodiversity Conservation SA); Mani Burghout (Department of the Environment, Water, Heritage and the Arts, Canberra); Nico Marcar (CSIRO) and many scientists, landowners and naturalists including Daryl Barber, Wendy Beumer, N. & K. Boschen, Barry Clugston, Fabian Douglas, Vanessa Drendel, Ann Dunstan, David Falla, Kerry Gilkes, Ron Hawkins, Shane Lavell, Lisa Macaulay, Neil Marriott, John Petering, Jim Sleep, Lindsay Smith, Huon Stephens, Rick Talbot, Fay White and Mollie Whitehorn.

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Appendix 1. Methodology Used for Analyses

The report of Sluiter *et al.* (1997) that forms the basis of the original nomination of Buloke Woodlands for listing under the EPBC Act is itself based on a comprehensive analysis of floristic data, most of which were extracted from the DSE Flora Information System. Since that work, further data have been added to this database and floristic data have become available from both South Australia (Department of Environment and Natural Resources) and New South Wales (Centre for Natural Resources, Department of Infrastructure, Planning and Natural Resources), enabling extension of floristic analyses to these States.

Furthermore, the (former and current) extent of Buloke Woodlands in south-western New South Wales is uncertain, owing to references that have confused Buloke Woodland with other, non-eucalypt semi-arid woodlands, and also due to extensive woodland degradation. Although a detailed reanalysis was beyond the scope of this Recovery Plan, a limited reanalysis was indicated, to overcome the Victorian bias of the initial work by Sluiter *et al*. (1997) and to more accurately determine the extent of Buloke Woodland in southern and south-western New South Wales.

Methods All quadrats from the South Australian and Victorian floristic datasets were selected for the analyses. In New South Wales, there is no statewide database of floristic quadrats, but floristic data from the Hay and Deniliquin regions were incorporated into the overall analysis. As these four datasets are maintained independently, nomenclature had to be standardized (e.g. the species known as *Billardiera sericophora* in South Australia is not recognized in Victoria, where all specimens are referred to *Billardiera cymosa*). There were 226 such discrepancies between the Victorian and the South Australian datasets alone. In addition, the scheme used to indicate the degree of presence of each taxon in the quadrat records varied amongst the four databases. Cover abundance values were therefore standardized (see Table 5 and below). A comprehensive data analysis would have required further data curation. Quadrats were not filtered according to season of survey nor to size.

The species on which the first cut of the data was based were:

- *Allocasuarina luehmannii* (Buloke) - a common (co)dominant in Buloke Woodlands
- *Callitris gracilis* (Slender Pine) - a common codominant
- *Callitris glaucophylla* (White Pine or Murray Pine) - a common associate of Buloke Woodlands
- *Eucalyptus largiflorens* (Black Box) - a frequent dominant from adjoining communities
- *Eucalyptus leucoxylon* subsp. *pruinosa* (Yellow Gum, Blue Gum) - a common codominant
- *Eucalyptus microcarpa* (Grey Box) - a common codominant

All quadrats containing one or more of these species were included in the initial analyses. As the data were not sifted for season of survey, herbaceous (often annual) species which may also be useful indicators of Buloke Woodland (e.g. *Hyalosperma semisterile* or *Triptilodiscus pygmaeus*) were not used for selecting quadrats which may contain Buloke Woodland.

Data were entered into PC-ORD version 4 and Cluster Analysis (based on Group Averaging) was used to partition the quadrats into similar groups. A Sorenson (Bray-Curtis) distance measure was used to calculate the dissimilarity matrix from which the values were compared stepwise. Linkage was by Group Averaging. As with Sluiter *et al.* (1997), the results for presence/absence data and utilizing the cover/abundance data were very similar.

The following discussion refers to variation within Buloke Woodland. It does not refer to vegetation communities outside Buloke Woodland.

