# The natural vegetation of the Hay Plain: Booligal–Hay and Deniliquin–Bendigo 1:250 000 maps

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## Abstract

*Porteners, Marianne F., (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1993. The natural vegetation of the Hay Plain: Booligal–Hay and Deniliquin–Bendigo 1:250 000 maps.* Cunninghamia *3(1): 1–122.* The composition and extent of the present native vegetation, both remnant and modified, covered by the following 1:250 000 map sheets is described and mapped from aerial photography and field traverses: Booligal (33°00'S to 34°00'S, 144°00'E to 145°30'E), Hay (34°00'S to 35°00'S, 144°00'E to 145°30'E) and Deniliquin-Bendigo (35°00'S to the Murray River, 144°00'E to 145°30'E). The Hay Plain is situated in south-western New South Wales and is covered by the South Western Plains botanical subdivision. The term Hay Plain is used to refer to that area of the riverine plain covered by these maps. In its wider context it refers to the whole of the riverine plain, comprising the extensive alluvial deposits of the Murray River and its major tributaries, the Murrumbidgee and Lachlan Rivers. The characteristic landscape is an alluvial plain with a westerly to northerly transition to aeolian landforms. Twenty-one vegetation communities occurring within the mapped area are described. These include saltbush (*Atriplex* spp.) and bluebush (*Maireana* spp.) shrublands, perennial grasslands, woodlands of *Callitris* and Belah–Rosewood (*Casuarina pauper* and *Alectryon oleifolius*), riparian forest and mallee communities. Few undisturbed areas of natural vegetation remain due to over 150 years of extensive land use. The poor conservation status of many of the communities is discussed.


## Introduction

*'It is impossible for me to describe the kind of country we were now traversing, or the dreariness of the view it presented. The plains were still open to the horizon, but here and there a stunted gum-tree, or a gloomy cypress, seemed placed by nature as mourners over the surrounding desolation'* (Charles Sturt 1833).

The Hay Plain in south-western New South Wales is an expansive alluvial plain dominated by chenopod shrublands and bisected by a network of wooded rivers and creeks. Known also as the saltbush plain it is considered by many to be a bleak and desolate place but to others it conjures up romantic images of Cobb and Co. coaches transporting mail and goods to lonely outposts; the solitary pub on the One Tree Plain and early settlers trying to make a living from marginal, inhospitable land. The landscape has been extensively modified over the past 150 years by European settlement. The saltbush plains have been heavily stocked with sheep and to a lesser extent with cattle and the more arable lands adjacent to the rivers have been cleared for cropping. Forests and woodlands of *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* still line the rivers and creeks and cover extensive floodplain areas. Relatively small areas remain of once-extensive *Callitris glaucophylla* and *Acacia pendula* woodlands, which were logged for building materials and fodder. Widespread dieback of *Atriplex vesicaria* has considerably reduced this once-dominant vegetation community. Little of the vegetation is represented in any conservation zone and few undisturbed areas exist today.

