The natural vegetation of the Balranald – Swan Hill area

J.A. Scott

Abstract

Scott, J.A. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1992. The natural vegetation of the Balranald – Swan Hill area. Cunninghamia *2(4): 597–652.* The present-day natural and semi-natural vegetation of the Balranald and the Swan Hill (New South Wales section) 1:250 000 map sheets (south from 34°00'S to the Murray River; 142°30'E to 144°00'E) in semi-arid south western New South Wales is described and mapped. The area is part of the South Western Plains and South Far Western Plains botanical subdivisions. Twenty vegetation communities are recognised including mallee, woodlands of Belah-Rosewood (*Casuarina pauper-Alectryon oleifolius* subsp. *canescens*) and *Callitris*, riverine forest and various chenopod shrublands. Vegetation has been mapped using a combination of aerial photographs, field survey and LANDSAT imagery. The vegetation patterns reflect landform (an east-west transition from the fluvial and lacustrine plains to the aeolian sand dunes) and soil types (heavy clays of the plain to calcareous sands). All vegetation shows disturbance (grazing, clearing and cropping, erosion and weeds). Most plant communities are poorly conserved, with less than half of the communities represented in the 3% of the mapped area currently reserved.

Introduction

Location

The mapped area (south from 34°00'S to the Murray River, 142°30' to 144°00'E) is located in the semi-arid zone of south-western New South Wales. It comprises the Balranald 1:250 000 map sheet (S1 54-12) and the New South Wales section of the Swan Hill 1:250 000 sheet (S1 54-16). This area adjoins the eastern edge of the Mildura sheet which was mapped as part of the Ana Branch - Mildura vegetation map (Fox 1991). This mapping is part of a major project of the Royal Botanic Gardens to map the vegetation of south-western New South Wales.

There are two main rivers in the area (Fig. 1). The Murray River flows from south-east to north-west, forming the southern boundary of New South Wales and of the mapped area. The Murrumbidgee River flows south-west joining the Murray approximately 35 km south-west of the town of Balranald. It also marks in part the boundary between the Central and Western Divisions of New South Wales. South-west of Balranald the division boundary leaves the river, passes through Kyalite, then down the Wakool River to its junction with the Murray River. The greater percentage of the mapped area falls within the Western Division under the tenure of the Western Lands leases.

The main towns are Balranald (population of 1 400) on the Murrumbidgee River and Euston (population of 400) on the Murray River. These towns are linked by the Sturt Highway which runs east-west from Wagga Wagga to South Australia. The main north-south road links Balranald to the Cobb Highway at Ivanhoe in the north. Swan

Hill is the largest centre in the area (population 9 500) located on the Victorian side of the Murray River. The area beyond these towns is sparsely settled. The map covers parts of four shires: Balranald, Wakool, the easternmost edge of Wentworth, and the westernmost edge of Hay. It covers sections of the botanical subdivisions of the South Far Western Plains and South Western Plains, the boundary between the two is through Balranald. The total area of the map sheet is approximately 17 000 km^2.

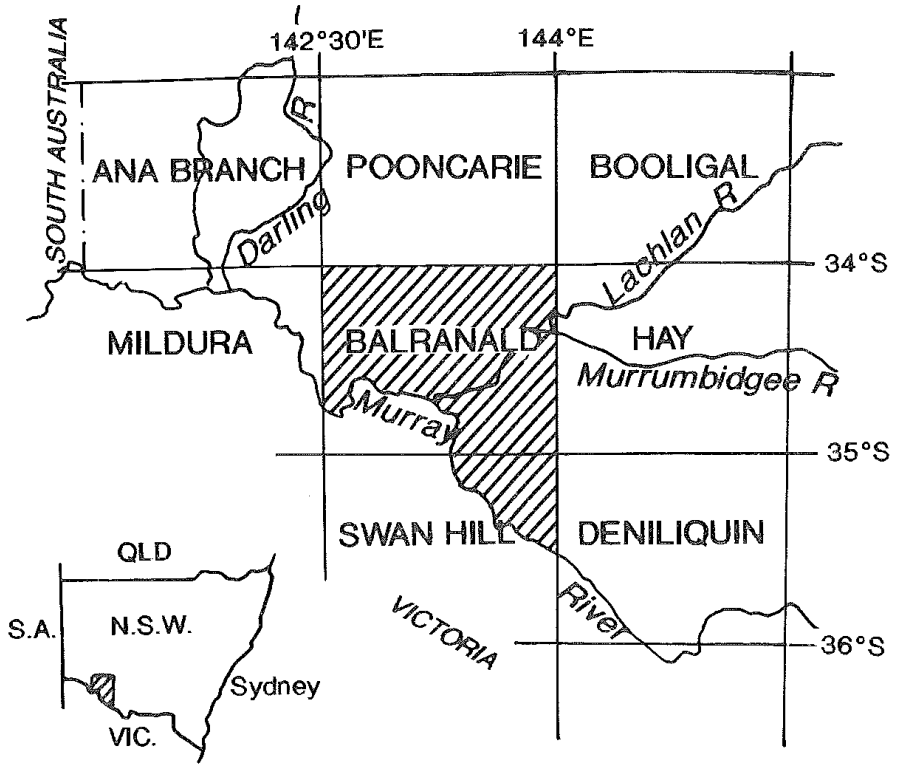

Figure 1. Locality map showing part of the 1:250 000 map grid.

Climate

The climate of the study area is semi-arid. Temperatures are hot in summer and mild in winter (Table 1). The hottest month is January with an average daily temperature range of 16–33°C; the coldest month is July with an average range of 3–16°C recorded at Balranald (Bureau of Meteorology, 1988).

Rainfall is low and highly variable. The mean yearly rainfall, based on 107 years of record, for Balranald is 320 mm, and gradually decreases to the north and west. The rainfall is relatively evenly distributed throughout the year, only slightly higher and more frequent in the winter/spring months of May to October. In the summer months there are occasional heavy rainfalls yielding the higher values for the mean compared to the median. The variation from year to year is high, for example 1973 had 692 mm whilst 1982 had 129 mm (Bureau of Meteorology 1988).

The high evaporation experienced during summer, greatly reduces the availability of moisture to plant growth. June to September is generally the most favourable period for plant growth (Rhodes 1990).

Table 1. Climatic averages for Balranald for temperature (20 years of record) and rainfall (107 years of record) (Bureau of Meteorology 1988).

	J	F	M	A	M	J	J	A	S	O	N	D
Daily Max. Temp. (°C)	32.6	32.5	29.0	24.2	19.5	16.1	15.8	17.5	20.1	23.9	27.4	30.5
Daily Min. Temp. (°C)	16.4	16.6	13.7	9.9	7.0	3.8	3.2	4.7	6.7	9.8	12.2	14.2
Rainfall (mm)												
Mean	21	24	24	24	32	30	25	30	29	32	26	23
Median	9	12	16	17	28	25	22	26	24	23	17	15
Rain days (Mean no.)	3	3	3	4	6	7	7	8	6	6	4	3

Geology and geomorphology

The mapped area falls within the Murray Geological Basin (Fig. 2), formed during the Tertiary period approximately 60 million years ago. The pre-Tertiary geology described in Pels (1969) and summarised in Fox (1991) indicates a long period of sedimentation underlying the basin. There are no rock outcrops within the mapped area unlike the edge of the basin in the Darnick and Manfred Ranges to the north-west.

Sedimentation in the Tertiary provided much of the source-material for the geomorphological processes in the Quaternary which shaped the landscape seen today. It also apparently controls some of the geomorphic features such as drainage and the presence of major aquifers (Soil Conservation Service 1990). Within the mapped area the landscape history can be best described in three sections according to the geomorphological processes responsible for their formation.

The western half of the Murray Basin encompassed the Murravian Gulf (Fig. 2) which was shaped and infilled largely with marine sediments in the late Tertiary. At its maximum (during Miocene time) the sea extended as far east as Balranald where marine sediments containing abundant fossils have been found at depths of 150–270 m (Pels 1969). Its regression left ridges of Parilla Sand (Firman as cited by Bowler & Magee 1978). Further sedimentation took place when most of this area was again inundated, this time with fresh water from the damming of the Murray River forming Lake Bungunnia. This drained out approximately 700 000 years ago (Bowler 1980). During the Quaternary the deposits were reworked by the wind into dunefields and sandplains of the Woorinen formation (Lawrence 1966). This aeolian landscape has its easternmost edge in a line approximately north-south through Balranald.

East of Balranald is the riverine plain. This is a fluviatile landscape deposited by the system of prior streams that eroded the Murrumbidgee and Lachlan valleys in the late Pliocene and Pleistocene times (Woolley 1978, Butler 1950). The present surface of the plain represents the final phase of prior stream deposition that took place in

the Quaternary and is regarded as a relic landform of this age (Pels 1969). The raised stream beds and levee banks of the last of the prior stream channels can be seen on the plain today as slight sandy rises. They are more easily seen from the air. These rivers carried greater discharges than the present rivers, as evident from the greater channel width and longer meander wavelengths. Clays were deposited from the prior streams when water was isolated beyond its levees on extensive floodplains (Pels 1969). The present-day rivers, the Murrumbidgee, Lachlan and Murray which meander across the landscape, have not been responsible for the topography of the plain (Pels 1969).

The transition zone between these two distinctive landscapes, fluviatile in the east and aeolian to the west, runs through the centre of the mapped area (Fig. 3). It marks the transition from riverine sources of sediment from the east to the marine and littoral sources of sediments from the west (Mabbutt 1980). This boundary has fluctuated over time and is important in providing landform evidence of climatic change (Mabbutt 1980). The landforms are possibly of riverine or lacustrine origin with a veneer of aeolian material (Scriven 1988*b*). Fluviatile sediments are thin, and ancient lunettes formed in the Tertiary period are often exposed (Pels 1969). The two processes, aeolian and fluvial, have combined to produce lake basins that were active in a

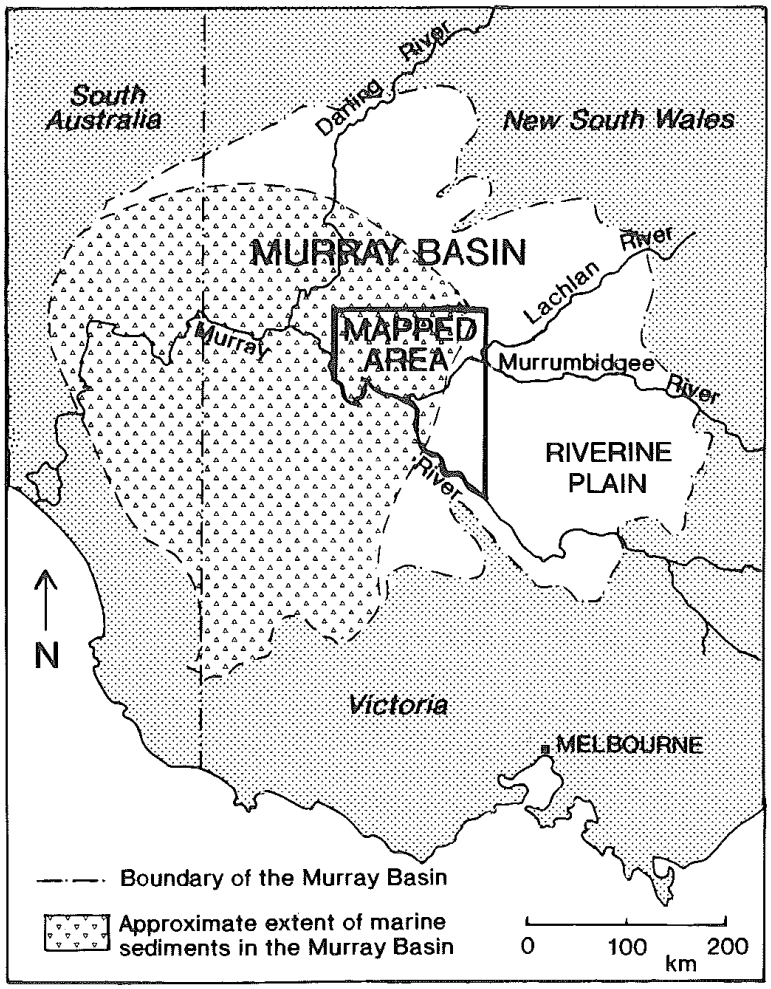

Figure 2. Map of south-eastern Australia showing the location of the mapped area within the Murray Basin. Based on a map by Lawrence (1966).

wet phase of the Pleistocene 50 000 to 25 000 years ago (Bowler & Magee 1978). A drying-out phase followed, with its peak in the last glacial period 18 000 to 16 000 years before present. During this time dune building occurred on the eastern edges of each lake, forming lunettes. These are still present today.

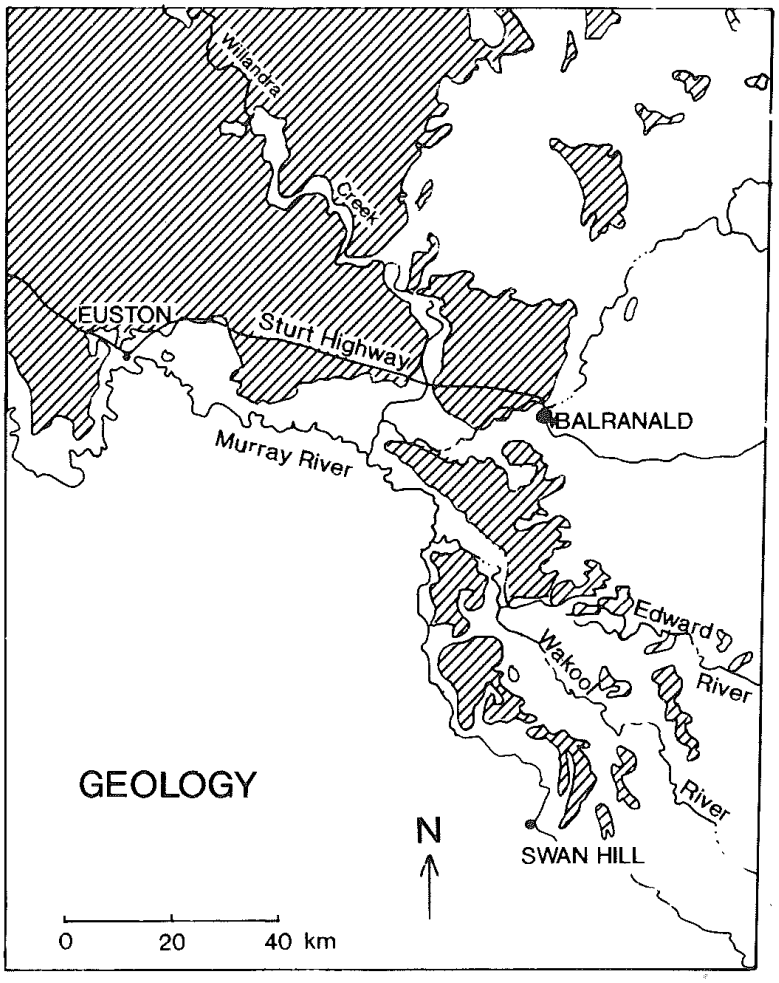

Figure 3. The geology of the mapped area based on a map by the Soil Conservation Service of New South Wales (1990). Hatched areas are largely aeolian, flat to gently undulating plains and dunes of red and red-brown clayey sands and loams. Unhatched areas are flat alluvial and lacustrine deposits of gravel, sand, silt and clay.

Present landforms

Rivers

The major rivers flowing through the area are the Murray and the Murrumbidgee, which enters the Murray 35 km south-west of Balranald. The Edward and Wakool Rivers, which branch near Deniliquin, flow to the west in parallel courses and reunite near Kyalite before entering the Murray just upstream from the Murrumbidgee. The rivers carry water from the tablelands and slopes in the east across the Riverine Plain where there is limited contribution from runoff. The Great Cumbung Swamp occurs on the Lachlan River just north of where it enters the Murrumbidgee on the easternmost side of the mapped area. It is one of the most significant inland wetlands in NSW (Pressey *et al.* 1984).