Sands vs. Loams - When only 5 groups from the cluster analysis are recognized, three groups are non-Buloke Woodland. The remaining two groups illustrate the greatest discontinuity within Buloke Woodland, between Buloke Woodlands of the loamy plains and Buloke Woodlands of riparian or lacustrine loamy sands in the Mallee. The first type, Buloke Woodland (*Loams)*, occurs in a more or less continuous band from the South Australian occurrences near Bordertown, through the Victorian Wimmera and Northern Plains, to the southern Riverina in New South Wales. In Victoria, this type is restricted to south of Lake Albacutya. Buloke Woodlands (*Loams*) occur on heavy loams or clay loams that are frequently waterlogged in winter and not closely associated with rivers or streams. Buloke Woodland (*Loams*) includes Groups 8, 10 and 12 of Sluiter *et al.* (1997). The second type of Buloke Woodland (*Sands*) is largely inland of the first type of Buloke Woodland and principally Victorian, tho' with a minor extension into far south-western New South Wales, Benson (2008) and north of Lake Hindmarsh (it is reasonable to expect there to have been former occurrences scattered in the Murray Mallee in South Australia). This second type occurs adjacent to

freshwater river systems (such as the Wimmera and Murray Rivers) or in association with boinkas (groundwater discharge sites), such as Pink Lakes, the Raak and Rocket Lake. Buloke Woodland (*Sands*) includes all or part of Groups 1, 2, 3, 4 and 7 of Sluiter *et al*. (1977).

NSW Occurrences - The current and former occurrences of Buloke Woodland in New South Wales are problematic. All cluster analyses demonstrated that nearly all of the quadrats from the NSW Riverina are not Buloke Woodland. Very few sites in New South Wales were classified with Buloke Woodlands, even when clustering was curtailed at as few as five groups. Nevertheless, there are some occurrences of Buloke Woodland in New South Wales, as outlined by Benson *pers. comm.* These are mostly south of Deniliquin, between the Edwards and the Murray Rivers and east thereof, usually within 80-100 km of the Murray River, in the zone mapped as 'Grey Box'. A small number of sites has been identified farther west and inland, adjacent to the riverine vegetation fringing the Murray River.

Analysis by Sluiter et al *(1997)* - The clustering generally supported the earlier analyses by Sluiter *et al*.(1997) (see Table 6). Clustering could be curtailed such that most of their groups were recognized.

Data Curation - Considerable time must be spent in data curation before a comprehensive regional floristic analysis of Buloke Woodland is possible. When clustering was curtailed at as few as nine groups, dataset-based vegetation units were detected (i.e. one of the groups detected in the nine comprized all the South Australian data; Victorian data from near the South Australian border did not cluster with these South Australian quadrats). Additional floristic data are required to accommodate seasonal differences in Buloke Woodland.

Table 5 Importance (Cover-abundance) conversions for discordant state-based data sets

Victoria	South Australia	New South Wales				Adjusted Score
		Hay		Deniliquin		
		Cover Score	Abundance Score	% Cover	Abundance Score	
+	N,T	1	1,2	0 -1% 2-5%	1-2 1-2	1
1		1 2	3,4 1,2,3,4	0-1% 2-5%	3-6 3-6	2
2	1 –2	3	1 - 4	6-10% 11-20%	1-6 1-6	3
3	3	4	1 - 4	21-30% 31-40% 41-50%	1-6 1-6 1-6	4
4	4	5	1 - 4	51-60 61-70	1-6 1-6	5
5	5	6	1 - 4	>=71%	1-6	6

Cover Abundance Values

Victoria

+	cover <5%, few individuals
1	cover <5%, any no. of individuals
2	cover<5% many individuals or 5-20%, any no. individuals
3	cover 20-50%, any no. of individuals
4	cover 50-75%, any no. of individuals
5	cover 75 - 100%, any no. of individuals

South Australia

N	not many, 1-10 individuals
T	sparsely or very sparsely present (<5% cover)
1	plentiful but small cover (<5%)
2	any number of individuals (5-25%)
3	any number of individuals (25-50%)
4	any number of individuals (50-75%)
5	covering more than 75% of area

New South Wales: Hay Surveys

	% Cover	Abundance Score
1	0-1%	1 one/few
2	2-10%	2 uncommon
3	11-20%	3 common
4	21-40%	4 very abundant
5	41-70%	
6	>70%	