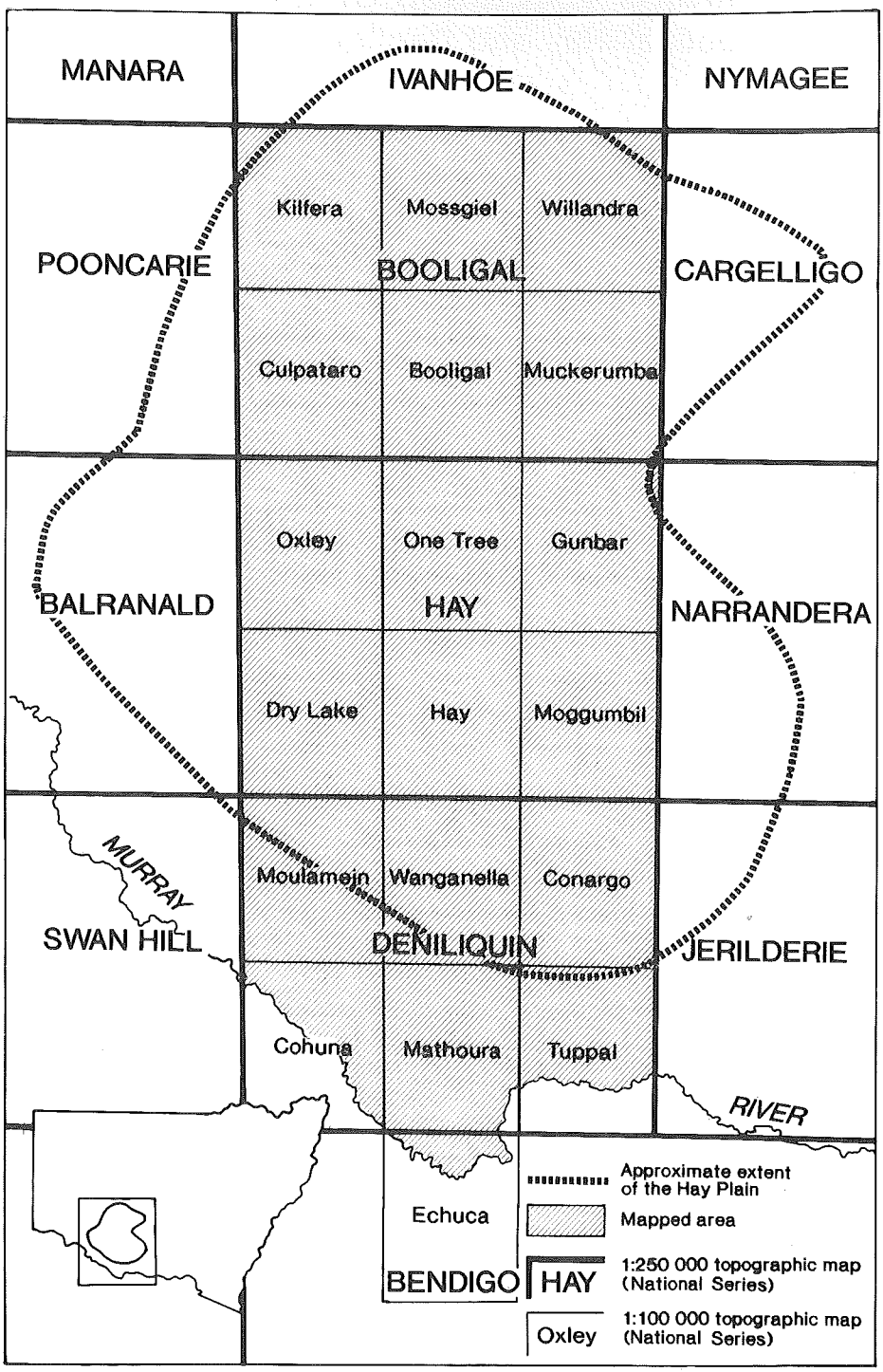


**Figure 1.** Locality map showing the extent of the Hay Plain in south-western New South Wales, and the associated map sheets.

## Location

The Hay Plain in south-western New South Wales is covered by the Australian 1:250 000 Topographic Survey sheets Booligal, Hay and Deniliquin (SI 55–5, SI 55–9, SI 55–13) and a portion of the Bendigo Joint Operations Graphic (SJ 55–1) (Fig. 1). The term riverine plain has also been used to describe the larger area covering the whole alluvial plain across which the Murray and Murrumbidgee Rivers flow westward from the eastern highlands (Beadle 1948, Moore 1953, Butler 1950). Portions of the Hay Plain occur on the Cargelligo, Narrandera, Jerilderie and Balranald–Swan Hill 1:250 000 maps and many of the vegetation communities identified in the current survey extend to these areas. The Lowbidgee region, a low, very flat and relatively recent floodplain where the surface relief of palaeochannels has been obscured by more recent deposition, occurs further west between Maude and Balranald.

The total area mapped is 4 392 200 ha or almost 4.5 million ha. Each complete 1:250 000 map covers an area of 138 X 110 km (or 1 524 900 ha) and the New South Wales portion of the Deniliquin–Bendigo map covers an area of 1 342 400 ha. Much of the mapped area falls within the Central Division of New South Wales, where the land is under freehold tenure. North of the Lachlan River in the Western Division, most of the land is held under perpetual grazing lease with some areas of freehold country.