Dunefields

The linear dunes are relic features stabilised for the last 15 000 years by vegetative cover. They occur on the western half of the map-sheet area forming a series of parallel rounded ridges with a west-east orientation. These dunes vary in height from 2 m to 6 m from crest to swale, spaced with approximately 0.2–1.2 km between adjacent dune crests, and are commonly 0.5–1 km in length, sometimes to 3 km in the west. Their average composition is 7–10% clay content and 5% calcium carbonate, with the highest values in the swales and the lowest on the dune crests (Bowler & Magee 1978). The swales contain fine-grained clay loam, often with limestone nodules.

The dunefields are a part of the Woorinen Formation (Lawrence 1980), which extends into northern Victoria. The sand content of these dunes is thought to have originated from the Parilla sands deposited with the retreat of the Murravian Gulf in the upper Miocene to lower Pliocene (Bowler & Magee 1978, Lawrence 1980, Semple 1990). The clays are thought to have originated from the lacustrine sediments of the Quaternary, whilst the calcite from cyclic salts and as dust derived from shells exposed on the South Australian coastline at times of low sea level (Lawrence 1980). The dunes become less frequent in their distribution from west to east, becoming absent on the sandplains.

North of Lake Benanee lies a broad flattish NW-SE aligned area of non-linear sand dunes (Fig. 4). Similar ridges in south-west Victoria and South Australia are postulated to be relic Tertiary shoreline features formed by the retreat of the sea in the Late Tertiary (Bowler & Magee 1978, Blackburn 1962), depositing Parilla Sands (Macumber 1969, Bowler & Magee 1978, Lawrence 1980).

Sandplains

Sandplains occur in the middle of the map-sheet area where the aeolian sand cover is thinner, in the zone of transition between the dunefields to the west and the Riverine plain in the east. They support Mallee, and Belah-Rosewood woodland (*Casuarina pauper* with *Alectryon oleifolius* subsp. *canescens*). The land is flat and there are generally no dunes. The clay and calcium content is higher than in the dunes, but the origin of the sediments is similar.

Lakes

The numerous lakes in the area are relic features relating to hydrologic events of the late Pleistocene (Bowler & Magee 1978). They were full when the climate was wetter 50 000 to 25 000 years ago. At this time the lakes of the Willandra system to the north overflowed through an outlet channel, still evident today west of Balranald, to join the Murrumbidgee River. The Prungle Lakes are the southernmost of this system and part of the Willandra World Heritage area. The lakes nearer Balranald also date from this time; their water source was probably from an elevated water-table across the region (Pressey *et al.* 1984).

In appearance, the lakes are typically smooth and elliptical, often kidney-shaped in outline with the long axis oriented north-south. They vary in size from 2 km long (Moonlight Lake) to 10 km long (Pitarpunga Lake). Most lake basins are dry although some near the floodplains of the Murray and Murrumbidgee Rivers are intermittently filled when the rivers are flooded. Others are now artifically filled for use as water storage basins. The sediments on the lake floors consist of slightly saline calcareous clays, with silts and sands more prominent on the eastern downwind margins (Mabbutt *et al.* 1982).

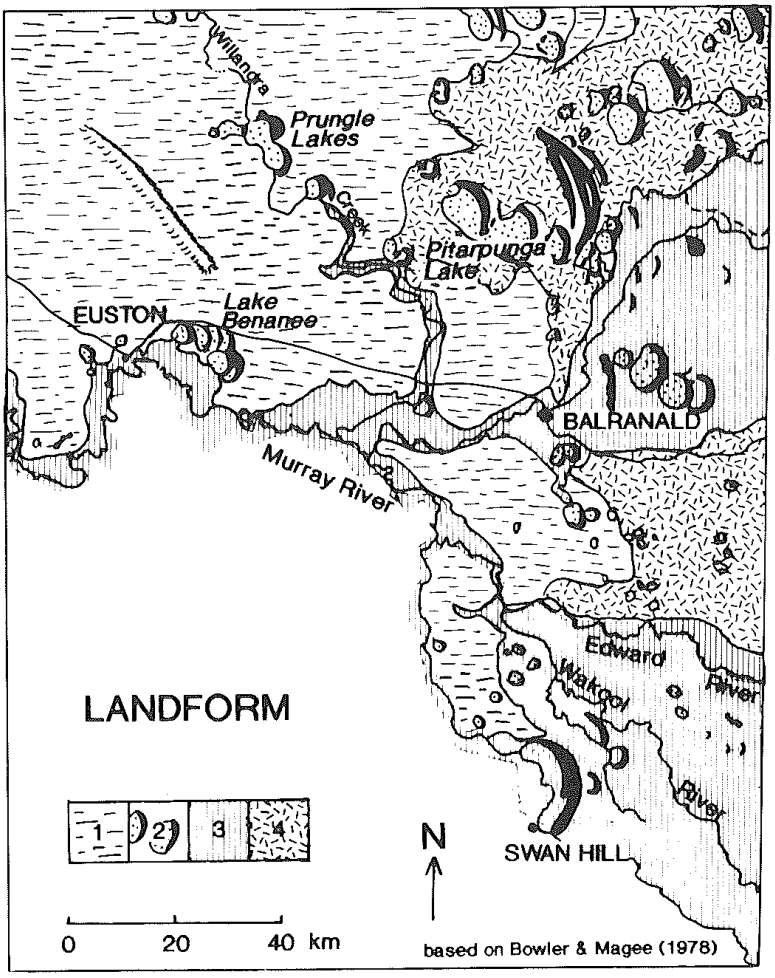

Figure 4. Landform features and geomorphology of the mapped area. Aeolian: 1. linear dunes and sand plain, 2. lunettes on eastern side of lakes. Fluvial: 3. low level alluvium, 4. clay plain. Based on a map by Bowler and Magee (1978).

Lunettes

Lunettes are the smooth cresent-shaped dunes on the eastern edge of the lakes. They are thought to be formed 40 000 to 15 000 years ago with the most intensive phase at the peak of the last glaciation 18 000 to 16 000 years before present (Bowler 1976). At this time the climate was drier and slightly cooler with temperatures several degrees below their present mean (Bowler 1980). The lunette building process occurred as a result of the seasonal flooding and drying out of the lake leaving a salt residue on the lake bed which helps break up the clay soil. The clay particles are then blown by unidirectional winds and deposited to form a dune (Bowler 1980). The resulting lunettes are composed predominantly of clayey sands, gypseous clays and, as in Prungle Lake, almost pure gypsum (Australian Heritage Commission 1980). The size of the lunette is proportional to the size of the lake.

Riverine plain

The western edge of the riverine plain covers the eastern quarter of the map sheet. The plain, consisting of Quaternary alluvium, is mostly treeless except for the forests

and woodlands along the rivers, and the woodlands on the levees and raised beds of prior streams. The soils are mainly heavy clays and the dominant vegetation communities are chenopod shrublands.

Prior streams and source-bordering dunes

Prior streams (Butler 1950) were major river systems active in the Pleistocene which deposited sediment forming the present-day Riverine Plain. The stream traces, seen on the present landscape most clearly from the air, cross the plain and fragment as they near the transition zone on the western edge of the plain. They appear on the ground as a change to redder sandier soil and/or slight sandy rises, representing the old source-bordering dunes and raised stream bed. South-east of Balranald the remains of one such prior stream is seen as red sandy rises across the landscape with remnants of *Callitris* mixed woodland.

Soils

There is a high correlation between soil type and landform. The following soil descriptions have been taken from Charman and Murphy (1991), Northcote (1980) and from the soil map for Balranald (Eldridge 1985). Much of this area is covered in a fine-grained sediment known as parna, which covers the plain and swales of the dunefields (Butler 1956).

Plains of calcareous earths

The most extensive soil type is grey-brown loamy calcareous earths, often with exposed cemented carbonate at the surface. They are found between and to the north of Balranald and Euston. Isolated sandy dunes of low relief are associated with flats of various duplex soils. To the east of Balranald calcareous earths, transitional hard red and yellow duplex soils and areas of grey cracking clays are present. Many of these areas have lost their topsoil through wind and water erosion (in the case of duplex soils), or winnowing of the finer particles (in the case of the calcareous earths) (Eldridge 1985).

Dunefields of calcareous and brownish sands

Linear dunes of deep brownish sands in association with calcareous sands are found in the west and north-west of the map sheet. These support mallee vegetation. Plains and swales of brown calcareous earths and assorted duplex soils are associated with these dunes.

Plains of grey cracking clays

Self-mulching grey and yellow-grey cracking clays are associated with the rivers and floodplains. East of Balranald there is a mosaic of grey cracking clays and hard duplex soils (red-brown earths). The remains of prior streams south-east of Balranald have typically scalded margins and levees, and beds of shallow, calcareous sands. Their source-bordering dunes are composed of deep, calcareous and siliceous sands. The lunettes and rises consist of yellow duplex soils and granulated clays.

Dunes with sands and calcareous earths are highly susceptible to wind erosion if vegetative cover is removed (Semple 1989). In contrast, high clay content of the riverine plain soils reduces their susceptability to erosion.

Previous vegetation surveys

General surveys

The survey and mapping by Beadle (1948), at a scale of 1 inch: 16 miles, is the most comprehensive survey covering the whole of western New South Wales. Beadle delineated 22 major vegetation associations for the Western Division, five of which occur within the mapped area. Mallee *Eucalyptus oleosa* (referring chiefly to *E. socialis*) - *Eucalyptus dumosa* association covers much of the western half of the study area on dunefields of aeolian sandy soils. Patches of *Casuarina* - *Alectryon* [*Heterodendrum*] association (Belah and Rosewood) occur throughout but are more extensive to the north of the mapped area. Shrublands are important in the east, the main ones being *Maireana pyramidata* - *Maireana sedifolia* [*Kochia pyramidata* - *K. sedifolia*] association (Bluebush) and *Atriplex vesicaria* [*Atriplex vesicarium*] association (Saltbush). The river floodplains in the east and along the Murray River support forests of *Eucalyptus largiflorens* association (Black Box) [*Eucalyptus bicolor*].

Noy-Meir (1971, 1974, 1980) has produced an unpublished map of south-western New South Wales at a scale 1:1 000 000. Plants of Western New South Wales (Cunningham *et al.* 1981) and the Flora of New South Wales (Harden 1990, 1991) are the main reference books for the identification of plant species. The N.S.W. Soil Conservation Service also has a range of 'Technical Manuals' which contain a review of literature and other souces of information for various vegetation types. That Service also produced a number of 'Working Documents', which give a literature review of specific chenopod species.

Surveys specific to the Balranald – Swan Hill map area

The present distribution and status of the vegetation of the riverine forests along the Murray River, its anabranches, and the Edward and Wakool system, were assessed in a detailed survey for the Murray - Darling Basin Commission (Margules and Partners *et al.* 1990). The 1:50 000 maps produced from this survey were incorporated in this mapping project.

The maps produced from a survey of the confluence of the Lachlan with the Murrumbidgee rivers by Pressey *et al.* (1984) were also used. This study covers 88 000 ha, of which approximately 90% is on the Balranald sheet, and the remainder on the adjacent Hay sheet.

Located on the western boundary of the Balranald map sheet is Mallee Cliffs National Park. A vegetation map of the Park at 1:50 000 was produced by Morcom and Westbrooke (1990) with descriptions of the various plant communities. Approximately 90% of the 58 000 ha park is located on the Balranald sheet.

An extensive study of the mallee lands of north western Victoria (Land Conservation Council of Victoria 1987) included a vegetation map at a scale of 1:250 000. Their close proximity allows comparisons to be made between the Victorian mallee and the mallee in NSW.

The N.S.W. Soil Conservation Service has produced a series of Land Systems maps for the Western Division. The vegetation component of 22 land systems is described briefly for the Balranald 1:250 000 map sheet (Walker 1991).

Table 2. Map unit, main species and structure for plant communities shown on Balranald – Swan Hill 1:250 000 map sheet. Where communities occupy significant areas of the adjacent Ana Branch – Mildura map sheet, equivalent numbers used by Fox (1991) are given.

No.	Plant community	Main species	Structure (*Specht 1981 **Walker & Hopkins 1990)	Fox No.
1	Riverine Forest	*Eucalyptus camaldulensis*	open forest * & **	1
2	Black Box Woodland	*Eucalyptus largiflorens*	woodland *; woodland - open woodland **	2
3a	Mallee on Irregular Dunefield	*Eucalyptus dumosa, E.socialis, E. costata, E. leptophylla,Triodia scariosa*	tall shrubland *; mallee shrubland - open mallee shrubland **	
3b	Dune-Crest Mallee	*Eucalyptus dumosa, E. socialis, Triodia scariosa*	tall shrubland *; mallee shrubland - open mallee shrubland **	3
3c	Swale Mallee	*Eucalyptus dumosa, E. socialis, E. oleosa, E. gracilis*	tall shrubland *; mallee shrubland - open mallee shrubland **	
3d	Sandplain Mallee	*Eucalyptus dumosa, E. oleosa*	tall shrubland *; mallee shrubland - mallee woodland **	
4	Belah-Rosewood	*Casuarina pauper, Alectryon oleifolius* subsp. *canescens*	woodland *; open woodland - isolated clumps **	4
8	Black Bluebush	*Maireana pyramidata*	low - low-open shrubland *; open - sparse chenopod shrubland **	8
9	Pearl Bluebush	*Maireana sedifolia*	low shrubland *; open - sparse chenopod shrubland **	9
11	Bladder Saltbush	*Atriplex vesicaria, Sclerostegia tenuis*	low shrubland *; open - sparse chenopod shrubland **	11
13	Canegrass	*Eragrostis australasica*	grassland * & **	13
16	*Callitris* Mixed Woodland	*Callitris glaucophylla, Hakea tephrosperma, Hakea leucoptera*	open woodland *; open woodland - isolated trees **	
17	*Acacia melvillei* Woodland	*Acacia melvillei*	tall shrubland - low woodland *; open woodland - open shrubland **	
18	Lignum	*Muehlenbeckia florulenta*	open scrub *; shrubland - open shrubland **	
19	Old Man Saltbush	*Atriplex nummularia*	low shrubland *; open - sparse chenopod shrubland **	
20	Bull Oak	*Allocasuarina luehmannii*	open woodland *; isolated plants **	
21	Cotton-bush	*Maireana aphylla*	low shrubland *; open - sparse chenopod shrubland **	
22	Dillon bush	*Nitraria billardieri*	low open shrubland *; sparse shrubland **	
23	Great Cumbung Swamp	*Phragmites australis Senecio cunninghamii*	closed-open herbland *; closed-open grassland/ forbland **	
OA	Open Areas	various shrubs & grasses	low open shrubland *; sparse chenopod shrubland**	

Methods

This project is part of an ongoing vegetation mapping project of south western New South Wales. Methodology is similar to that for Fox (1991). The best available aerial photography is provided by air photomosaics 1961 to 1970 (NSW Dept of Lands) at 1:50 000. These were used to distinguish different vegetation units. Boundaries were marked directly onto the photomosaics. An initial field survey enabled names to be assigned to the vegetation units. These were then reduced and transferred to 1:100 000 topographic maps, which were used as provisional maps. The term 'community' is used for the basic vegetation unit describing areas with similar structural and floristic characteristics.

The provisional maps were field-checked. Twenty-one days of field work during 1990–1991 made it possible to check the different vegetation communities. Notes were taken on the soil type, landform, degree of disturbance of the vegetation and vegetation structure at localities over the whole of the map sheet. For some of the sites a measured area of 0.2 ha (100 m by 20 m) was thoroughly searched and all vascular plants recorded. Lignum (*Muehlenbeckia florulenta*) (community 18), and Great Cumbung Swamp (*Phragmites australis - Senecio cunninghamii*) (community 23), were not sampled due to limited access but information was available from Pressey *et al.* (1984). Areas for which surveys already exist were not sampled as extensively.