New South Wales: Deniliquin Surveys

% Cover	Abundance Score
0-1%	1 one individual/shoot
2-5%	2 2-10 individuals/shoots
6-10%	3 11-25 individuals/shoot
11-20%	4 26-100 individuals/shoot
21-30%	5 101 -1000 individuals/shoot
31-40%	6 >1000 individuals/shoot

41-50%, 51-60%, 61-70%, 71-80%, >81%

All (species) records with an adjusted cover-abundance value of 1 or 2 were excluded from each quadrat before analysis. Quadrats containing less than 5 species were eliminated from the analysis *a priori*. If the number of species for quadrat exclusion had been set any higher, then most of the NSW data would have been excluded. Species which occurred in less than two quadrats in the total data set were also excluded. The data were not otherwise filtered nor standardized.

Table 6 The Buloke communities described by Sluiter *et al*:-

Group	Name	Notes	Common species	Distribution
1	Semi-arid herbaceous Pine-Buloke woodland	*Listed under the Victorian FFG Act.* *Nomination No 433 (Scientific Advisory Committee 1997c)*	*Allocasuarina luehmannii, Callitris gracilis, Crassula sieberiana, Crassula colorata, Brachyscome lineariloba, Calandrinia eremaea, Daucus glochidiatus*	On dune systems. Mainly in the northwest Victorian Mallee in the Mallee Parks.
2	Semi-arid shrubby Pine-Buloke woodland	*Listed under the Victorian FFG Act* *Nomination No 430 (Scientific Advisory Committee 1997a)*	*Allocasuarina luehmannii, Callitris gracilis, Enchylaena tomentosa, Sclerolaena diacantha, Calandrinia eremaea, Brachyscome lineariloba, Calotis hispidula*	On sandy loams. Mainly in the northwest Victorian Mallee in Parks and Reserves.
3	Semi-arid grassy Pine-Buloke woodland		*Callitris gracilis, Allocasuarina luehmannii, Danthonia caespitosa, Einadia nutans, Austrostipa elegantissima, Wahlenbergia luteola, Pittosporum angustifolium, Austrostipa eremophila*	Widespread on loams. In reserves, roadsides and private land.
8	Semi-arid Northwest Plains Buloke grassy woodland	*Listed under the Victorian FFG Act* *Nomination No 431 (Scientific Advisory Committee 1997b)*	*Allocasuarina luehmannii, Eucalyptus largiflorens, Eucalyptus leucoxylon, Sida corrugata, Oxalis perennans, Einadia nutans, Austrodanthonia setacea.*	Wimmera and Northern Plains. In reserves, roadsides and private land
9	Buloke grassy woodland		*Allocasuarina luehmannii, Callitris gracilis, Sida corrugata, Vittadinia gracilis, Convolvulus remotus , Austrostipa blackii*	Mainly on the northern plains of Victoria on roadsides
10	Grey Box – Buloke grassy woodland	*Listed under the Victorian FFG Act* Overlaps with EPBC listed Grey Box grassy woodland *Nomination No 434 (Scientific Advisory Committee 1997d)*	*Allocasuarina luehmannii, Eucalyptus macrocarpa, Austrodanthonia setacea, Maireana enchylaenoides, Chloris truncata, Elymus scabra, Rumex brownii.*	Mainly on the Northern and Wimmera Plains on reserves, roadsides and private land.