The major townships are Hay and Deniliquin with populations of 3000 and 7250 respectively (Fig. 2). Smaller towns from north to south include Mossgiel, Booligal, Oxley, Carrathool, Maude, Moulamein, Wanganella, Conargo, Barham, Mathoura and Moama. Just off the map but used for reference are Hillston to the east of the Booligal map and Ivanhoe to the north. Most of the mapped area falls under the Carrathool, Hay, Windouran, Conargo and Murray Shires with small portions in the Central Darling, Balranald, Murrumbidgee and Wakool Shires. The Sturt and Cobb Highways traverse the mapped area from east to west and north to south respectively. The Mid-western Highway enters the Hay map in the north-east from West Wyalong while the Riverina Highway similarly connects Deniliquin to towns further east. The now unused Junee–Hay railway line enters the map area from the east, terminating at Hay and a portion of the Sydney–Broken Hill line crosses in the far north-east of the Booligal map sheet.

The eastern boundary of the mapped area is at longitude 145°30'E which runs east of Roto, Gunbar, Carrathool, Four Corners and Conargo and west of Hillston and Tocumwal. The western boundary is at longitude 144°00'E which runs west of Ivanhoe, Oxley, Moulamein and Barham. The northern boundary runs almost parallel with the Sydney to Broken Hill railway line but south of Ivanhoe and Conoble siding, with Trida and Roto sidings and Warranary Hill within the mapped area in the east. The Murray River forms the southern boundary with the townships of Barham, Moama and Echuca (Vic.) on its banks.

The dominant features of the mapped area are the major rivers. The Murrumbidgee River runs east-west through the Hay map area, with the Lachlan River joining in the west at the Great Cumbung Swamp. The Murray River in the south defines the state border between New South Wales and Victoria at its southern bank. Its anabranch, the Edward River, traverses the Deniliquin map and rejoins the Murray to the west of the mapped area near Kyalite. Willandra Creek crosses the Booligal map in the north, terminating in the depressions of the Willandra Lakes system further west.

## Climate

The general climate of the Hay Plain is semi-arid, with very hot summers, mild winters and a winter-dominant rainfall (Edwards 1979). The diurnal contrast is one of