Only present-day vegetation is mapped. A combination of field notes with recent (1991) LANDSAT images at 1:250 000 were used to delineate cleared mallee and woodlands. Where possible the pre-clearing vegetation type has been indicated. Some patches of natural vegetation may be present within the areas marked as cleared and along roadsides. These may be important but could not be mapped at this scale. LANDSAT was also useful in defining structurally variable communities such as community 4: Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) woodland. The level of disturbance in the chenopod shrublands was variable and could not be consistently defined from the images.

Surveys for the Lowbidgee (Pressey *et al.* 1984), the Murray River (Margules and Partners *et al.* 1990), and Mallee Cliffs National Park (Morcom and Westbrooke 1990), all at 1:50 000 were referred to in compiling this map.

Many of the vegetation units also occur on the adjacent Ana Branch - Mildura map sheet to the west (Fox 1991). There are, however, slight differences in the numbering of the communities in this survey from that of Fox's survey (Table 2). In addition, the structural classification system of Walker and Hopkins (1990) has been used, as well as Specht (1981).

Within any one community, patches of other communities may occur, for example, patches of mallee in the Belah-Rosewood unit. The dominant community has been indicated on the map.

Botanical names used are those currently recognised at the National Herbarium of New South Wales.

Results

Twenty plant communities are recognised. The main structural formations are mallee shrublands, Belah-Rosewood woodland (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*), mixed woodland of *Callitris* and various chenopod shrublands. Open-forest of *Eucalyptus camaldulensis* occurs along the rivers and open-woodland of *Eucalyptus largiflorens* occurs on the periodically flooded river flats.

The communities described are mostly based on perennial species. Annuals and short-lived perennials vary with seasonal and year-to-year changes (details are given in the 'discussion' section).

A species list for the mapped area is given in Appendix 1. It has been derived from field observations and published lists.

Description of map units shown on the Balranald - Swan Hill sheet

Structure: Specht (1981) = * ; Walker and Hopkins (1990) = **

* When placed before a species name, indicates the species is exotic.

Map unit 1: Riverine Forest
Structure: open forest * & **
Characteristic species: *Eucalyptus camaldulensis* (River Red Gum)
Associated species: *Muehlenbeckia florulenta, Wahlenbergia fluminalis, Paspalidium jubiflorum, Acacia stenophylla, Eucalyptus largiflorens, Cynodon dactylon, Ranunculus lappaceus, Brachycome basaltica* var. *gracilis.*
On the extensive floodplain of the Murrumbidgee River two subunits have been described by Pressey *et al.* (1984).
Levees: *Eucalyptus camaldulensis, Carex appressa, Paspalidium jubiflorum, Wahlenbergia fluminalis,* Cirsium vulgare, *Sonchus oleraceus, Pratia concolor.*
Floodplain: *Eucalyptus camaldulensis, Marsilea drummondii, Phragmites australis, Eragrostis australasica, Centipeda minima, Pratia concolor, Ranunculus lappaceus, Chenopodium nitrariaceum, Atriplex nummularia.*
Soils: levees of grey, massive, non-cracking clays; at low elevations strongly gilgaied, grey self-mulching clays to massive non-cracking clays near the top of the floodplain (Pressey *et al.* 1984).
Occurrence: This community is found on the banks nearest the channels of the major rivers and creeks throughout the region, and on low-lying flats subject to flooding. The largest area of this community is found in the Lowbidgee District along the Murrumbidgee River. The densest stands of this community are along the banks nearest the river channels (Fig. 5). Extensive areas on the flats have a more 'open woodland' structure. For the length of the Murrumbidgee River within the mapped area, Black Box (*Eucalyptus largiflorens*) usually occurs as an adjacent community (2) on the floodplain flats. On parts of the Murray River the floodplain is much narrower and often the River Red Gum forest is abruptly bounded by higher ground of red/brown earths supporting mallee or *Callitris* mixed woodland, much of which has been cleared. This is most apparent along the stretch of the Murray River between the points of entry of the Wakool and Murrummbidgee Rivers.
Comments: The main tree species, *Eucalyptus camaldulensis*, is the tallest tree species in the area and forms the only 'forest' type vegetation. Inundation of varying frequency and duration is important for the survival of this species (Somerville 1988). It often occurs near Black Box (*Eucalyptus largiflorens*) which occupies slightly higher ground on the floodplain a distance from the channel, where flooding is less frequent.
Most of these forests have been logged and grazed at various times. Those most disturbed by grazing had very little ground cover and much bare earth and leaf litter at the time of the survey.

Figure 5. River Red Gum forest (*Eucalyptus camaldulensis*) along the banks of a back-water channel of the Murrumbidgee River, near Redbank Weir.

Map unit 2: Black Box
Structure: woodland *, woodland - open woodland **
Characteristic species: *Eucalyptus largiflorens*
Associated species: *Chenopodium nitrariaceum, Atriplex nummularia, Muehlenbeckia florulenta, Enchylaena tomentosa, Einadia nutans, Sclerolaena tricuspis*, often with *Chamaesyce drummondii, Atriplex lindleyi.*
Soils: Grey clays rarely cracking and with a flat or gently undulating surface.
Occurrence: Throughout the region on the uppermost level of the floodplain; beyond the floodplain it may occur in depressions along creeks, drains and old stream beds (e.g. Box Creek), and fringing ephemeral lakes (Fig. 6.). Examples of this community include Yanga Nature Reserve, the floodplain just west of Euston on the south side of the Sturt Highway, and ringing many of the lakes such as Lake Marimley, Lake Talbetts, Harveys Lake and Chillichil Lake.
Comments: Black Box woodland occurs on the floodplain of the major rivers usually beyond the River Red Gum forest. These areas are at the upper levels of the floodplain where flooding is less frequent. It also occurs along creek lines and is often seen forming a line of trees marking an intermittent or permanent creek. Areas of impeded drainage amongst other vegetation units ranging from mallee to shrublands may also support Black Box, but often as an isolated tree or group of trees. These areas, often too small to map, are most common in the region of the prior stream remains south-east of Balranald. The understorey here was often similar to the surrounding vegetation community. Yanga Nature Reserve consists almost entirely of this community. It has a more diverse understorey with the most abundant species in the Chenopodiaceae, Asteraceae and Poaceae. Within this community at Yanga are open areas of higher ground with grasses and *Maireana pyramidata* shrubland. Along the drainage

channels are Lignum (*Muehlenbeckia florulenta*) and *Chenopodium nitrariaceum*.

Chenopodium nitrariaceum is closely associated with Black Box as an understorey species, but can also extend beyond the tree line forming a shrubland. This may be seen east of Perekerten where it dominates a lake-bed, and in smaller patches south-east of Balranald.

Some areas of this unit showed only a scattered distribution of trees, for example in the Swan Hill section of the map. These areas have probably been cleared or thinned in the past.

A less common variant of this community consists of a *Eucalyptus largiflorens* overstorey with the understorey dominated by *Melaleuca lanceolata*. This subunit was restricted to a few localities within the mapped area, the main one of which is located on the Euston-Prungle road just north of Euston. Here the other understorey species are more typical of the adjacent woodland of Belah-Rosewood, (*Casuarina pauper-Alectryon oleifolius* subsp. *canescens*), with *Callitris glaucophylla* into which this community grades. They include *Olearia pimeleoides*, *Dodonaea viscosa* subsp. *angustissima*, the chenopods *Enchylaena tomentosa*, *Einadia nutans* and *Chenopodium desertorum* subsp. *microphyllum*, with many annuals including three species of *Vittadinia*: *V. gracilis*, *V. cervicularis* var. *cervicularis* and *V. dissecta* var. *hirta*. It is located on higher ground consisting of brown-red loam soil between the floodplain associated with the Murray River and the mallee country. Two smaller populations occur within the mapped area, one on the edge of the Murrumbidgee floodplain on the road to Red Bank Weir, and the other on the southern edge of Pitarpunga Lake.

A small population of *Eucalyptus intertexta* is located to the west of Euston, adjacent to the Black Box community. The area lies between the Black Box woodland, on the floodplain, and the mallee, on the raised sand country.

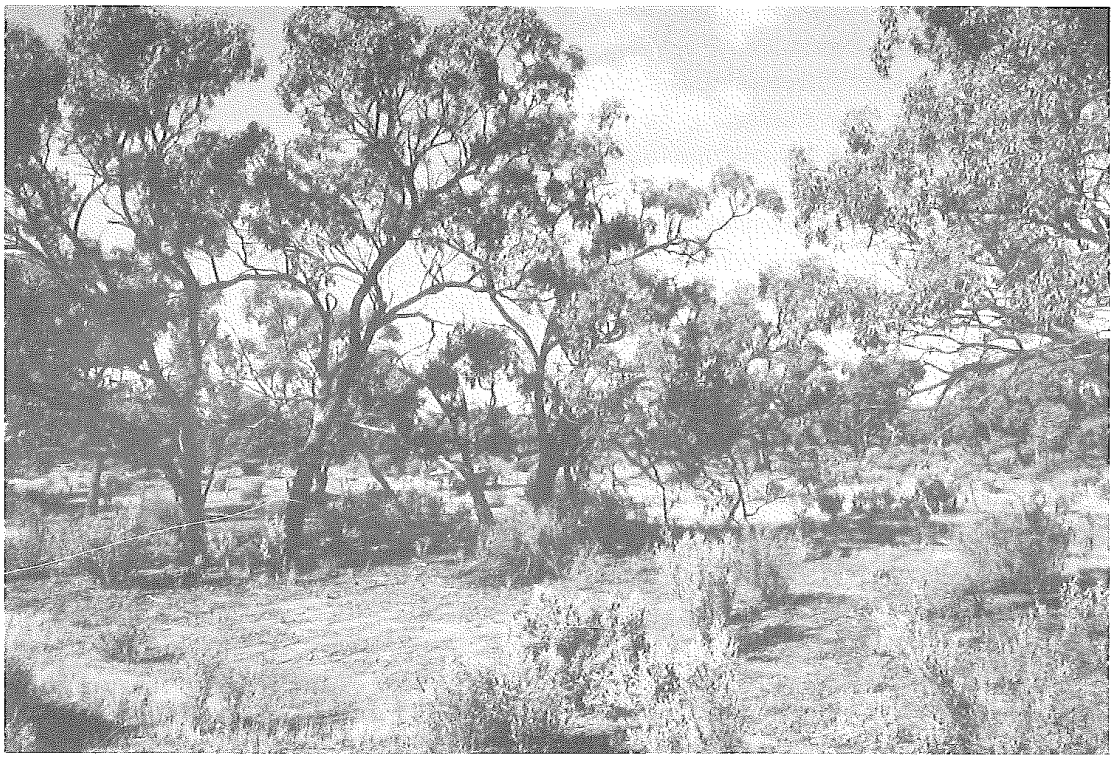

Figure 6. Floodplain with Black Box (*Eucalyptus largiflorens*) and Old Man Saltbush (*Atriplex nummularia*) in the foreground.

Map unit 3: Mallee

3a. Mallee on Irregular Dunefield

Structure: tall shrubland *; mallee shrubland - open mallee shrubland **

Characteristic species: *Eucalyptus dumosa, E. socialis, E. costata, E. leptophylla, E. oleosa, Triodia scariosa*

Associated species: *Olearia muelleri, Grevillea huegelii, Acacia colletioides, Bossiaea walkeri.*

Soils: Deep red-brown siliceous sands (Eldridge 1985).

Occurrence: The only area is in Mallee Cliffs National Park just north of Chalky Tank; it occurs more commonly to the north on the Pooncarie map.

Comments: This community consists of very even low mallee. The trees are approximately 3 m high, with many thin stems arising from the lignotubers ('whipstick' mallee, Beadle 1948). Geomorphological evidence suggests the dune landform supporting this vegetation may consist of Parilla sands, laid down when the Murravian Gulf was a marine environment between 6 and 26 million years ago (Blakers & Macmillan 1988). Even when buried, the sands influence the plant communities by altering the moisture regime of the soil.

3b. Dune-Crest Mallee

Structure: tall shrubland *; mallee shrubland - open mallee shrubland **

Characteristic species: *Eucalyptus socialis, E. dumosa, E. gracilis, Triodia scariosa.*

Associated species: *Olearia pimeleoides, Acacia colletioides, Dodonaea viscosa* subsp. *angustissima, Eremophila glabra, Eucalyptus costata, Senna artemisioides* subsp. *filifolia, Chenopodium curvispicatum, Maireana pentatropis, Westringia rigida, Myoporum platycarpum,* occasional *Callitris verrucosa.*

Soils: Deep brown calcareous and siliceous sands (Eldridge 1985).

Occurrence: Throughout the western half of the map sheet on the aeolian sands. In the north-west it is associated with Belah-Rosewood woodland (community 4) that occurs in the swales. This pattern is more common on the Ana Branch map sheet in the north-west, mapped as unit 5 by Fox (1991). Fig. 7

Comments: This community is fairly widespread in the west but varies in the frequency of dunes, which is higher on the western boundary of the map on both sides of the the Sturt Highway where the swales support community 3c. Further east the frequency decreases as the Sandplain Mallee community dominates. There are remnants of Dune-Crest Mallee found in the Kyalite area with community 3c in the swales.

3c. Swale Mallee.

Structure: tall shrubland *; mallee shrubland - open mallee shrubland **

Characteristic species: Eu*calyptus dumosa, E. socialis, E. oleosa, E. gracilis*

Associated species: *Enchylaena tomentosa, Maireana pentatropis, Maireana sclerolaenoides, Atriplex stipitata, Zygophyllum apiculatum, Zygophyllum aurantiacum, Westringia rigida, Senna artemisioides* subsp. *filifolia, Sclerolaena obliquicuspis, Acacia colletioides, Dodonaea viscosa* subsp. *angustissima.*

Soils: Brown loamy calcareous earths (Eldridge 1985).

Occurrence: Throughout the dune-fields on the western half of the map sheet associated with the Dune-Crest Mallee community of 3b, particularly south of the mosaic pattern of 3b/4. Isolated Belah (*Casuarina pauper*) occurs in some of the swales.

Comments: *Eucalyptus oleosa* tends to occur on the lowest areas of the swales, with *Eucalyptus socialis* on the dune flanks (Hill 1989). The trees are usually larger than

Figure 7. Disturbed sandy rise with Dune-Crest Mallee. Clumps of *Triodia scariosa* in the foreground.

Figure 8. Sandplain Mallee along Abbots Tank - Prungle road.

those on the adjacent dune crests. This community merges with the Sandplain Mallee of 3d.

3d. Sandplain Mallee

Structure: tall shrubland *; mallee shrubland - mallee woodland **

Characteristic species: *Eucalyptus dumosa, E. oleosa,*

Associated species: *Atriplex stipitata, Zygophyllum apiculatum, Z. aurantiacum, Maireana pentatropis, Maireana pyramidata, Maireana* spp., *Enchylaena tomentosa, Sclerolaena obliquicuspis, Chenopodium curvispicatum, *Psilocaulon tenue,* often with *Dissocarpus paradoxus* and some *Eucalyptus gracilis.*

Soils: Grey-brown loam to clay-loam calcareous earths on extensive level plains often with limestone nodules on the surface (Eldridge 1985).

Occurrence: Within transition zone between aeolian and alluvial landscapes, on southern part of the Willandra Lakes system. Flat plains with no dunes. Fig. 8.

Comments: Like the Swale Mallee the trees here tend to be larger with fewer stems. The understorey is shrubby with many chenopods. The structure becomes more open as the soils become clayier nearer the transition to the riverine plain. This form of mallee overlaps somewhat with the Swale Mallee (3c).

Map unit 4: Belah-Rosewood

Structure: woodland *; open woodland - isolated clumps **

Characteristic species: *Casuarina pauper, Alectryon oleifolius* subsp. *canescens.*

Associated species: *Exocarpos aphyllus, Olearia muelleri, Myoporum platycarpum, Enchylaena tomentosa, Einadia nutans, Sclerolaena* spp., *Maireana* spp.

Geijera parviflora in the larger stands in the north.

Soils: Brown calcareous earths on plains with isolated sandy rises; deep brown and red loam to loamy sands. *Casuarina pauper* is an indicator of the presence of calcium carbonate in the lower soil horizons (Johnson pers. comm.)