Appendix 2. Rare or Threatened Vascular Plants of Buloke Woodland

Scientific Name	Common Name	Presence*	EPBC status[1]	NSW status[2]	SA Status[3]	Vic Status[4]
Acacia enterocarpa	Jumping-jack Wattle	Peripheral	EN		EN	L, EN
Acacia glandulicarpa	Hairy-pod Wattle	Peripheral	VU		EN	L, VU
Acacia rupicola	Rock Wattle	Peripheral				RA
Acacia trineura	Three-nerve Wattle	Peripheral			EN	
Acacia victoriae	Bramble Wattle	Peripheral				RA
Acacia X *grayana*	Wimmera Wattle	Peripheral				RA
Allocasuarina luehmannii (Casuarina luehmannii)	Buloke	Principal				L
Amyema linophyllum subsp. *orientale*	Buloke Mistletoe	Principal				VU
Austrodanthonia monticola (Rytidosperma monticola)	Small-flower Wallaby Grass	Important				RA
Austrostipa exilis	Heath Spear-grass	Peripheral				RA
Austrostipa gibbosa	Spurred Spear-grass	Important			RA	
Austrostipa puberula	Fine-hairy Spear-grass	Important			RA	RA
Brachyscome chrysoglossa	Yellow-tongue Daisy	Important				L, VU
Caladenia lowanensis	Wimmera Spider-orchid	Principal	EN			L, EN
Caladenia stricta	Rigid-combed Spider-orchid	Important				L, VU
Caladenia tensa	Rigid Spider-orchid	Important	EN			VU
Caladenia xanthochila	Yellow-lip Spider-orchid	Important	EN			L, EN
Callitriche cyclocarpa	Western Water-starwort	Important	VU	VU		L
Choretrum spicatum	Spiked Sour-bush	Peripheral				PA
Comesperma polygaloides	Small Milkwort	Important				L, VU
Cymbonotus lawsonianus	Bear's-ear	Important				RA
Daviesia pectinata	Thorny Bitter-pea	Peripheral			RA	RA
Eremophila gibbifolia	Coccid Emu-bush	Peripheral				RA
Eryngium paludosum	Long Eryngium	Important				VU
Eryngium rostratum/ovinum	Blue Devil	Important			VU	
Eucalyptus silvestris	Woodland Box	Peripheral				VU
Glycine canescens	Silky Glycine	Peripheral				L, EN
Glycine latrobeana	Clover Glycine	Important	VU		VU	L, VU
Goodenia heteromera	Spreading Goodenia	Important			RA	
Hakea tephrosperma	Hooked Needlewood	Principal			RA	
Juncus radula	Hoary Rush	Important			VU	
Lachnagrostis adamsonii	Adamson's Blown-grass		EN			L, VU
Lepidium monoplocoides	Winged Pepper-cress	Important	EN		EN	L, EN
Lepidium pseudopapillosum	Erect Pepper-cress	Principal	VU	VU	VU	L, VU
Maireana cheelii	Chariot Wheels	Peripheral	VU			VU
Maireana excavata	Bottle Fissure-plant	Principal			VU	
Maireana rohrlachii	Rohrlach's Bluebush	Principal			RA	

Microtis orbicularis	Swamp Onion-orchid	Peripheral			RA	
Minuria cunninghamii	Bush Minuria	Peripheral				RA
Minuria integerrima	Smooth Minuria	Peripheral				RA
Pimelea spinescens subsp. *pubiflora*	Spiny Rice-flower	Principal	X			L, EN
Pimelea spinescens subsp.. *spinescens*	Spiny Rice-flower	Peripheral				L
Pomaderris paniculosa subsp. *paniculosa*	Inland Pomaderris	Peripheral	CR			VU
Prasophyllum sp. aff. *occidentale* A[10]	Western Leek Orchid	Principal				L, EN
Ptilotus erubescens	Hairy-tails	Principal			RA	L
Ptilotus exaltatus var. *semilanatus*	Lamb's Tails	Principal			EN	
Rhyncharrhena linearis	Purple Pentatrope	Important				VU
Sclerolaena napiformis	Turnip Bassia	Important	EN			L, EN
Senecio platylepis	Toothed Groundsel	Important				RA
Sida fibulifera	Pin Sida	Important				VU
Sporobolus caroli	Yakka Grass	Peripheral				RA
Swainsona behriana	Southern Swainson-pea	Peripheral				RA
Swainsona murrayana	Murray Swainson-pea	Important	VU		VU	L, EN
Swainsona procumbens	Broughton Pea	Principal			VU	
Swainsona swainsonioides	Downy Swainson-pea	Important				L, EN
Templetonia stenophylla	Leafy Templetonia	Principal			VU	
Thelymitra epipactoides	Metallic Sun-orchid	Peripheral	EN			L. EN
Vittadinia blackii	Western New Holland Daisy	Peripheral				VU
Vittadinia condyloides	Club-hair New Holland Daisy	Important				L, RA
Vittadinia cuneata var. *hirsuta*	Fuzzy New Holland Daisy	Peripheral				RA
Vittadinia megacephala	Giant New Holland Daisy	Important				VU
Vittadinia pterochaeta	Winged New Holland Daisy	Principal				VU