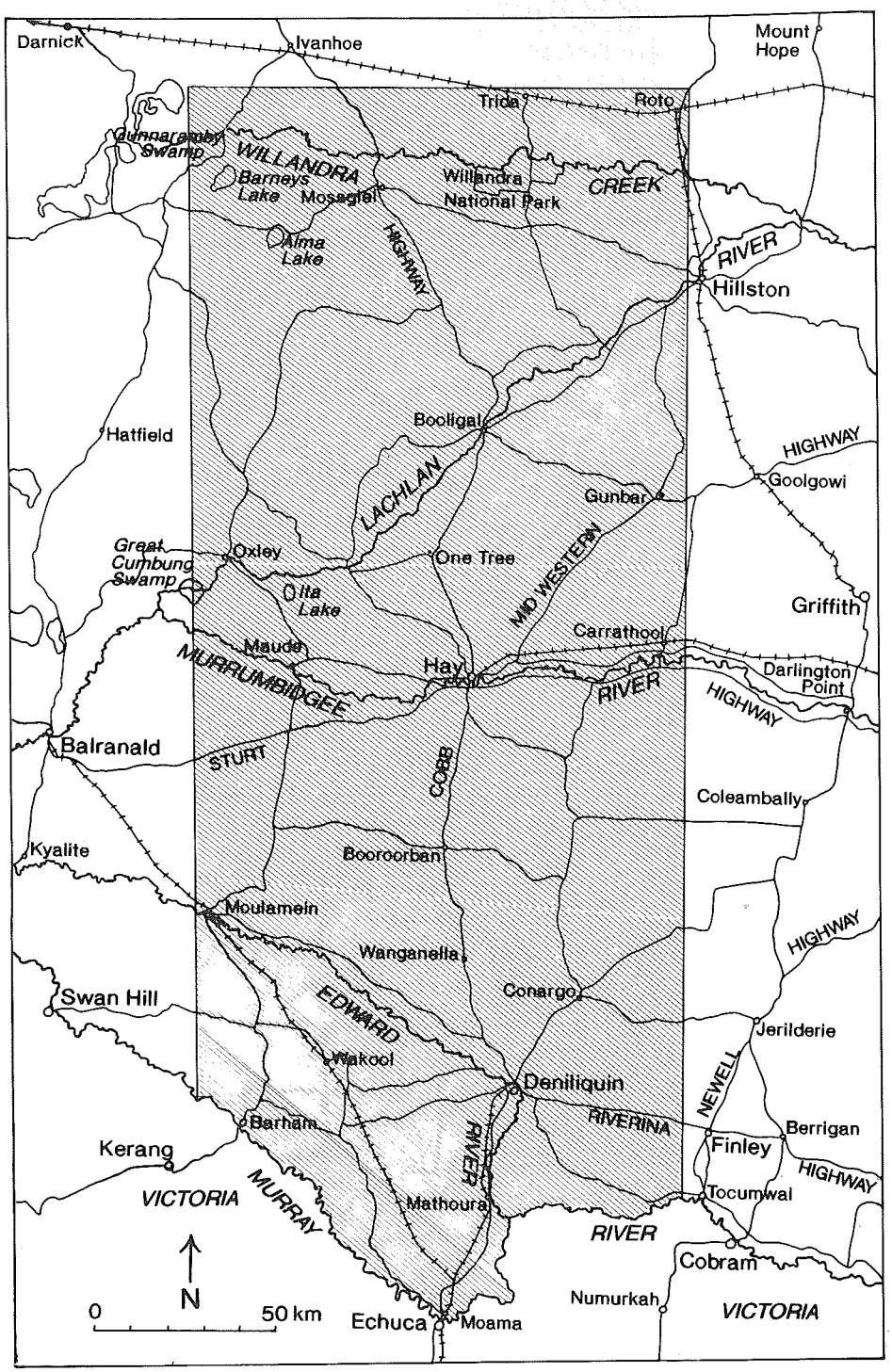


**Figure 2.** Major natural features and communications of the mapped area (Booligal–Hay and Deniliquin–Bendigo map areas shaded).

hot days and cool nights in summer and warm days and cold nights in winter. Dry years are common and often consecutive, resulting in prolonged periods of drought, often lasting several years. Topography does not exert a strong influence on the climate of the region, except for local restrictions and modifications of air flow. Most of the climatic variation is due to the wide longitudinal spread of the region (Bureau of Meteorology 1955). Climatic averages for Deniliquin, Hay and Ivanhoe (temperature and rainfall data) and Booligal and Mossgiel (rainfall data only) are given in Table 1.

The hottest month is January when average daily temperatures range from 17.2–33.0°C at Hay while the lowest temperatures normally occur in July, with an average range of 3.6–14.8°C (Bureau of Meteorology 1988). Ivanhoe, at the far northern edge of the Plain experiences slightly hotter summer and cooler winter temperatures while temperatures in Deniliquin, in far south of the mapped area are slightly lower in summer and winter.

In south-western New South Wales, annual rainfall decreases from east to west with a predominantly winter dominance that increases towards the south. Further north, the rainfall decreases and is more evenly spread throughout the year. Correspondingly, evaporation increases from east to west. Summer rainfall is generally from localised thunderstorms, while the more reliable winter rains result from cold fronts associated with the passage of depressions across the southern ocean (Rhodes 1990). The average annual rainfall decreases from about 400 mm at Deniliquin to 300 mm at Ivanhoe in the far north-west. The peak winter rainfall for the Hay district is 240–360 mm (Edwards 1979).

Rainfall is most reliable during the months of July and August and the most variable during the January to March quarter. Rainfall variability increases in the north and west of the area. Evaporation is at its highest during the period of November to February. The June to September period is generally the most favourable for plant growth due to the higher winter rainfalls (Rhodes 1990). Dry periods are not unusual and approximately 29 drought years were experienced in western New South Wales between 1900 and 1986 (Dalton 1988).

## Geology

The Hay Plain consists of two broad geological types: the fluvial plains comprising alluvial and lacustrine deposits of gravel, sand, silt and clay, and the aeolian landscape of flat to gently undulating plains and dunes of red clayey sands and loams (Semple 1990) (Fig. 3). Bedrock hills of Palaeozoic sediments mark the edge of the Murray Basin in the extreme north-east of the mapped area at Warranary Hill and on the Manfred Range in the central north (Norris & Thomas 1991). Low ranges and rocky outcrops to the east represent the boundary between outcropping Palaeozoic bedrock and the Tertiary/Quaternary alluvial plains (Norris & Thomas 1991). To the west the landscape becomes aeolian in character, marking the transition from riverine sediment sources in the east to marine and littoral sources from the west (Mabbutt 1980).