Occurrence: This woodland is widespread throughout the mapped area. In the far north of the map in the mallee sand dune country it occurs in the low-lying areas of the swales where the soil is heavier. These areas were too small to map separately but due to their consistent recurring pattern were shown as a mosaic unit (mapped as 3b/4). This unit is more extensive to the north-west of the map on the Ana Branch - Mildura sheet (Fox 1991).

Larger areas of this community have been delineated, such as a band to the north-west of 'Bidura'. Much of this has been cleared for crops. This was also the case further south in the Sandplain Mallee, unit 3d, just north of the Sturt Highway. It is also associated with old lake and river systems in the north-east of the map, often seen with *Callitris* mixed woodland in undulating country.

Dotted in the south-east on heavy clay soils associated with the floodplains between the Murrumbidgee and Edward Rivers in close proximity to unit 2, *Eucalyptus largiflorens,* Belah (*Casuarina pauper*) dominates the groves, many of which are cleared or thinned. With further sampling this may be seen as a separate unit to that in the north.

Comments: This community showed the greatest variability of all those mapped. The main canopy species is Belah (*Casuarina pauper*) with varying amounts of Rosewood (*Alectryon oleifolius* subsp. *canescens*). Both species may form single-species groves, for example, in the centre-north of the mapped area to the east of the mallee, and scattered throughout the transition zone in the middle of the map, often within chenopod shrublands. They also commonly occur as a mixture forming woodlands proper, with Belah the dominant tree species, for example in Mallee Cliffs National Park and the

dune country. These characteristics are also noted by Cunningham *et al.* (1981). Beadle (1948) has a separate classification for the two dominants but at this mapping scale they have been placed in the one community. *Casuarina pauper* (Belah), is referred to as *Casuarina lepidophloia* by Beadle, and later, by authors, as *Casuarina cristata* (Belah).

Map unit 8: Black Bluebush
Structure: Low - low open shrubland *; open - sparse chenopod shrubland **
8a. Characteristic species: *Maireana pyramidata*
Associated species: *Rhagodia spinescens, Enchylaena tomentosa, Atriplex* spp., *Sclerolaena* spp., *Stipa nodosa, Stipa elegantissima,* annuals.
8b. = same community as 8a but a more sparse shrubland usually on scalded areas often associated with areas along old stream beds and lunettes, or areas that have been particularly overgrazed and/or cleared.
Soils: Red-brown sand and loam duplex soils. Deep sandy soils in which limestone exists at a greater depth than 1.2 m below the surface (Beadle 1948).
Occurrence: This community occurs throughout the whole map area, most common in the transition zone between the aeolian sand-dune country and the riverine plain. It is closely associated with lunettes and source-bordering dunes of old river systems. The best stands are in the area of the north-east corner of the map through to the boundary with the mallee country to the west. However, it also occurs south-east of Balranald. It may occur as the understorey of an adjacent woodland, such as Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) (community 4) near Prungle, or of mallee such as on the Prungle Mail road. Fig. 9.
Comments: This community is the most widespread of the shrublands in the mapped area. It is found on slightly higher ground than the saltbush shrublands of *Atriplex vesicaria - Sclerostegia tenuis*, an adjacent community (11) in the far north-east of the map. It occasionally grades into Pearl Bluebush (*Maireana sedifolia*) (community 9), which occupies areas of higher elevation.
The soils are susceptible to scalding whereby the topsoil is removed by wind leaving a hard bare B-horizon surface devoid of vegetation. Scalded areas have been mapped as a subunit of this community to indicate this sparse shrub cover. Grazing pressure also reduces shrub cover and heavily disturbed areas are also included in this subunit.

Map unit 9: Pearl Bluebush
Structure: low shrubland *; open - sparse chenopod shrubland **
Characteristic species: *Maireana sedifolia*
Associated species: *Enchylaena tomentosa, Rhagodia spinescens, Stipa elegantissima, Maireana pyramidata.*
Soils: Red-brown sand or loam duplex soils. Deep sandy calcareous soils in which limestone exists less than 60 cm below the surface (Beadle 1948).
Occurrence: Closely associated with Black Bluebush (*Maireana pyramidata*) (community 8) usually on slightly higher ground, such as on the crest of a rise in the undulating country in the north-east sector of the map. Occasionally occurs in open areas within the mallee country such as to the north of and along the eastern boundary of Mallee Cliffs National Park. Fig. 10.
Comments: *Maireana sedifolia* is much less common than *Maireana pyramidata* and can occur as a mixed community or as a dominant in itself. Many patches are too small to include on a map at this scale. This community is more common west of the

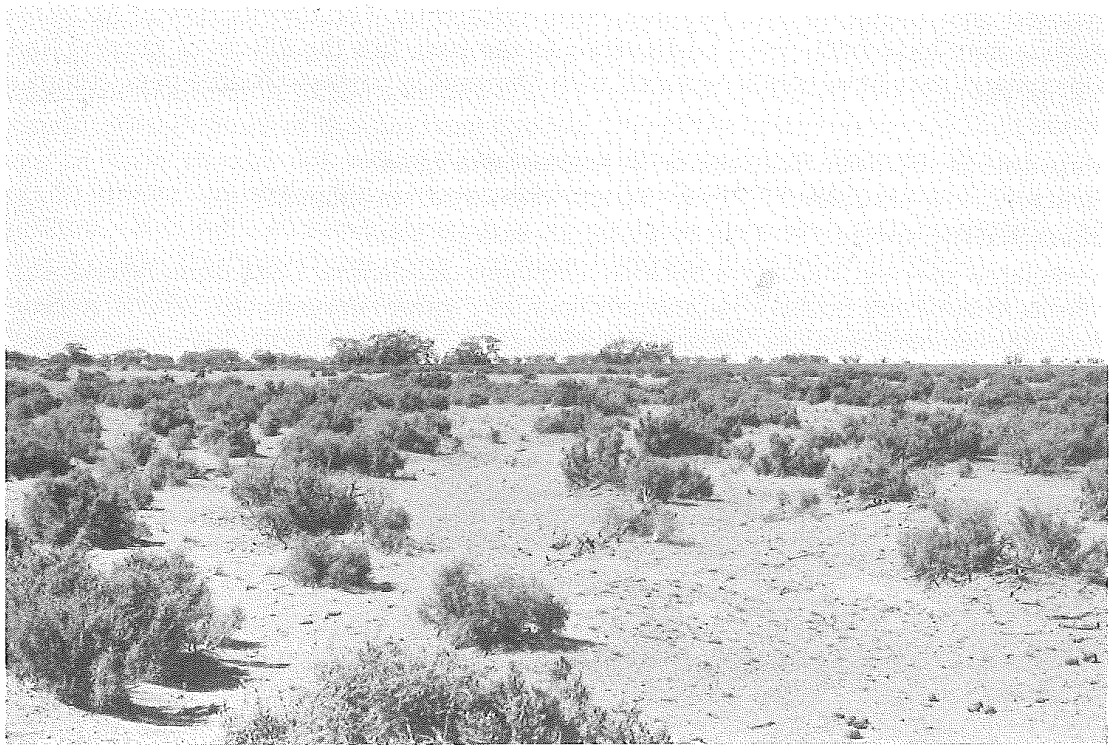

Figure 9. Black Bluebush shrubland (*Maireana pyramidata*) with very little ground cover after recent grazing.

Figure 10. Pearl Bluebush (*Maireana sedifolia*) occurs on the crests of an undulating plain with Black Bluebush (*Maireana pyramidata*) downslope.

mapped area where the soil becomes more calcareous. The distribution of *Maireana sedifolia* may have been more widespread in the past, but the effects of grazing and soil changes may have seen it replaced with *Maireana pyramidata* (Beadle pers. comm.).

Map unit 11: Bladder Saltbush with *Sclerostegia tenuis*
Structure: low shrubland *; open - sparse chenopod shrubland **
Characteristic species: *Atriplex vesicaria, Sclerostegia tenuis.*
Associated species: *Malacocera tricornis, Disphyma clavellatum, Dissocarpus biflorus* var. *biflorus, Brachycome trachycarpa,* annuals such as *Plantago drummondii, Senecio glossanthus, Brachycome lineariloba, Rhodanthe corymbiflora, *Bromus rubens, *Lamarckia aurea.*
Soils: Red and brown or yellow-grey compact clay or clay-loam soils.
Occurrence: In the eastern half of the region, the vastest areas in the north. It is often broken by areas of *Maireana pyramidata* (community 8) and *Atriplex nummularia* (community 19).
Comments: There is considerable variation in the degree of dominance of the two main species, ranging from the dominance of one with the absence of the other to varying abundance of both. In the north-east corner of the map area there are extensive shrublands dominated by *Sclerostegia tenuis* with small circular depressions of Canegrass, *Eragrostis australasica. Disphyma clavellatum* also occurs in this community in certain low-lying, saline areas but is not nearly as common as it is further west (Fox 1991) and it has not been mapped as a separate unit. One example of this is along the Nap Nap road on flat areas with *Atriplex vesicaria.* This community occurs in greater extent on the Riverine Plain to the east.

Map unit 13: Canegrass
Structure: grassland * & **
Characteristic species: *Eragrostis australasica*
Associated species: *Eleocharis pallens, Juncus aridicola, Juncus flavidus, Muehlenbeckia florulenta.*
Soils: Slightly saline, compact heavy grey clay soils on which water is ponded for several months (Cunningham *et al.* 1981).
Occurrence: Generally throughout the eastern half of the area in low-lying areas of swamps, table-drains and claypans within the chenopod shrublands of communities 11 and 21. Typically occurring in small depressions (each one unmappable at this scale) within *Atriplex vesicaria - Sclerostegia tenuis* shrublands (community 11) in the north-east of the map area. Areas with the highest occurrence of Canegrass depressions have been mapped as a mosaic unit 11/13. It also occurs along the old creekline of Box Creek on the Prungle Mail road. It is seen in larger stands south-west of Perekerten and may grow with Lignum and in the riverine communities.
Comments: Areas of canegrass are subject to regular, but generally not prolonged inundation (Semple 1990).

Map unit 16: *Callitris* mixed woodland
Structure: open woodland *; open woodland - isolated trees **
Characteristic species: *Callitris glaucophylla, Hakea leucoptera , H. tephrosperma.*
Associated species: *Eremophila longifolia, Dodonaea viscosa* subsp. *angustissima, Pittosporum phillyreoides,* also at times with *Alectryon oleifolius* subsp. *canescens, Casuarina pauper* or *Allocasuarina luehmannii, Acacia melvillei, Geijera parviflora.* Near the Murray River *Callitris preissii* subsp. *murrayensis* may replace *C. glaucophylla.*
Soils: Deep coarse-textured red and brown sands and sand-loams.

Occurrence: Usually as remnants on elevated red sandy ridges occurring throughout the region, usually corresponding to old source bordering dunes of prior streams and lakes. More common in the south-east such as near Condoulpe Lake, south of Balranald, though much of this has been cleared. One of the best remnants is 2 km north-east of 'Lyle' though this would have been more extensive in the past. Raised areas of old lunette remnants on the Murrumbidgee floodplain have remnants of this community, often with *Maireana pyramidata*. These areas have been heavily grazed and much of the previous shrub cover has been removed (Pressey *et al.* 1984).

C. glaucophylla with or without associated species may occur in a mosaic with Belah-Rosewood (community 4) in the mallee dune country and the undulating country in the north to the Balranald - Ivanhoe road.

Comments: Much of this community in the south-east of the region has been cleared leaving only a few isolated individual trees or roadside patches. The understorey is often disturbed by rabbits which find this soil ideal for burrowing with its sandier texture than that of the clays of the plains further east. The only regeneration of *Callitris* was observed in roadside remnants in the Swan Hill area. The isolated trees remaining in many of the paddocks in the Swan Hill area are indicative of a greater abundance in the past. In 1836 Mitchell reported sand hills in this area 'covered with pine' (Andrews 1986). Early settlers cleared most of this community for crops and used the hard timber of the *Callitris* for fence posts and buildings.

In the south *Callitris preissii* subsp. *murrayensis* may replace *Callitris glaucophylla*. These two species readily hybridize. Only isolated trees, often in cleared paddocks or roadsides remain. This community has not been separated here for mapping purposes as its remnant nature posed a difficulty to map.

The associated species, particularly *Eremophila longifolia* and *Dodonaea viscosa* subsp. *angustissima*, are occasionally seen in the south-east of the mapped area as forming a separate shrubland on source bordering dunes. These species are known locally as woody weeds.

Map unit 17: *Acacia melvillei* woodland

Structure: tall shrubland - low woodland *; open woodland - open shrubland

Characteristic species: *Acacia melvillei*

Associated species: *Enchylaena tomentosa, Sida corrugata, Rhagodia spinescens, Nitraria billardieri*, often with **Medicago* spp., *Tetragonia tetragonioides, Goodenia fascicularis* and *Zygophyllum* spp.

Soils: Brown-red loamy calcareous earths.

Occurrence: *Acacia melvillei* may form groves as a single dominant species. The largest of these is located just to the south and the north of Balranald, where they are large enough to be mapped as a separate unit. Grazing of stock and rabbits has resulted in a sparse understorey. Some resprouting of the acacias occurs, but generally very little regeneration is to be seen at present.

Groves of smaller size occur throughout the area, less so in the mallee of the north-west. *Acacia melvillei* also appears dotted throughout the south-east of the map area, often as one or two trees, possibly remnants of once larger areas that have been cleared or grazed.

Comments: *Acacia melvillei* may have been formerly included under *Acacia homalophylla* (Yarran). These 2 species are often confused.

Map unit 18: Lignum
Structure: open scrub *; shrubland - open shrubland **
This unit was not sampled, so information has been taken from literature.

- Murray River floodplain (Margules & Partners *et al.* 1990): *Muehlenbeckia florulenta, Einadia nutans, *Bromus rubens,* with or without *Chenopodium nitrariaceum;*
- Murrumbidgee (Pressey *et al.* 1984): *Muehlenbeckia florulenta, Senecio cunninghamii, *Medicago* spp., *Phalaris paradoxa.*

Soil: Strongly gilgaied, grey self-mulching clay soils (Pressey *et al.* 1984)
Occurrence: This community generally occurs on the floodplains at a higher elevation than *Eucalyptus camaldulensis* around the fringes of grey-soil open country (Pressey *et al.* 1984). It is most abundant in the Lowbidgee Area, under River Red Gum, (*Eucalyptus camaldulensis*) and Black Box, (*Eucalyptus largiflorens*) or as vast areas of monospecific stands. On the road to 'Yanga' station much of the Lignum has been cleared for cropping.
Comments: *Muehlenbeckia florulenta* (previously *Muehlenbeckia cunninghamii*) generally occupies areas that experience relatively infrequent (e.g. once in 3 years) but often prolonged flooding (Semple 1990).

Map unit 19: Old Man Saltbush
Structure: low shrubland *; open-sparse chenopod shrubland **
Characteristic species: *Atriplex nummularia*
Associated species: *Atriplex vesicaria, Rhagodia spinescens, Atriplex* spp., *Sclerolaena* spp.
Soils: Mostly on grey and brown clay soils, usually in flat or low-lying situations. Can be found on practically all soils and at all levels (Cunningham *et al.* 1981).
Occurrence: Throughout the mapped area except the mallee, in a range of situations. Most often on grey clay soils near *Eucalyptus largiflorens* woodlands and along drainage lines. The largest areas are just north of Yanga Nature Reserve and south of Waldaira Lake. The community also occurs on red-brown earths in other chenopod shrublands such as communities 8, Black Bluebush and 11, Bladder Saltbush with *Sclerostegia*, throughout the north-east sector of the map, for example on the Ivanhoe road north of Box Creek and along the old drainage line of Box Creek following Prungle Mail road, though separate populations are too small to map. Fig. 11.
Comments: The current distribution within these communities ranges from small clumps to scattered isolated individuals. This community had a much greater distribution on the Riverine Plain in the past, but has diminished as a result of grazing (Beadle 1948). It is deep rooted and a palatable species to stock (Cunningham *et al.* 1981).