1 - Listed under the *Environment Protection and Biodiversity Conservation Act 1999*

2 - Listed under Schedules 1, 2 and 3 of the *Threatened Species Conservation Act 1995*

3 - Listed under Schedules 7, 8 and 9 of the *National Park and Wildlife Act 1972*

4 - Listed under the Victorian Advisory Lists and/or under Schedule 2 of the *Flora and Fauna Guarantee Act 1988*

*Presence: Principal – ecological range is predominantly within Buloke Woodlands; Important – occurrence in Buloke Woodlands represents a major part of its ecological range, but it also occurs in other communities; Peripheral – occurrence in Buloke Woodlands is peripheral to its principal ecological range elsewhere

EX=Extinct; CR=Critically Endangered, EN=Endangered; VU=Vulnerable; RA=Rare; L=Listed under the Victorian Flora and Fauna Guarantee

[10] Prasophyllum occidentale *sensu* Backhouse G., Jeanes J. (1995) 'The Orchids of Victoria.' (Miegunyah Press: Carlton, Victoria)

Appendix 3. Rare or Threatened Vertebrate Fauna (& some invertebrates) of Buloke Woodland

Scientific Name	Common Name	Presence*	EPBC status[1]	NSW status[2]	SA Status[3]	Vic Status[4]
Bettongia penicillata	Woylie	Important	EN	EX	EX	L
Burhinus grallarius	Bush Stone-curlew	Important		EN	VU	L
Calyptorhynchus banksii graptogyne	Red-tailed Black Cockatoo	Important	EN		EN	L
Climacteris affinis	White-browed Treecreeper	Principal		EN^	RA	L
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern subspecies)	Important		VU		
Delma impar	Striped Legless Lizard	Peripheral				L
Delma inornata	Olive Legless-lizard	Peripheral		RA		
Macropus rufogriseus rufogriseus	Red-necked Wallaby	Peripheral			RA	
Melanodryas cucullata	Hooded Robin	Principal		VU		
Melithreptus gularsi	Black-chinned Honeyeater	Important			RA	
Onychogalea fraenata	Bridled Nailtail Wallaby	Important	EN	EX	EX	L
Phascogale calura	Wambenger	Principal?	EN	EX	EX	L
Paralucia pyrodiscus lucida	Eltham Copper Butterfly	Peripheral				L
Stagonopleura guttata	Diamond Firetail	Important			VU	L
Synemon plana	Golden Sun Moth	Peripheral				L

1 - Listed under the *Environment Protection and Biodiversity Conservation Act 1999*

2 - Listed under Schedules 1, 2 and 3 of the *Threatened Species Conservation Act 1995*

3 - Listed under Schedules 7, 8 and 9 of the *National Park and Wildlife Act 1972*

4 - Listed under Schedule 2 of the *Flora and Fauna Guarantee Act 1988*

*Presence: Principal – ecological range is predominantly within Buloke Woodlands; Important – occurrence in Buloke Woodlands represents a major part of its ecological range, but it also occurs in other communities; Peripheral – occurrence in Buloke Woodlands is peripheral to its principal ecological range elsewhere

EX=Extinct; EN=Endangered; VU=Vulnerable; RA=Rare

^ Carrathoo population

Amongst the species listed above are three that are now extinct in Buloke Woodlands, i.e. *Bettongia penicillata*, *Onychogalea fraenata* and *Phascogale calura.* Other mammals that probably formerly occurred in Buloke Woodlands but are now extinct there include *Macrotis lagotis*, *Myrmecobius fasciatus* and others for which the data are less reliable (e.g. at least one species of *Dasyurus* almost certainly occurred in Buloke Woodlands, either *Dasyurus geoffroii*, *Dasyurus viverrinus*, or both). Whilst these species no longer occur in Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions, the woodlands provide habitat for potential reintroductions.