Map unit 20: Bull Oak
Structure: open woodland *; isolated plants - isolated clumps **
Characteristic species: *Allocasuarina luehmannii*
Soils: Deep brown and red sands and sand-loam.
Occurrence: This community is found on sandy rises in the south-east of the map. Usually it is seen as a few single trees, rarely in groves as in *Casuarina pauper* and usually in association with *Callitris preissii* subsp. *murrayensis*. It is more frequent further east and thought to have originally occurred in association with *Callitris* which have been removed for fencing and building purposes (Cunningham *et al.* 1981). An example in the mapped area is near 'Lyle', south-east of Balranald, in the area of mixed *Callitris* woodland mentioned in the description for community 16. Isolated trees are

found on the corner of the Swan Hill and Moulamein roads south of Balranald. Also present here is Wilga (*Geijera parviflora*), *Acacia oswaldii* and *Callitris preissii* subsp. *murrayensis* and mallee nearby. This community was not extensive enough to be mapped as a separate unit.

Map unit 21: Cottonbush
Structure: low shrubland *; open-sparse chenopod shrubland **
Characteristic species: *Maireana aphylla*
Associated species: *Atriplex vesicaria, Atriplex leptocarpa, Nitraria billardieri, Sclerolaena* spp. and annual species *Calocephalus sonderi, Rhodanthe stuartiana, *Cotula bipinnata.*
Soils: Yellow-grey and grey clay soils.
Occurrence: Restricted to the south-eastern corner of the map area on flat plain country south of the Murrumbidgee River. For example along the Keri Keri road.
Comments: This community is typical of the Riverine Plain to the east. Commonly in association with *Atriplex vesicaria*, it occupies areas of flat plain, marking the westernmost edge of the Riverine Plain. The patches are discontinuous (unlike the community on the plain further east), broken up by the other landforms and associated vegetation types of this transition zone between the plain and the mallee. Many of the associated species are indicative of disturbance from grazing, the main land-use of this area.

Figure 11. Old Man Saltbush (*Atriplex nummularia*) in an area of restricted drainage, with Black Box (*Eucalyptus largiflorens*) in the background.

Map unit 22: Dillon Bush
Structure: low - low open shrubland *; sparse shrubland **
Characteristic species: *Nitraria billardieri*
This community usually occupies a disturbed area and can occur within most communities as a result of overgrazing or clearing. Associated species vary depending on the original vegetation. Usually there is a high percentage of grasses, weeds and annuals with the occasional shrub for example, *Einadia nutans, Sclerolaena spp.* and *Atriplex spp.* Annual grasses and Asteraceae commonly occur. *Nitraria billardieri* may be present only as an occasional shrub. Before European settlement, *Nitraria billardieri* probably occurred in very small quantities in the shrubland communities (Beadle 1948). Since then, the occurrence of this species has increased with the subsequent changes in landuse (Beadle pers. comm.).
Soils: usually clay and loam soils, often saline areas. In the Lowbidgee the soils are strongly gilgaied grey self-mulching clays (Pressey *et al.* 1984).
Occurrence: On plains and floodplains throughout the region, predominantly in the east, such as dry lakebeds that have been grazed or left after cropping, overgrazed areas, and previously cropped areas.

Map unit 23: Great Cumbung Swamp
This unit was not sampled and is taken from Pressey *et al.* (1984).
Structure: closed - open herbland *; closed - open grassland/forbland **
Characteristic species: *Phragmites australis, Senecio cunninghamii*
Associated species: *Paspalum distichum, *Cirsium vulgare, Pratia concolor,* often with **Hordeum leporinum,* and **Polypogon monspeliensis.*
Within this unit *Senecio cunninghamii* occurs on the higher ground on the edge of the swamp, with *Phragmites australis* in the swales and down to the upper limit of *Typha orientalis* which grows in the water.
Soils: Heavy clay soils.
Occurrence: In the Great Cumbung swamp at the far eastern edge of the map.

Map unit OA: Open Areas
'OA' indicates 'open areas' occurring mostly on the aeolian soils of the mallee country. They are thought to be naturally occurring areas of heavier soil (Eldridge pers. comm.) supporting shrubs, herbs and grasses. Within the Sandplain Mallee many of the 'open areas' follow old drainage lines. Within Mallee Cliffs National Park, Morcom and Westbrooke (1990) referred to these areas as 'herbland - open herbland' resulting from the modification of chenopod shrublands or arid woodlands caused by grazing pressure.
Some of the less disturbed open areas to the north of and on the eastern boundary of Mallee Cliffs National Park support Pearl Bluebush (*Maireana sedifolia*) shrubland (community 9). Close to tanks, stocking pressure may have reduced many of these areas to predominantly grasslands. South of Mallee Cliffs National Park the open areas occasionally have patches of Belah (*Casuarina pauper*). Some areas of mallee cleared for grazing in the earlier years may have partially regrown where lignotubers have not been completely removed (Fitzpatrick 1982) creating areas of open mallee.
Open areas in the mallee west of Euston are a result of frequent prescribed burning. Three fires in the space of seven years have led to a depletion of mallee in the swales creating open grasslands (Noble 1984). Common species include *Sclerolaena obliquicuspis, Stipa nitida, Stipa nodosa,* often with *Dissocarpus paradoxa, Salsola kali,* and **Silene apetala.*

Discussion

Distribution of plant communities

The major cause of variation in vegetation in semi-arid south-eastern Australia is the interaction between soil texture and rainfall (Noy-Meir 1974, Beadle 1948). Within the mapped area the distribution of the vegetation communities also strongly reflects landform.

Aeolian landscape

Mallee dominates the aeolian sandsheet that stretches across South Australia, northern Victoria and south-western New South Wales. Within this map sheet differences in species composition and structure resulted in the four broad mallee communities described. The various mallee communities mapped overlap and grade into each other. The map attempts to reflect the major trends. A high variability of species composition was observed in the mallee which would only be objectively delineated with extensive sampling.

Dune Mallee predominates in the west and north of the map, but varies from north to south. In the north the dune-crests are dominated by Dune-Crest Mallee (3b) with species such as *Triodia scariosa, Eucalyptus costata* and *Callitris verrucosa* restricted to the deep sands. The swales, where the soils are heavier and have a greater clay content, support Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) (community 4). It was not feasible at this scale to map the individual clumps of Belah-Rosewood in the swales. For mapping purposes these two communities have been combined as a mosaic unit due to the consistent recurring pattern. This pattern is more extensive to the west and north of this map. This unit mapped is equivalent to unit 5 in Fox (1991).

In the south this pattern changes with swales comprising mallee (3c) with a chenopod dominated understorey. There is an occasional Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) patch but these are isolated and do not follow the pattern observed further north. Larger patches of Belah-Rosewood appear in the Sandplain Mallee in the centre of the region, though many of these have been cleared.

The sandplains are devoid of dunes and have heavier soils with a greater water-holding capacity. There is a dominance of chenopods in the understorey and the trees are often larger and with fewer stems. They are structually referred to as 'bull mallee' as opposed to 'whipstick mallee' typical of the dune crests (Beadle 1948). In western NSW these growth forms are thought to be a result of differences in soil type (Beadle 1948) or more recently, of fire occurrence (Noble 1982). *Triodia scariosa* on the dune crests is more flammable than the shrubs in the understorey of the swales and sandplains. When 'bull' mallee is burnt, often after the buildup of *Stipa* spp. in the understorey, it regenerates first as a 'whipstick' form but eventually regains its 'bull' mallee form (Noble 1982). Fire in the mallee can also create differences in floristic composition at different stages of regeneration (Brickhill 1988, Noble 1989). Within the mapped area the last major fires were in 1974-75, but there were experimental fires just west of Euston in 1980 and 1982 (Noble 1984). Open treeless areas within the mallee are flats of hard pedal red duplex soils (Walker 1991) supporting grasses and herbs. Many such areas have been caused by frequent fires (Noble 1984).

The Sandplain Mallee community correlates closely with the soil-landform association type 'O1' of Eldridge (1985). This form of mallee is similar to the 'chenopod mallee' of the Sunset country in Victoria (Land Conservation Council 1987).

A larger percentage of Sandplain Mallee has been cleared than of the other mallee types. The topography is flatter, the soil is heavier and less susceptible to erosion as well as being easier to clear.

Of higher preference for clearing is Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) woodland. This community occurs on the lower flatter areas within the aeolian country in the west, and on the undulating country in the transition between the aeolian landform to the riverine plain in the east. It is far more extensive to the north and north-west of the mapped area (Fox 1991, Beadle 1948). This community shows the greatest variability of all the communities mapped. Structurally it forms woodlands covering fairly large areas such as on the northern boundary of Mallee Cliffs National Park, or isolated clumps in chenopod shrublands as on the undulating country bordering the riverine plain. Floristically it commonly consists of a mixture of the two tree species, or single-species stands of either species often appearing in groves.

Often associated with the Belah-Rosewood woodlands is Black Bluebush (*Maireana pyramidata*) shrubland (community 8). This community is the most widespread of the shrublands in the mapped area. It occurs most commonly on the undulating country marking the transition from the riverine plain in the east to the aeolian sand dunes to the west. It is closely associated with lunettes and source-bordering dunes of old river systems. The soils have a lower clay content on these elevated areas than on the riverine plain. Pearl Bluebush (*Maireana sedifolia*) (community 9) is less common but also found on this landform, often mixed with and/or on slightly higher elevated land than community 8. Extensive areas of this community occur west of the mapped area and into South Australia where the soil becomes more calcareous (Scriven 1988b, Dalton 1988).

Fluvial landform

The vegetation on the eastern edge of the map sheet begins to reflect the Riverine Plain vegetation. Communities extensive on the grey-brown clays further east occur as discontinuous patches in the transition zone between the plain and the mallee. Bladder Saltbush (*Atriplex vesicaria*) with *Sclerostegia tenuis* (community 11) occurs throughout this zone but is more extensive in the north in association with Canegrass (*Eragrostis australis*) depressions. South of the Murrumbidgee River, Cotton Bush (*Maireana aphylla*) (community 21), commonly in association with *Atriplex vesicaria* occupies flat plain areas of grey clay soils. Many of the species in this community are indicative of disturbance from grazing. This trend in the shrubland communities continues further east onto the Hay Plain.

The landforms associated with the prior stream traces which cut across the Hay Plain continue into the south-east of the mapped area. The old raised stream beds and source-bordering dunes support remnant *Callitris* Mixed Woodland (community 16) and Black Bluebush (*Maireana pyramidata*) (community 8). Extensive clearing of *Callitris* has had the result that only remnants of this community remain. These remnants are highly threatened also by the grazing of stock and goats, and the destructive burrowing of rabbits, which prefer the sandier soil of this habitat to the clays of the Riverine Plain.

The only 'forest' type vegetation on the map sheet is Riverine Forest (community 1) dominated by *Eucalyptus camaldulensis* (River Red Gum). This community continues along the length of the inland rivers from NSW into South Australia, differing along its length in its associated species (Margules & Partners *et al.* 1990). Closely associated is Black Box woodland (*Eucalyptus largiflorens*) (community 2), also continuing to the

east and the west, and patches of Lignum (*Muehlenbeckia florulenta*) (community 18). A comprehensive study of the Murray River system has been prepared by Margules & Partners *et al.* (1990) for the Murray Darling Basin Commission giving greater detail of the vegetation than presented here.

Old Man Saltbush (*Atriplex nummularia*) (community 19) may grow on many soil types (Cunningham *et al.* 1981) but is found in greatest numbers on the floodplains and the loamier soils of the undulating country of the 'transition zone'.

Species composition and variability of the vegetation

A total of 81 families of plants were represented in the mapped area, the main ones being Chenopodiaceae, Asteraceae and Poaceae. These families contain a large number of annual and short-lived perennial species.

A major drawback with this form of mapping in the semi-arid region is the lack of sampling throughout the year and from year to year. Similarity of plant community composition between sequential seasons in south-western New South Wales is very low, commonly 55–70%, with the turnover of the ephemeral component of the understorey very great (Fox 1990). Fox (1990) has found both the number and particular combination of species is a function of the seasonal rainfall. This mapping project has largely based the community descriptions on perennial species. Many of the annual grasses and herbs were not specific to a particular shrubland community, but are very widespread. Common annual and short-lived perennial species are the grasses **Hordeum leporinum*, **Bromus rubens*, *Danthonia caespitosa*, *Stipa* spp.; and forbs such as *Rhodanthe* spp., *Brachycome lineariloba*, **Sonchus oleraceus*, *Senecio glossanthus*, *Vittadinia* spp., (Asteraceae); *Atriplex lindleyi*, *Atriplex pseudocampanulata*, *Sclerolaena brachyptera*, *S. muricata*, *S. diacantha* (Chenopodiaceae); and a number from other families such as **Medicago* spp. (Fabaceae). A large component of the annual flora are introduced species.

Landuse and changes to native vegetation

The vegetation of the mapped area has been altered since the European settlers came to the area 160 years ago. The degree of disturbance increases generally from the north to the south of the mapped area, that is, along a gradient of water availability and better soils. The following impacts on the native vegetation were observed, but not investigated, in the course of this study.

Grazing effects

The grazing of sheep on native pastures is the main land use of the region (Semple 1989). Some cattle grazing occurs on the eastern edge of the mapped area. Grazing of the Riverine Plain in the east has occurred since 1830. By the 1840s there were reports that grazing had led to the reduction of the proportion and the regional distribution of saltbushes (*Atriplex* spp. and *Sclerolaena* spp.) replacing them with grasses (Williams 1962 & Buxton 1967 cited in Butler *et al*, 1973). Scriven (1988*b*) outlines the effects of grazing as reflected in the change in composition and biomass of the vegetation, and the compaction and erosion of the soils. Areas of Dillon Bush (*Nitraria billardieri*) (community 22) are indicative of disturbance from grazing and clearing.

The mallee country was less suitable for grazing because of its low productivity, inaccessibility and lack of reliable water supplies. However, grazing occurs throughout the mallee and in Mallee Cliffs National Park high levels of weediness can be directly linked with previous grazing history (Westbrooke 1990).

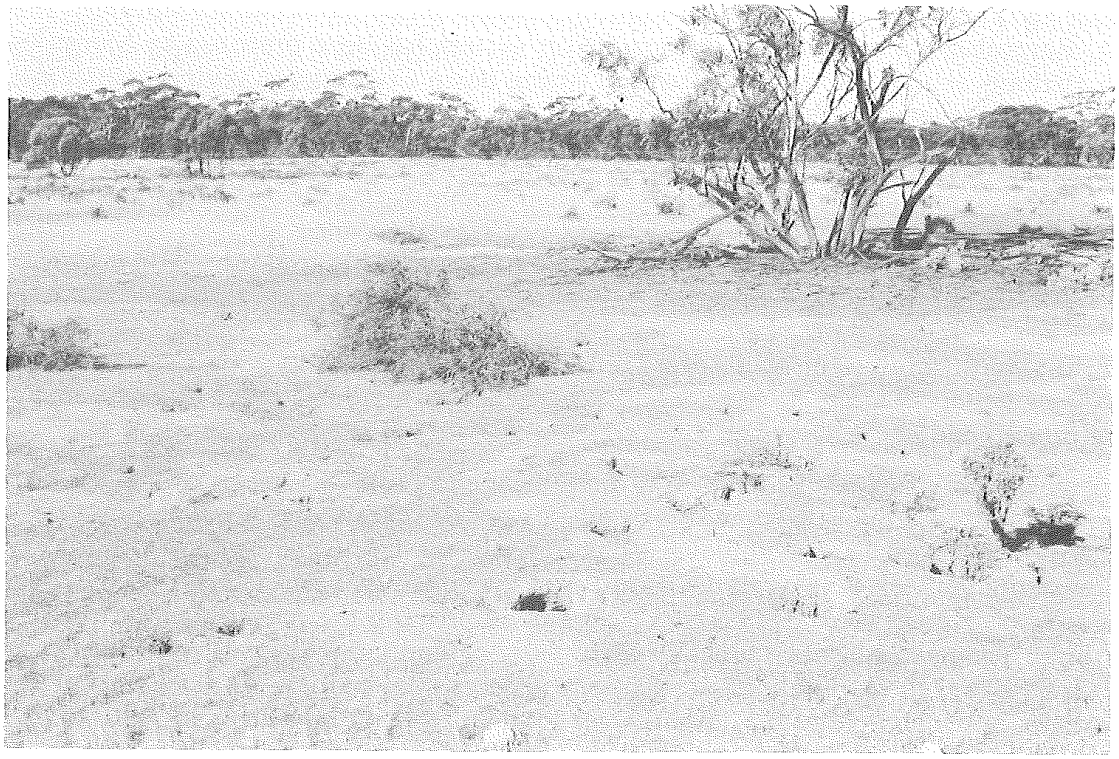

Figure 12. Disturbance by rabbits is a problem in areas with sand and loam soils, such as this area of cleared mallee.

Figure 13. *Callitris* woodland has been extensively cleared for cropping and for the use of its timber. In the south, often a lone tree in a cleared paddock is indicative of its once greater abundance.

Rabbits and goats compete with sheep and native fauna for forage. This places added pressure on the native vegetation. Continual grazing changes the original herbaceous ground layer of predominantly perennial native plants to predominantly annual species with a high percentage of introduced weeds (Land Conservation Council Victoria 1987, Calder 1990). Large areas of Belah (*Casuarina pauper*) and *Callitris* woodland and 'savannah mallee' in Victoria have been so degraded from grazing that the original community is being destroyed and replaced by annual herblands and grasslands (Land Conservation Council Victoria 1987).

Lack of regeneration, particularly in the woodland communities, seen in the course of this work and by other authors (Wilson *et al.* 1976, Chesterfield and Parsons 1985) is a serious problem that needs immediate attention. Fig. 12.

Clearing and Cropping

The Weimby-Kyalite area south-west of Balranald, and the Benanee area to the north-east of Euston are major dryland cropping areas in the Western Division. They are regarded as marginal cropping areas because of the low and erratic rainfall (Eldridge & Semple 1982). The greatest clearing has occurred very recently, with a ten-fold increase in dryland cropping in the Western Division since the mid-1960s (Pressey 1990).

This agricultural use started with small-scale cropping for horse feed and was replaced by commercial cropping on soldier settlements in the 1920s (Mabbutt & Williamson 1982). Over-clearing and over-cultivation in the Benanee area caused serious soil erosion in the early years (Alchin 1980).

The original vegetation for this area was mallee and Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) woodland growing on calcareous sands and earths and red and yellow duplex soils. The woodland was preferentially cleared because of its more suitable soil type for cropping and the greater ease of clearing than the mallee with its large lignotubers (Stanley & Lawrie 1980). Dryland cropping has also occurred in the old lake beds around Balranald, where the previous vegetation was probably chenopod shrublands or grasslands. The principal crops are wheat, barley and other cereals.

Adverse effects of land clearing in this landscape have been outlined by authors Melville, Mabbutt, Williamson and Dodson in Mabbutt (1982), Leys (1990) and Pressey (1990*c*). They include a decline in the abundance and diversity of species, fragmentation and reduction in the area of some natural environments, and changes in the water balance of the soils that lead to soil erosion and invasion of noxious weeds.

Clearing is more extensive in the Central Division of NSW., which consists of freehold land, where there are less restrictions. Clearing in the Swan Hill area has left very little remaining natural vegetation. Only remnant trees in paddocks and on roadsides remain of the previously extensive *Callitris* woodlands (Andrews 1986). Black Box (*Eucalyptus largiflorens*) would also have covered much of the floodplain here. Fig. 13.

The Lowbidgee District to the east of Balranald and south of the Murrumbidgee River, has the most agriculturally productive land due to its fertile alluvial soil and water supply (Department of Water Resources 1991). Grazing is the dominant land-use, supplemented by the growing of agricultural crops. This area has the best stands of Lignum (*Muehlenbeckia florulenta*) in NSW (Department of Water Resources 1991). Landholders use the Lignum for grazing stock and 40% has been cleared for cropping.

In the immediate surroundings of the towns of Balranald, Euston and Swan Hill, and along the Murray River, irrigation is used for crops of predominantly grapes and citrus. The native vegetation affected in these areas would most probably have been Black Box (*Eucalyptus largiflorens*) woodlands, on the grey clay soils of the floodplain, and *Callitris* Mixed Woodland, on the sandier rises.

Fire

Fire has been used by landholders to clear mallee land, manage native pastures for maximum grazing production, and protect life and property by fuel reduction. Prescribed burning, however, is out of phase with the natural wildfires which occur in semi-arid lands every 10–15 years or longer (McArthur 1972). The last major wildfire in the area was in 1975. Prior to European settlement, however, Aboriginal burning practices would have influenced the vegetation over a long period of time. In western New South Wales generally, Aborigines used fire for food-gathering and hunting (Mullins *et al.* 1982).

The mallee communities are the most fire-prone due to the presence of a flammable canopy and grassy understorey. The buildup of speargrass (*Stipa* spp.) in the swales following good seasonal rains produces abundant fuel for fires (Noble 1984). Noble has shown, in an area west of Euston, that two or three fire events in quick succession can markedly reduce mallee densities creating open areas. Gill (1990) and Ludwig *et al.* (1990) recommend predictive modelling and monitoring of mallee vegetation and fire events to ensure species conservation.

Salinity

Salinity has been a part of the semi-arid landscape since Pleistocene time (Macumber 1990). Land use changes over the last one hundred years however, has led to a rise in salinisation. River salinity of the Murray is outlined in Margules & Partners *et al.* (1990). Dryland salinity results from a rise in the water table bringing dissolved salts to the surface. It is caused by the clearing of trees which no longer remove the water from the soil, increasing the recharge rate to the water table. Clearing and farming practices used over the last fifty years in the Balranald area have resulted in an approximate 100-fold increase in recharge to ground water (Budd *et al.* 1990*a*). The sandier soils of the mallee have higher recharge rates than the soils with a higher clay content (Budd *et al.* 1990*b*).

Salinisation has been observed at two sites near Balranald and may be contributing to poor crop yields on dry lake beds (Eldridge & Semple 1982). The land-use and prevailing climate will determine the rate of increase and future extent of salinisation (Macumber 1990). The management of soil salinity across south-east Australia is discussed in Humphreys *et al.* (1990). Retention of native vegetation, particularly mallee on the highly susceptible light-textured soils, will reduce future salinisation problems.

Feral animals

Cooke (1990) outlines the damage in mallee lands caused by rabbits, goats, foxes, cats, hares, house mice and feral pigs. The effect of grazing in the riverine communities is reviewed by Margules & Partners *et al.* (1990). Besides sheep, the two introduced animals that have greatest impact on the native vegetation are rabbits and goats. Evidence of rabbits are most apparent in the 'transition zone' between the plain and the aeolian landscape. They also prefer calcareous red earths (Parer & Libke 1985) for burrowing, leading to erosion and damage to plant roots. They destroy

the vegetation by grazing and ringbarking. Poison baits and ripping of warrens is the present method of rabbit control, since myxomatosis appears to be becoming less effective. Different means of future biological control may be a long-term means of controlling rabbit numbers.

Goats are found in greatest numbers in the aeolian sand country in mallee shrublands and Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) and *Callitris* woodlands. Their grazing of native vegetation may lead to changes in the composition of the tree and shrub components in some woodland communities (Wilson *et al.* 1976). Whilst sheep prefer short herbs, goats are more selective in their feeding and may pull down branches and climb into bushes (Downing and Mitchell 1988).

Erosion

Wind erosion leads to the removal of nutrients, the reduction of water-holding capacity on sandy soils, and exposure of the hard clay subsoils of the duplex soils (Land Conservation Council 1987, Soil Conservation Service 1989). Where the exposed clay subsoils are saline, they are referred to as *scalds*. This is the most obvious form of erosion within the mapped area, associated with old stream traces and lake systems, for example in the system to the north-west of Morvan Tank in the north-east corner of the mapped area. Scalding was noted throughout the area in the 1940s by Beadle (1948). The process of scalding is accelerated by the removal of protective vegetation by overgrazing, clearing and inappropriate cropping practices (Margules & Partners *et al.* 1990). Methods for rehabilitation of eroded areas are outlined in Scriven (1988b). As with the salinity problem, retention of native vegetation will reduce erosion. Fig. 14.

Figure 14. Overgrazing, clearing and inappropriate cropping practices may lead to vast areas of scalding.

Introduced Plants

The spread of weeds is largely associated with cropping (Eldridge and Semple 1982) and grazing (Margules & Partners *et al.* 1990, Wilson & Harrington 1984). Introduced plants seen to be particularly abundant are annuals such as **Hordeum leporinum*, **Bromus* spp., **Brassica tournefortii*, **Medicago* spp., **Sisymbrium irio*, **Sonchus oleraceus*, **Malva parviflora*. The perennial **Marrubium vulgare* (Horehound) is common along roadsides. These are replacing native perennial grasses and forbs. In all, 19% of species recorded for the mapped area are introduced. The native shrub *Nitraria billarieri* (Dillon Bush) has also colonized disturbed shrubland areas.

Conservation of the vegetation

Reserves

There are only two conservation reserves in the mapped area, and these cover only about 3% of the area.

Yanga Nature Reserve, gazetted in 1972, is located approximately 25 km by road east of Balranald. It consists of 1772 ha, mostly of Black Box (*Eucalyptus largiflorens*) woodland (community 2) with a few open areas of grasses and herbs. On a few of the raised areas are the remains of mud ovens from Aboriginal occupation of the area. These important archaeological sites are threatened by the impact of rabbits burrowing and breaking up the earthen mounds.

Mallee Cliffs National Park, gazetted in 1977, is located approximately 35 km north of Euston. Approximately 90% of the 57 969 ha is located in the mapped area, the remainder is on the adjacent Mildura map sheet to the west. The dominant plant community is mallee with areas of Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) woodland. This area contributes to the 2814 sq km or 6% of the mallee land systems conserved in the Western Division of NSW (Pressey *et al.* 1989). Rabbits and goats are a problem in the Park.

The southern-most part of the Willandra Lakes World Heritage Region occurs in the mapped area. It is a system of now dry lakes fed by Willandra Billabong Creek, a former distributary of the Lachlan River. It was declared a World Heritage area due to its outstanding cultural values (Australian Heritage Commission 1980). The lakes on the properties of 'Prungle', 'Benenong', 'Gulthul', 'Koolaman' and 'Banoon' are within the mapped area. Grazing continues in these areas under lease conditions administered by the Western Lands Commission. Mungo National Park, to the north of the mapped area, covers a part of the World Heritage area.

Conservation of vegetation communities

Benson (1989) lists the conservation status of most of the major plant communities in western New South Wales as poor or very poor, noting that the greatest impacts of European settlement have been from clearing and grazing, leading to a reduction in abundance and composition of the understorey. Within the mapped area most of the plant communities are not represented in reserves.

In the semi-arid region conservation studies have recently focussed on the mallee (Noble *et al.* 1990; Groves & Parsons 1989; Pressey *et al.* 1990*a*; Brickhill 1988; Urwin 1981). As a result some large areas of mallee such as Nombinnie Nature Reserve to the north of the mapped area, have been recently conserved.

Within the mapped area Irregular Dune Mallee (3a), Dune-Crest Mallee (3b) and Swale Mallee (3c) are represented in Mallee Cliffs National Park. Sandplain Mallee (3d) has limited representation on the eastern edge of the Park. It is the main mallee community licenced for clearing. Of this community ('chenopod mallee') 180 km^2 has been conserved in Victoria (Land Conservation Council 1987). This is 11% of the total for that state (Pressey *et al.* 1990a).

Belah-Rosewood (*Casuarina pauper - Alectryon oleifolius* subsp. *canescens*) (community 4), is also conserved in Mallee Cliffs National Park but occurs as a dominant over only 13% of the Park (Morcom & Westbrooke 1990). It is not conserved in the undulating transition zone or on the floodplain south-east of Balranald, where it occurs on the Condoulpe land system (Walker 1991). Cropping is widespread in areas occupied by this community. It also suffers from a severe reduction of understorey structure and lack of regeneration of the dominant species. Studies of the regeneration of these species have shown that grazing pressure is the major cause of decline in the populations (Chesterfield & Parsons 1985). Feral goats browse Belah and Rosewood and may change the tree and shrub component of this community (Wilson *et al.* 1976).

The *Callitris* Mixed Woodland (community 16), is one of the most threatened communities in the mapped area. It has been heavily cleared in the past and little regeneration is occurring. It is particularly vulnerable along the Murray River where *Callitris preissii* subsp. *murrayensis* occurs. Only remnants remain, often consisting of roadside trees with the understorey removed or heavily disturbed by rabbits. Most trees observed were very old and often visibly senescent. Very little recruitment is occurring.

Similarly, Bull Oak (*Allocasuarina luehmannii*) (community 20) in the south-east of the region is in poor condition. This, together with *Callitris preissii* subsp. *murrayensis*, is one of the most threatened communities in the mallee region of Victoria (Blakers & Macmillan 1988). They report that widespread degradation has resulted from grazing and weed invasion with all the best remaining areas, comprising less than 1% of the original cover, classed as 'disturbed'.

Likewise, there are no reserves conserving the riverine vegetation within the mapped area. Kemendok Nature Reserve (1 043 ha) is just west of the mapped area and is the only reserve along the Murray River in New South Wales that conserves Riverine Forest dominated by *Eucalyptus camaldulensis* (River Red Gum) (community 1). Margules and Partners *et al.* (1990) noted a general poor condition of the vegetation along the Murray River resulting from clearing, grazing, river regulation and soil salinisation.

Acacia melvillei shrubland is not conserved in any reserve system. Benson (1989) lists the inland *Acacia* and *Casuarina* shrublands/woodlands as one of the groups with the poorest conservation status in New South Wales. The scattered nature of the groves and individual plants of this species do not lend themselves easily to reserve protection. Retention of this community through altered management practices by individual property managers may be an answer to the its future survival.

Benson (1989) lists all chenopod shrublands as poorly conserved. Grazing has an impact on all the communities. None of the shrublands are conserved within the mapped area. The most threatened is Old Man Saltbush (*Atriplex nummularia*) (community 19) which has declined since European settlement. Similarly, no areas of Bladder Saltbush (*Atriplex vesicaria*) with *Sclerostegia tenuis* (community 11), Cottonbush (*Maireana aphylla*) (community 21), or Canegrass (*Eragrostis australasica*) (community 13) are reserved in the mapped area, or on the riverine plain to the east where they are more extensive.

Table 3. Species of particular conservation significance within the Balranald – Swan Hill 1:250 000 map sheet area. (a) = species nationally listed as rare or threatened (Briggs & Leigh 1988). (b) = species with restricted distributions in the Western Division of NSW (Pressey *et al.* 1990*b*).

(a) Taxa	Risk Code	Habitat
ASTERACEAE		
Brachycome papillosa	3V	On saltbush plains on grey clay soil.
BRASSICACEAE		
Lepidium monoplocoides	3ECi	Woodlands near the Murray & Murrumbidgee River junction.
CALLITRICHACEAE		
Callitriche cyclocarpa	3V	Aquatic herb on Murray-Wakool floodplain.
SOLANACEAE		
Solanum karsensis	3RCa	On river floodplains & flooded depressions or lakebed, or disturbed area in mallee.
POACEAE		
Stipa metatoris	3V	On sandy rises with *Callitris* Mixed Woodland & mallee on red-brown sandy-loam.
Stipa wakoolica	2K	Floodplain on grey sandy-loam to clay-loam.

(b) Taxa	Category/ priority	Habitat
ASTERACEAE		
Podotheca angustifolia	3B/4	In mallee on deep red sand.
Rhodanthe tietkensii	3B/4	In mallee on sandy soils.
Senecio murrayanus	3B/4	In woodlands.
BRASSICACEAE		
Pachymitus cardaminoides	3B/4	An ephemeral species on sandy soils.
CHENOPODIACEAE		
Sclerolaena limbata	3B/4	Heavy slightly saline soils.