Appendix 4. Scientific Names of all Species in the Recovery Plan

Scientific Name	Author Citation	Common Name
Acacia enterocarpa	R.V. Sm.	Jumping-jack Wattle
Acacia glandulicarpa	Reader	Hairy-pod Wattle
Acacia ligulata	A. Cunn. ex Benth.	Small Cooba
Acacia melvillei	Pedley	Yarran
Acacia trineura	F. Muell.	Three-nerve Wattle
Alectryon oleifolius	(Desf.) S.T. Reynolds	Rosewood, Cattle Bush, Cabbage Bush
Allocasuarina luehmannii	(R.T. Baker) L.A.S. Johnson	Buloke, Bull-oak, She-oak, Sheoke, Oak
Amyema linophyllum orientale	Barlow	Buloke Mistletoe, Bull-oak Mistletoe
Austrostipa exilis	(Vickery) S.W.L. Jacobs & J. Everett	Heath Spear-grass
Austrostipa gibbosa	(Vickery) S.W.L. Jacobs & J. Everett	Spurred Spear-grass
Austrostipa puberula	(Steud.) S.W.L. Jacobs & J. Everett	Fine-hairy Spear-grass
Bettongia penicillata	Gray	Woylie, Brush-tailed Bettong
Billardiera cymosa	F. Muell.	Apple-berry
Billardiera sericophora	F. Muell.	Apple-berry
Brachyscome chrysoglossa	F. Muell.	Yellow-tongue Daisy
Briza minor	L.	Small Quaking-grass, Silvery Grass, Shivery Grass
Bromus rubens	L.	Red Brome
Burhinus grallarius	(Latham)	Bush Stone-curlew
Caladenia lowanensis	G. W. Carr	Wimmera Spider-orchid
Caladenia stricta	(R. J. Bates) R. J. Bates	Rigid-combed Spider-orchid
Callistemon brachyandrus	Lindl.	Prickly Bottlebrush
Callitriche cyclocarpa	Hegelm.	Western Water-starwort
Callitris glaucophylla	Joy Thomps. & L.A.S. Johnson	White Pine, White-cypress-pine, Murray Pine, Native Pine
Callitris gracilis	R. Baker	Slender Pine, Slender Cypress-pine, Murray Pine
Calotis erinacea	Steetz in Lehm.	Tangled Burr-daisy
Calyptorhynchus banksii graptogyne	(Latham)	Red-tailed Black Cockatoo
Casuarina cristata	Miq.	Belah, Belar, Black Oak, Oak
Casuarina luehmannii	R. T. Baker	Buloke, Bull-oak, She-oak, Sheoke, Oak
Casuarina pauper	F. Muell. ex L.A.S. Johnson	Belah, Belar, Black Oak, Oak
Climacteris affinis	Blyth	White-browed Treecreeper
Climacteris picumnus victoriae	Temminck	Brown Treecreeper
Comesperma polygaloides	F. Muell.	Small Milkwort
Crinum flaccidum	Herb.	Darling Lily, Murray Lily
Dasyurus geoffroii	Gould	Chuditch, Western Quoll, Western Native Cat
Dasyurus viverrinus	(Shaw)	Quoll, Eastern Quoll, Eastern Native Cat
Daviesia pectinata	Lindl. in T. Mitch.	Thorny Bitter-pea
Delma inornata		Olive Legless-lizard
Dianella longifolia var. *grandis*	R. J. F. Hend.	Pale Flax-lily, Glaucous Flax-lily
Ehrharta calycina	Sm.	Panic Veldt-grass
Eremophila longifolia	(R. Br.) F. Muell.	Berrigan, Emu-bush
Eryngium paludosum	(Moore & Betche) P.W. Michael	Long Eryngium
Eryngium rostratum	Cav.	Blue Devil
Eucalyptus camaldulensis.	DENRnh.	River Red Gum, Red Gum