FABACEAE		
Swainsona murrayana	3A/2	Grey & brown heavy clay & clay-loam soils in shrublands, Black Box & grassland communities.
Templetonia sulcata	3B/4	In mallee on sandy red earths.
MALVACEAE		
Lawrencia squamata	3B/4	In shrublands of *Maireana sedifolia*.
MYRTACEAE		
Eucalyptus porosa	3B/4	In mallee on sandy-loam soils.
POLYGONACEAE		
Muehlenbeckia diclina	3B/4	In mallee.
RUBIACEAE		
Opercularia turpis	3B/4	In mallee in the Balranald-Euston area.
SANTALACEAE		
Exocarpos sparteus	3B,4A/4	In mallee near Euston.
Santalum murrayanum	3B/4	In mallee near Euston.
THYMELAEACEAE		
Pimelea simplex subsp. *continua*	3B/4	On heavy-textured soils or sometimes in red sand.
ZYGOPHYLLACEAE		
Zygophyllum angustifolium	not yet allocated	On calcareous red & brown soils in mallee or chenopod shrublands.
CYPERACEAE		
Gahnia lanigera	3B/4	In mallee.

Risk Codes in Briggs & Leigh (1988). **2** Maximun geographic range of 100 km. **3** Range over 100 km but restricted to highly specific habitats. **E** Endangered species at risk with one or two decades under present land use. **V** Vulnerable species at risk over a longer period. **R** Rare within Australia. **K** Poorly known, field distribution information is inadequate. **Ca** adequately reserved with 1000 or more plants in a reserve. **Ci** inadequately reserved with less than 1000 plants in a reserve.

Category and Priority Codes in Pressey *et al.* (1990b). **3** Species restricted in the Western Division but also occurs interstate with **A**: few records, or **B**: many records. **4A** has disjunct occurrences in the Western Division with the main population interstate. **2** protection in the Western Division for these rare and/or threatened taxa is very important. **4** protection in Western Division is desirable to conserve the genetic variation within the ranges of the taxa.

Stands of Black Bluebush (*Maireana pyramidata*) and Pearl Bluebush (*Maireana sedifolia*) (communities 8 and 9) are reserved north of the mapped area in Mungo National Park. Forty per cent of the Park consists of the 'Mungo landsystem' (Walker 1991) dominated by these shrublands and Bladder Saltbush *Atriplex vesicaria*.

The Lowbidgee District has the best stands of Lignum (*Muehlenbeckia florulenta*) in New South Wales and possibly south-eastern Australia (Department of Water Resource 1991). A Plan of Management for the District by the Department of Water Resources (DWR) is near completion. Information from the draft of the management plan (DWR 1991) indicates that it is also one of the most significant wetland habitats for water birds, particularly ibis, in eastern Australia. As it is also highly productive agricultural land, clearing has removed 40% of Lignum in the last 20 years, the remainder is grazed. 'Protected lands' have been established but they do not preclude grazing activities. The water flow to the whole area is under control of the DWR. Smaller areas of Lignum occur along the Murray floodplain but have not been separated at this mapping scale (see Margules and Partners *et al.* 1990).

Conservation of species

Of all vulnerable plants in NSW, 44% occur on the western slopes and plains (Benson 1989). Pressey *et al.* (1990*b*) lists 239 plant taxa with restricted distributions in the Western Division. Of those, some species are considered endangered, vulnerable or rare (Briggs & Leigh 1988). Table 3 lists the species of conservation significance for the mapped area. Data for the rare or threatened species have been provided from ROTAP database (NSW National Parks & Wildlife Service).

Options for improving conservation

The two existing reserves conserve only a small part of the diversity of plant communities. The major conservation concerns result from the effects of the agricultural practices of grazing and clearing. The dedication of further areas as conservation reserves and the modification of land-management practices may improve the current situation.

Such improvement may be achieved by encouraging retention of native vegetation. Fencing off areas of native vegetation to exclude stock and rabbits facilitates the regeneration of the tree and shrub species and helps to restore the understorey. This is particularly necessary for the survival of the *Callitris* Mixed Woodland on the source-bordering dunes. Retention of native vegetation also is a means of preventing salinisation and soil loss.

Acknowledgements

I wish to thank Marilyn Fox who initiated the project and provided her knowledge on the vegetation of the area, data from permanent sites and field assistance. Thanks are due also to John Benson, Doug Benson and Lawrie Johnson for advice and comments on the text. John Benson and Vicki Logan also provided field assistance and Jocelyn Howell, Liz Norris, Marianne Porteners, Peter Bowen and Paul Flemmons assisted throughout the project. I thank Anne Parsons and Martin Westbrooke for unpublished site data, and David Eldridge for comments on the map. Thanks are due also to the staff of the National Herbarium of NSW for identifying plant specimens, to the National Parks and Wildlife Service for information on reserves and rare species, and to the landowners and leaseholders for access to their land and local knowledge.

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APPENDIX 1

Species list for communities identified on the Balranald – Swan Hill 1:250 000 map sheet. (Key on page 652).

Botanical name	**Community**				**Other Records**
	forest	mallee	w'land	shrub/grasslands	
PTERIDOPHYTES					
Adiantaceae					
Cheilanthes austrotenuifolia			4		
Azollaceae					
Azolla filiculoides	1				e
Marsileaceae					
Marsilea drummondii	1 2				
M. hirsuta					a
GYMNOSPERMS					
Cupressaceae					
Callitris glaucophylla		3b	4 16		
C. preissii subsp. *murrayensis*			16 20		
C. verrucosa		3b			
ANGIOSPERMS					
Aizoaceae					
Disphyma crassifolium subsp. *clavellatum*	1 2			11	
Glinus lotoides	1 2				
**Psilocaulon tenue*		3c3d	4		
Tetragonia tetragonioides	2	3c3d	4	9 21	
Amaranthaceae					
Alternanthera denticulata	1 2				
A. nodiflora	2				ac
**A. pungens*					a
A. sp. *A*				17	
Amaranthus macrocarpus	1				
Ptilotus atriplicifolius					
P. exaltatus var. *exaltatus*		3b			bc
P. nobilis		3c			
P. obovatus var. *obovatus*			17		
P. seminudus		3c			c
P. spathulatus		3b3c	4 17		
Apiaceae					
Daucus glochidiatus	2	3b	4 17	8 9 11 21	
Eryngium plantagineum					a
Asclepiadaceae					
Marsdenia australis		3c			
Asteraceae					
Actinobole uliginosum		3b	4 16 17	9	
Angianthus brachypappus				11	
A. tomentosus		3d			

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Asteraceae (cont'd)					
**Arctotheca calendula*		3c	4		
**Aster subulatus*					ab
Brachycome basaltica var. *gracilis*	1		4	23	
B. ciliaris var. *ciliaris*		3b3d	4	8	
B. goniocarpa	2				a
B. gracilis	2				a
B. lineariloba	2	3b3c	4 17	8 9 11 19	
B. papillosa					g
B. trachycarpa	3c				
Bracteantha bracteata [*Helichrysum bracteatum*]			4 17		
Calocephalus sonderi	1 2		4 16	11 21	
Calotis cuneifolia	1 2				a
C. erinacea					a
C. hispidula		3b3c3d	4	8 9	
C. scabiosifolia var. *scabiosifolia*	2				c
C. scapigera	af	2			
**Carthamus lanatus*	1		17		
Cassinia arcuata					b
**Centaurea melitensis*	2	3d	4 17	8 9 22	
Centipeda cunninghamii	1 2			22 23	
C. minima	1				aef
C. thespidioides	2				ac
**Chondrilla juncea*	1				
Chrysocephalum apiculatum [*Helichrysum apiculatum*]		3b	16		cd
**Cirsium vulgare*	1 2			22 23	
**Conyza bonariensis*	1				
Cotula australis	1 2				
**C. bipinnata*				11 21	
C. coronopifolia				23	e
Cymbonotus lawsonianus	1 2				a
Dittrichia graveolens	1				af
Eclipta platyglossa	1 2				
Elachanthus pusillus		3d			c
Epaltes australis	1 2				a
E. cunninghamii					a
Eriochlamys behrii				8 11	
Gnaphalium sphaericum	2		4		ac
**Hedypnois rhagadioloides* subsp. *cretica*			4 17	8 9 22	
Helichrysum leucopsideum		3c			b
Hyalosperma demissum [*Helipterum demissum*]	2				c

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Asteraceae (cont'd)					
H. semisterile [*Helipterum jessenii*]	2		17	9 11	
**Hypochaeris glabra*	1 2	3b	4 5 17	8 9 11	
**H. radicata*	2		4	9	c
Isoetopsis graminifolia	2	3b3c		9	abcd
Ixiolaena chloroleuca					a
I. leptolepis				21	
**Lactuca serriola*	1 2				a
Leucochrysum molle [*Helipterum molle*]			4		c
Microseris lanceolata				11	
Millotia myosotidifolia	1				a
Minuria cunninghamii			4 17	9 11 21	
M. integerrima	2				ac
M. leptophylla			17	8 9	
Myriocephalus rhizocephalus	2			11	
M. stuartii		3b	16		ac
Olearia lepidophylla		3b			
O. magniflora		3b	4		b
O. muelleri		3a3b3c	4		
O. pimeleoides	2	3b3c	4		
O. rudis					d
**Onopordum acaulon*	2				
**Picris sp.*	1				e
Podolepis canescens		3b			f
P. capillaris		3b			
P. jaceoides		3c			
P. muelleri				11	
Podotheca angustifolia		3b			
Pogonolepis muelleriana			17	9 11 19	
Pseudognaphalium luteoalbum	1				ab
Pycnosorus pleiocephalus [*Craspedia pleiocephala*]			17	8 9 19	
**Reichardia tingitana*			17	22	
Rhodanthe corymbiflora [*Helipterum corymbiflorum*]	2	3b	4 17	8 9 11 19 21	
R. diffusa [*Helipterum diffusum*]					d
R. floribunda [*Helipterum floribundum*]	2		4	8	
R. pygmaea [*Helipterum pygmaeum*]			4 17		
R. stuartiana [*Helipterum stuartianum*]		3c3d	4 16 17	8 9 21 22	
R. tietkensii [*Helipterum tietkensii*]					g

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Asteraceae (cont'd)					
Senecio cunninghamii	1			18 23	be
S. glossanthus	2	3b3c3d	4	8 9 11	
S. lautus subsp. *dissectifolius*					b
S. murrayanus					g
S. quadridentatus	1 2	3b			
S. runcinifolius	1 2		4		
**Sonchus asper* subsp. *glaucescens*	1				ae
**S. oleraceus*	1 2	3b3c3d	4 17	8 9 11 19 22	
Triptilodiscus pygmaeus [*Helipterum australe*]	2		4		
**Urospermum picroides*					a
Vittadinia cervicularis		3b			
V. cervicularis var. *cervicularis*	2	3b3c3d	4 16		
V. condyloides			4 17		
V. cuneata var. *cuneata*	2				
V. dissecta var. *hirta*	2	3b	4		
V. gracilis	1 2				
V. pterochaeta			9		
Waitzia acuminata		3b			c
**Xanthium occidentale*	1		23		aef
**X. spinosum*	1			18 21 23	
Boraginaceae					
**Echium plantagineum*	1 2	3c	4	21	
Halgania andromedifolia		3b	4		bd
H. cyanea		3b			
**Heliotropium europaeum*	1			9	
**H. supinum*	1 2			18 23	
Omphalolappula concava	2	3b3c3d	4 17	9	
Plagiobothrys elachanthus					a
Brassicaceae					
**Alyssum linifolium*		3c	4		
Arabidella trisecta		3c			
**Brassica tournefortii*	1 2	3b3c3d	4 17		
**Carrichtera annua*		3b3c3d			
Geococcus pusillus	2		4		ac
Harmsiodoxa blennodioides					
**Lepidium africanum*					ab
L. leptopetalum		3c	4		
L. monoplocoides					g
L. papillosum					a
L. phlebopetalum					a
L. pseudohyssopifolium				21	
Pachymitus cardaminoides					adg
Rorippa laciniata	1		23		e
**Sisymbrium erysimoides*	1 2	3d	4 17	19	

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Brassicaceae (cont'd)					
**S. irio*	1	3b3c3d	4		
**S. orientale*	2	3c	4		
Stenopetalum lineare		3b3d			
Callitrichaceae					
Callitriche cyclocarpa					g
Campanulaceae					
Wahlenbergia communis			17		
W. fluminalis	1 2	3b3c			
W. gracilenta			9		ac
W. luteola			4 16 17		
Caryophyllaceae					
**Herniaria cinerea*		3d		9	
**Polycarpon tetraphyllum*					a
**Scleranthus minusculus*		3b	17		
**Silene apetala*		3b3d	4 17	11 19	
**S. gallica*		3b	4		
**S. longicaulis*					a
**S. nocturna*					a
**Spergularia diandra*	2		4	8 11 19	
**S. rubra*	2		4 17	8 11 21	
Casuarinaceae					
Allocasuarina luehmannii			16 20		
Casuarina pauper			4 16	8	
Chenopodiaceae					
Atriplex acutibractea subsp. *acutibractea*		3c3d			
A. angulata		3c		8 9	
A. conduplicata			4	8 11	
A. eardleyae	2	3c	4	9	
A. holocarpa				9	bc
A. infrequens	2				
A. leptocarpa	2		4	21	
A. lindleyi	2	3c	4 17	8 9 19 11 21 22	
A. nummularia	1 2	3c3d		9 19 11	
A. pseudocampanulata	2		17	19 11 21 22	
A. semibaccata	1 2	3b3c	4	21 23	
A. spinibractea					b
A. stipitata	2	3b3c3d			
A. suberecta	2				
A. vesicaria		3b3c3d	4	8 9 19 11 21	
**Chenopodium album*					b
C. cristatum					a
C. curvispicatum [*Rhagodia gaudichaudiana*]	2	3b3c3d	4	9	
C. desertorum subsp. *microphyllum*	2	3b3c	4 16		

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Chenopodiaceae (cont'd)					
**C. murale*	2				
C. nitrariaceum	1 2		4	11	
C. pumilio	1 2				
Dissocarpus biflorus var. *biflorus*			9 19 11		
D. paradoxus		3c3d	4	8 9 21 22	
Dysphania glomulifera	1				a
Einadia nutans	1 2	3b3c	4 16	9 19 21	
Enchylaena tomentosa	1 2	3b3c3d	4 16	8 9 19	
Halosarcia pergranulata	2				a
Maireana aphylla		2		4	9 21
M. appressa		3b	4	22	
M. brevifolia	2	3b3c3d	4	21	
M. ciliata	2		4	9	ac
M. coronata				21?	
M. decalvans	2	3a	4	21	
M. enchylaenoides		3b			c
M. erioclada		3b3c3d			
M. georgei		3c		8 9	
M. pentagona	1 2			21	
M. pentatropis		3b3c3d	4		
M. pyramidata	2	3c3c3d	4 16	8 9 19 22	
M. radiata		3b3c3d	4	9	
M. sclerolaenoides		3b3c3d	4 17	9 21 22	
M. sedifolia	2	3b3c		8 9	
M. trichoptera			4		b
M. triptera		3b3c3d	4	8	
M. turbinata		3d	4 16	8 22	
Malacocera tricornis	2			8 11 19 21	
Neobassia proceriflora					a
Osteocarpum acropterum var. *deminuta* [*Babbagia acroptera*]	2		4	8 19	
Pachycornia triandra	2				a
Rhagodia spinescens	2	3a3b3c3d	4 16	8 19 22	
R. ulicina		3b			
Salsola kali	1 2	3b3c3d	4	21	
Scleroblitum atriplicinum	2		4		
Sclerolaena bicornis		3c	4?	9 11	
S. brachyptera	2		4	8 9 11 19 21	
S. diacantha	2	3b3c3d	4 17	8 9 11 21	
S. divaricata	2		4	11 19	
S. intricata				11	
S. limbata					g
S. muricata	1 2			18 11 19 21 22 23	