Eucalyptus largiflorens	F. Muell.	Black Box, Flooded Box, Box
Eucalyptus leucoxylon	F. Muell.	White Ironbark, Yellow Gum, Blue Gum
Eucalyptus microcarpa	(Maiden) Maiden	Grey Box
Eutaxia microphylla	(R. Br.) C.H. Wright *sens. lat.*	Eutaxia
Glycine canescens	F. J. Herm.	Silky Glycine
Glycine latrobeana	(Meisn.) Benth.	Clover Glycine
Goodenia heteromera	F. Muell.	Spreading Goodenia
Hakea leucoptera	R. Br.	White Needlewood, Hakea, Needlewood
Hakea tephrosperma	R. Br.	Hooked Needlewood, Hakea, Needlewood
Hyalosperma semisterile	(F. Muell.) Paul G. Wilson	Orange Sunray
Isolepis marginata	(Thunb.) A. Dietr	Little Club-sedge
Juncus radula	Buchenau	Hoary Rush
Lepidium monoplocoides	F. Muell.	Winged Peppercress
Lepidium pseudopapillosum	Thell.	Erect Peppercress, Peppercress
Lycium ferocissimum	Miers.	African Boxthorn
Macropus rufogriseus	(Desmarest)	Red-necked Wallaby
Macrotis lagotis	(Reid)	Bilby
Maireana aphylla	R. Br. (Paul G. Wilson)	Leafless Bluebush
Maireana excavata	(J.M. Black) Paul G. Wilson	Bottle Bluebush, Bottle Fissure-plant
Maireana rohrlachii	(Paul G. Wilson) Paul G. Wilson	Rohrlach's Bluebush, Bluebush
Melaleuca lanceolata	Otto	Moonah, Moonbah, Black Tea-tree
Melanodryas cucullata	(Latham)	Hooded Robin
Melithreptus gularsi	(Gould)	Black-chinned Honeyeater
Microtis orbicularis	R.S. Rogers	Swamp Onion-orchid, Dark Mignonette-orchid
Myrmecobius fasciatus	Waterhouse	Numbat, Anteater
Olearia pimeleoides	(DC.) Benth.	Pimelea Daisy-bush
Onychogalea fraenata	(Gould)	Bridled Nailtail, Bridled Nailtail Wallaby
Pentaschistis airoides	(Nees) Stapf in Harvey & Sonder	False Hair-grass
Phascogale calura	Gould	Wambenger, Red-tailed Phascogale
Pimelea spinescens subsp. *pubiflora*	Rye	Spiny Rice-flower
Pimelea spinescens subsp. *spinescens*	Rye	Spiny Rice-flower
Pittosporum angustifolium	Lodd.	Weeping Pittosporum, Native Willow
Prasophyllum sp. aff. *occidentale* A		Buloke Leek Orchid
Ptilotus erubescens	Schltdl.	Hairy-tails
Ptilotus exaltatus var. *semilanatus*	(Lindl.) Maiden & Betche	Pink Mulla Mulla, Lambs' Tails
Rhyncharrhena linearis	(Decne.) K. L. Wilson	Purple Pentatrope
Sclerolaena napiformis	Paul G. Wilson	Turnip Bassia
Senecio platylepis	DC.	Toothed Groundsel
Stagonopleura guttata	(Shaw)	Diamond Firetail
Swainsona murrayana	Wawra	Murray Swainson-pea, Slender Darling-pea
Swainsona procumbens	(F. Muell.) F. Muell.	Broughton Pea
Swainsona swainsonioides	(Benth.) A.T. Lee ex J.M. Black	Downy Swainson-pea
Templetonia stenophylla	(F. Muell.) J.M. Black	Leafy Templetonia
Triptilodiscus pygmaeus	Turcz.	
Vittadinia condyloides	N.T. Burb.	Club-hair New Holland Daisy
Vittadinia megacephala	(F. Muell. ex Benth.) J.M. Black	Giant New Holland Daisy

Vittadinia pterochaeta	(F. Muell. ex Benth.) J.M. Black	Winged New Holland Daisy
Wahlenbergia gracilenta	Loth.	Annual Bluebell
Zygophyllum ammophilum	F. Muell.	Sand Twinleaf