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Chenopodiaceae (cont'd)					
S. obliquicuspis	2	3b3c3d	4	8 9	
S. parviflora		3b			
S. patenticuspis	3c		9		cf
S. stelligera					a
S. tricuspis	2	3b	4	8 11 19	
S. ventricosa					b
Sclerostegia tenuis				11	
Convolvulaceae					
Convolvulus erubescens	1 2		4 17	8 9	
C. remotus			17		
Cressa cretica	2				a
Crassulaceae					
Crassula colorata var. *acuminata*	2	3c	4 17	9 19 21	
C. decumbens var. *decumbens*	2				a
C. sieberiana	1 2	3c	4		
Cucurbitaceae					
**Cucumis myriocarpus*	2				
Euphorbiaceae					
Adriana hookeri					c
Beyeria opaca		3c			b
Chamaesyce dallachyana	1				e
C. drummondii	1 2			9	
Euphorbia planiticola	2				c
Phyllanthus lacunarius	2				
Fabaceae-Caesalpinoideae					
Senna artemisioides notho subsp. *coriacea* [*Cassia eremophila* var. *coriacea*]		3b			
Senna artemisioides subsp. *filifolia* [*Cassia eremophila* var. *eremophila*]		3a3b3c	4		
Senna artemisioides subsp. *petiolaris* [*Cassia eremophila* var. *platypoda*]		3c	4 16		
S. artemisioides subsp. *zygophylla* [*Cassia eremophila* var. *zygophylla*]		3c	4 17		
S. artemisioides subsp. *zygophylla* x *sturtii*			16		

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Fabaceae-Faboideae					
Bossiaea walkeri		3a3b3c			
Daviesia arenaria		3b			
Eutaxia microphylla		3b			bf
Lotus australis	1				a
L. cruentus	1		4		ac
**Medicago laciniata*		3c	4 17	22	
**M. minima*	1 2	3c	4 17	9	
**M. polymorpha* var. *vulgaris*	1 2	3c3d	4	19 21 22	
**M. praecox*	1		4	8 9 11 19 21	
**M. truncatula*		3c	4 17	8 11	
**Melilotus indica*	1				e
Psoralea cinerea					a
P. pallida					a
P. tenax	1 2				a
Swainsona microphylla	1				a
S. murrayana					g
S. phacoides					a
Templetonia egena		3b3c	4 17	8	
T. sulcata					g
**Trifolium arvense*			17		
**T. subterraneum*	1				e
**T. tomentosum*				22	
Fabaceae-Mimosoideae					
Acacia aneura			4		b
A. brachybotrya		3b	16		
A. buxifolia subsp. *buxifolia*		3b			
A. colletioides		3a3b3c	4		
A. hakeoides		3c			
A. halliana		3c	16		
A. ligulata	2	3b3c	16		
A. melvillei		3c	4 16 17		
A. microcarpa		3b3c			b
A. nyssophylla					a
A. oswaldii	2	3b3c3d	4 16 20 8		
A. rigens		3a3b	4		
A. salicina	1		16		
A. sclerophylla	2	3b3c			
A. stenophylla	1 2			18	
A. victoriae		3b3d		22	
A. wilhelmiana		3b			
Frankeniaceae					
Frankenia serpyllifolia	2			11	
Fumariaceae					
**Fumaria densiflora*	2				a
Gentianaceae					
Centaurium spicatum	1 2				a

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Geraniaceae					
**Erodium cicutarium*	2	3c	4	9 21	
E. crinitum	1	3b3c	4 17		
Geranium retrorsum	1 2				a
Goodeniaceae					
Goodenia fascicularis			17	9	
G. glauca	1 2				aef
G. heteromera	1				a
G. pinnatifida	2		4	8	
G. pusilliflora	2	3b	4	9 19	
G. sp. (mallee *Goodenia*)		3b			
Scaevola spinescens					a
Gyrostemonaceae					
Codonocarpus cotinifolius		3b			
Haloragaceae					
Haloragis aspera	1 2				a
H. glauca	1				f
H. odontocarpa					bd
H. odontocarpa f. pterocarpa		3b			c
Myriophyllum caput-medusae	1			23	e
M. verrucosum	2			23	ef
Lamiaceae					
Ajuga australis	1 2				a
**Marrubium vulgare*	1 2	3c			
**Salvia verbenaca*		3b3c	4		
**Stachys arvensis*	1				e
Teucrium racemosum	1 2		17		
Westringia rigida		3b3c3d	4		
Lauraceae					
Cassytha melantha		3b			
Linaceae					
Linum marginale					b
Lobeliaceae					
Pratia concolor	1 2			23	
Loranthaceae					
Amyema linophyllum subsp. *orientale*	2		4		
A. miquelii	1 2	3b3c	4		
A. miraculosum subsp. *boormanii*		3b			f
A. preissii	2	3b		8	
A. quandang var. *quandang*					
Lysiana exocarpi subsp.*exocarpi*			16		
Lythraceae					
Ammannia multiflora var. *multiflora*					a

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Lythraceae (cont'd)					
Lythrum hyssopifolia	1 2				a
Malvaceae					
Abutilon theophrasti	2				f
Lavatera plebeia	1		4	8	
Lawrencia squamata		3d		9	
**Malva parviflora*	1 2		4	19 21 23	
Sida ammophila	2				a
S. corrugata	2		4		
S. cunninghamii			17		
S. fibulifera	2				a
S. filiformis				21	
S. trichopoda	1 2			21	
Menyanthaceae					
Nymphoides crenata	1				e
Myoporaceae					
Eremophila bignoniiflora					a
E. deserti		3b			
E. divaricata	1 2				af
E. glabra		3b3c	4		
E. longifolia	2		4		
E. maculata		3b			b
E. oppositifolia					b
E. polyclada					a
E. sturtii			4 16	8	
Myoporum parvifolium	1 2				a
M. platycarpum		3a3b3c3d		4	
Myrtaceae					
Baeckea crassifolia		3b			bc
Eucalyptus camaldulensis	1 2			18	
E. costata		3a3b			
E. dumosa		3a3b3c3d			
E. gracilis		3a3b3c3d			
E. intertexta	2				
E. largiflorens	1 2				
E. leptophylla		3b3d			
E. oleosa		3a3b3c3d			
E. porosa		3d			
E. socialis		3a3b3c3d			
E. socialis x oleosa		3c			
Melaleuca lanceolata	2				
Nitrariaceae					
Nitraria billardierei	2	3b3c3d	4	9 18 21 22 23	
Nyctaginaceae					
Boerhavia coccinea [*B. diffusa*]	2				

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Oleaceae					
Jasminum lineare			16		
Onagraceae					
Epilobium hirtigerum				23	e
Ludwigia peploides subsp. *montevidensis*	1			23	e
Oxalidaceae					
**Oxalis corniculata*	2	3b3c	4		
O. perennans	1 2		4 16 17	8 9 21	
**O. pes-caprae*					b
Papaveraceae					
**Papaver hybridum*			4		bd
Pittosporaceae					
Billardiera versicolor					b
Bursaria spinosa			16		
Pittosporum phillyreoides	2	3b3c	4 16	8 9	
Plantaginaceae					
Plantago cunninghamii	2		4 16 17	21	
P. drummondii			17	8 9 11 21	
Plumbaginaceae					
**Limonium lobatum*		3c	4		
Polygonaceae					
**Emex australis*			4		b
Muehlenbeckia florulenta	1 2			18	
M. diclina					g
Persicaria decipiens	1			23	ae
P. lapathifolia	1				a
P. orientalis	1				e
P. prostrata	1				aef
Polygonum plebeium	1				af
Rumex brownii	1				
**R. crispus*				23	e
R. crystallinus	1				a
R. tenax	2			21	
Portulacaceae					
Calandrinia calyptrata	2				a
C. eremaea	2	3b3c3d	4 17	19	
C. volubilis	2				a
Portulaca oleracea					b
Primulaceae					
**Anagallis arvensis*	1 2				a
Proteaceae					
Grevillea huegelii		3a3b3c			
Hakea leucoptera		3c	16 17		
H. tephrosperma		3c	16		
Ranunculaceae					
Clematis microphylla var. *microphylla*	2				f

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Ranunculaceae (cont'd)					
**Myosurus minimus* var.*australis*	1				af
Ranunculus inundatus	1				e
R. lappaceus	1				
R. pentandrus var. *platycarpus*	1 2				a
R. pumilio	2				f
R. undosus	1				e
Rubiaceae					
Asperula conferta	1 2				
A. geminifolia	1				f
**Galium aparine*	1 2				
Opercularia turpis					dg
Synaptantha tillaeacea	1				f
Rutaceae					
Geijera parviflora			4 16 20		
Salicaceae					
**Salix babylonica*	1				a
Santalaceae					
Exocarpos aphyllus	2	3c	4	8	
E. sparteus		3b			bg
E. strictus	1 2				
Santalum acuminatum			4		
S. murrayanum		3b3c			f
Sapindaceae					
Alectryon oleifolius subsp. *canescens*		3c	4 16 20		
Dodonaea viscosa subsp. *angustissima*	2	3b3c	4 16 20		
Scrophulariaceae					
Limosella curdieana					b
Stemodia florulenta	1 2	3b		8	
**Verbascum virgatum*					b
Solanaceae					
**Datura inoxia*	1				f
Lycium australe			4		bd
**L. ferocissimum*	2		4 16 17		
**Nicotiana glauca*		3b		23	
N. velutina	2				a
Solanum coactiliferum		3b			
S. esuriale	1 2		17	9 21	
S. karsensis					g
**S. nigrum*	1 2				ae
S. simile	1				a
Sterculiaceae					
Brachychiton populneus					a

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Thymelaeaceae					
Pimelea microcephala subsp. *microcephala*			16		
P. simplex subsp. *continua*		3b	16		
Urticaceae					
Parietaria debilis			4		cd
**Urtica urens*	1				e
Verbenaceae					
**Phyla nodiflora*	1 2				a
**Verbena officinalis*	2				
**V. supina*	1				
Zygophyllaceae					
Tribulus terrestris	2			21	
Zygophyllum ammophilum	2	3c3d	4	9	bc
Z. angustifolium			17		
Z. apiculatum		3b3c3d	4		
Z. aurantiacum		3b3c3d	4		
Z. confluens		3b3d	4	8 9	
Z. crenatum		3d		8 9	
Z. eremaeum		3b3c3d	4 17		
Z. glaucum		3b3c		21	
Z. iodocarpum	2	3c3d	4 17	8	
Z. ovatum		3c3d	4	8	
MONOCOTYLEDONS					
Alismataceae					
Damasonium minus	1				e
Amaryllidaceae					
Calostemma purpureum					a
Anthericaceae					
Arthropodium minus				9	c
Thysanotus baueri			17		
T. patersonii		3b			f
Asparagaceae					
**Asparagus officinalis*	1 2				a
Asphodelaceae					
**Asphodelus fistulosus*	1 2	3b			
Bulbine alata			17	9	
B. bulbosa					
B. semibarbata			17	8 11	
Colchicaceae					
Wurmbea dioica					d
Cyperaceae					
Carex appressa	1				e
Cyperus exaltatus	1				af
C. flaccidus					

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Cyperaceae (cont'd)					
C. gymnocaulos	1 2				af
C. pygmaeus					a
C. squarrosus					a
Eleocharis acuta	1 2				
E. pallens				11 13	
E. pusilla	1				e
Gahnia lanigera		3b			f
Isolepis marginata					a
I. platycarpa	1				a
Hypoxidaceae					
Hypoxis glabella var. *glabella*					b
Juncaceae					
**Juncus aridicola*	1			13	
J. flavidus	1			23	e
J. radula				23	
Juncaginaceae					
Triglochin centrocarpa					a
T. procera	1				e
Phormiaceae					
Dianella longifolia	2	3b			
Poaceae					
Agrostis avenacea	1 2		4	11 21 23	
**Alopecurus geniculatus*	1				e
Amphibromus sp.	1				e
Amphipogon caricinus					d
Aristida behriana			17	19	
**Avena barbata*	2			9 21 15	
**Avena fatua*					
Bromus arenarius	2			19 11	
**B. diandrus*			4	22	
**B. madritensis*				9	
**B. molliformis*			4		c
**B. rubens*	2	3b3c3d	4 16 17	8 9 11 19 21 22	
Chloris truncata	2			9	
Cynodon dactylon	1 2				
Danthonia caespitosa	1 2	3b	4 16 17	8 9 11 19 21 22	
D. eriantha			17		
D. setacea	1 2				a
Digitaria ammophila					a
Enneapogon avenaceus	2				
Enteropogon acicularis	2		4 17		
Eragrostis australasica	1 2			11 19 21 13	
E. dielsii				8	
E. elongata	1				a
E. lacunaria	1 2				a
**E. pilosa*	2				c

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Poaceae (cont'd)					
Eriochloa pseudoacrotricha	2				c
Eulalia aurea	1				a
Homopholis proluta				8	
**Hordeum hystrix*	2				c
**H. marinum*	1 2				a
**H. leporinum*	1 2	3b3c3d	4 17	8 9 11 19 21 23	
**Lamarckia aurea*	2			19 11	
**Lolium perenne*	1 2	3d		8 19 21	
**Panicum coloratum*	1				
Paspalidium constrictum				9	
P. jubiflorum	1 2				
P. distans	1				e
Paspalum distichum	1			23	ae
**Pentaschistis airoides*	1 2		16		a
**Phalaris minor*	1				e
**P. paradoxa*	1 2		4	11 18 21	
Phragmites australis	1			23	
Poa fordeana	1 2				
P. labillardieri	1				a
**Polypogon monspeliensis*				18 23	e
Pseudoraphis spinescens	1				a
**Puccinellia ciliata*				11	
**Rostraria cristata*	1 2			22	
**Rostraria pumila*	2		4	19	
**Schismus barbatus*	1 2	3c3d	4 16		
Sporobolus caroli				9	c
S. mitchellii	1 2				a
Stipa acrociliata		3b3c			c
S. elegantissima		3b3c	4 17	8 9 19 22	
S. eremophila			4 17	22	
S. metatoris					g
S. mollis		3b			
S. nitida	1	3c3d	4 16	8 9	
S. nodosa	2	3d	4 17	8 9 21 22	
S. platychaeta		3c			
S. scabra		3b			
S. scabra subsp. *scabra*	2				
S. trichophylla	1	3b			
S. wakoolica					g
Triodia scariosa		3b			
**Triticum aestivum*	1				a
**Vulpia myuros*	1 2	3d	16	11 21	
Potamogetonaceae					
Potamogeton tricarinatus	1				e

Botanical name	Community				Other Records
	forest	mallee	w'land	shrub/grasslands	
Typhaceae					
Typha domingensis				23	
T. orientalis	1			23	
Xanthorrhoeaceae					
Lomandra glauca		3b			f
L. leucocephala subsp. *robusta*		3b3c	4		bd
L. leucocephala subsp. *leucocephala*		3b			

Key

[ ] names in square brackets are synonyms.

a = Margules and Partners Pty Ltd, P. & J. Smith Ecological Consultants, & Department of Conservation Forests and Lands Victoria (1990) *River Murray riparian vegetation study* (Murray-Darling Basin Commission).

b = Morcomb L. & Westbrooke M., (1990). The vegetation of Mallee Cliffs National Park. *Cunninghamia* 2(2):147-165.

c = M. Fox study sites. Unpublished data (Royal Botanic Gardens, Sydney).

d = W.S. Semple (1979) *Species list for "Mallee Cliffs"* Soil Conservation Service of NSW

e = Pressey, R.L., Bell, F.C., Barker, J., Rundle, A.S. & Belcher, C.A. (1984) *Bio-physical features of the Lachlan-Murrumbidgee confluence, south-western New South Wales.* (N.S.W. National Parks and Wildlife Service).

f = A. Parsons (Unpublished species list for the area south of Mallee Cliffs National Park to the Murray River (NSW National Parks & Wildlife Service, Sydney).

g = Species of particular conservation significance within the mapped area (see Table 3).

Manuscript received 13 February 1992

Manuscript accepted 28 May 1992