APPENDIX 5. Priority, Feasibility and Estimated Costs of Recovery Actions

Action	*Description*	*Priority*	*Feasibility*	*Responsibility*	*Cost estimate ($)*					
					Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	**Distribution, condition**									
1.1	NSW locations & status	2	100%	OEH, SYD	$15,000	$30,000	$0	$0	$0	$45,000
1.2	Vic & eastern NSW locations	2	100%	DSE, OEH, SYD	$30,000	$35,000	$20,000	$0	$0	$90,000
1.3	Vic parks quality	1	100%	DSE, PV	$35,000	$50,000	$35,000	$0	$0	$120,000
1.4	Characterize components	1	75%	DSE, OEH, DENR	$0	$35,000	$35,000	$0	$0	$70,000
2	**Ecological understanding**									
2.1	Woody regeneration	2	80%	DSE, OEH, RBG, SYD	$0	$50,000	$40,000	$0	$0	$90,000
2.2	Salinity tolerances	3	75%	DSE, OEH, DENR	$0	$15,000	$20,000	$15,000	0	$50,000
3	**Stand protection**									
3.1	Reserve unprotected stands	2	100%	DENR, OEH, DSE	$30,000	$30,000	$30,000	$0	$0	$90,000
3.2	Roadside management	3	75%	OEH, DSE	$30,000	$40,000	$0	$0	$0	$70,000
3.3	Private land management	2	25%	TfN, DENR, DSE, OEH, CMAs, LG	$30,000	$120,000	$120,000	$160,000	$170,000	$600,000
3.4	Addition to reserve system	2	75%	DSE, DENR (SA)	$40,000	$80,000	$80,000	$120,000	$80,000	$400,000
4	**Manage threats**									
4.1	Goat reduction	2	75%	PV, OEH	$30,000	$30,000	$30,000	$30,000	$10,000	$130,000
4.2	Rabbit reduction	1	50%	PV, OEH	$80,000	$100,000	$100,000	$80,000	$50,000	$410,000
4.3	In-plant woody spp	3	50%	PV	$60,000	$60,000	$60,000	$30,000	$0	$210,000
4.4	Wimmera R flows - feasibility	1	10%	DSE, CMA	$20,000	$60,000	$0	$0	$0	$80,000
4.5	Kangaroo management	2	50%	PV, OEH	$50,000	$80,000	$50,000	$50,000	$30,000	$260,000
4.6	Buffers	3	50%	OEH, DENR, PV	$10,000	$20,000	$20,000	$20,000	$20,000	$90,000
4.7	Management plans	1	75%	OEH, DENR, DSE, PV	$30,000	$50,000	$50,000	$50,000	$50,000	$230,000
4.8	Weed control reserves	2	85%	OEH, DENR, DES, PV, CMAs	$50,000	$50,000	$50,000	$50,000	$50,000	$250,000
4.9	Reintroduce keystone spp	2	65%	OEH, DENR, PV, DSE	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000
4.10	Long-term Monitoring	1	100%	DES, OEH	$25,000	$25,000	$25,000	$25,000	$25,000	$125,000
5	**Rehabilitation**									
5.1	Spp composition of variants	1	100%	DSE, OEH	$40,000	$40,000	$0	$0	$0	$80,000
5.2	Regeneration techniques	2	75%	GA	$50,000	$80,000	$80,000	$50,000	$0	$260,000
5.3	Rehab plans	2	50%	CMAs, OEH , DSE	$20,000	$50,000	$50,000	$50,000	$30,000	$200,000
6	**Community support**									
6.1	Community involvement	2	100%	DSE, DENR, OEH	$20,000	$20,000	$20,000	$20,000	$20,000	$100,000
6.2	Covenants on private land	3	100%	TfN, DES, DENR, OEH	$15,000	$15,000	$15,000	$15,000	$15,000	$75,000
				Totals	**$720,000**	**$1,175,000**	**$940,000**	**$875,000**	**$560,000**	**$4,270,000**