The Hay Plain lies within the Murray Basin which was formed during the Tertiary Period about 60 million years ago (Semple & Eldridge 1989). Active sedimentation followed by fluvial deposition by prior streams gave the present landscape its form (Pels 1969a). In the late Tertiary the western part of the Basin was covered by sea and extensive deposits of marine sands were laid down. This area, known as the Murravian Gulf, extended east to about Hatfield and north to half-way between Mildura and Menindee. The gulf regressed during the Pliocene and carbonates and clays were deposited in the early Quaternary when the western part of the region was again

**Table 1.** Climatic averages for Deniliquin, Hay and Ivanhoe (temperature and rainfall data) (Bureau of Meteorology 1988) and Booligal and Mossgiel (rainfall data only) (National Climate Centre 1992).

| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deniliquin** (22 years of temperature record and 126 years of rainfall record) | | | | | | | | | | | | |
| Daily max. temp. (°C) | 31.5 | 31.8 | 27.8 | 22.8 | 18.1 | 14.8 | 13.9 | 16.0 | 18.7 | 22.7 | 26.4 | 29.4 |
| Daily min. temp. (°C) | 15.9 | 16.7 | 13.7 | 10.0 | 7.2 | 4.2 | 3.3 | 4.9 | 6.6 | 9.3 | 11.8 | 14.1 |
| Rainfall (mm) | | | | | | | | | | | | |
| Mean | 29 | 28 | 33 | 32 | 40 | 41 | 35 | 37 | 38 | 40 | 28 | 28 |
| Median | 16 | 15 | 21 | 23 | 34 | 36 | 31 | 35 | 33 | 33 | 20 | 20 |
| Mean no. raindays | 4 | 3 | 4 | 5 | 7 | 9 | 9 | 9 | 8 | 7 | 5 | 4 |
| **Hay** (29 years of temperature record and 106 years of rainfall record) | | | | | | | | | | | | |
| Daily max.temp. (°C) | 33.0 | 32.6 | 29.0 | 24.0 | 18.8 | 15.9 | 14.8 | 17.0 | 20.2 | 24.2 | 28.2 | 31.0 |
| Daily min. temp. (°C) | 17.2 | 17.2 | 14.6 | 10.6 | 7.4 | 4.6 | 3.6 | 5.0 | 6.9 | 10.1 | 12.8 | 15.3 |
| Rainfall (mm) | | | | | | | | | | | | |
| Mean | 27 | 29 | 30 | 30 | 35 | 36 | 29 | 32 | 31 | 36 | 25 | 25 |
| Median | 13 | 16 | 21 | 22 | 30 | 32 | 25 | 28 | 27 | 28 | 17 | 15 |
| Mean no. raindays | 3 | 3 | 4 | 5 | 6 | 8 | 8 | 8 | 6 | 6 | 4 | 4 |

**Booligal** (rainfall statistics for the period 1891 to 1991 using all available data)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | | | | | | | | | | | | |
| Mean | 26 | 22 | 32 | 26 | 34 | 32 | 27 | 28 | 25 | 31 | 24 | 24 |
| Median | 12 | 9 | 17 | 17 | 27 | 27 | 25 | 26 | 19 | 22 | 17 | 15 |
| Mean no. raindays | 3 | 3 | 3 | 3 | 5 | 6 | 7 | 6 | 5 | 5 | 4 | 3 |

**Mossgiel** (rainfall statistics for the period 1894 to 1978 using all available data)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | | | | | | | | | | | | |
| Mean | 26 | 26 | 28 | 19 | 28 | 29 | 23 | 25 | 23 | 29 | 22 | 26 |
| Median | 11 | 11 | 14 | 12 | 20 | 21 | 16 | 21 | 16 | 19 | 16 | 14 |
| Mean no. raindays | 3 | 3 | 3 | 3 | 4 | 5 | 5 | 5 | 4 | 4 | 3 | 3 |

**Ivanhoe** (25 years of temperature record and 101 years of rainfall record)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Daily max. temp. (°C) | 34.0 | 34.0 | 30.6 | 25.6 | 20.1 | 16.9 | 16.2 | 18.6 | 21.8 | 26.2 | 29.9 | 32.8 |
| Daily min. temp. (°C) | 17.9 | 18.2 | 15.0 | 10.5 | 6.9 | 3.9 | 3.2 | 5.0 | 7.2 | 11.1 | 13.8 | 16.4 |
| Rainfall (mm) | | | | | | | | | | | | |
| Mean | 28 | 26 | 28 | 20 | 27 | 26 | 22 | 24 | 21 | 28 | 23 | 26 |
| Median | 10 | 11 | 16 | 11 | 21 | 23 | 17 | 20 | 16 | 20 | 13 | 13 |
| Mean no. raindays | 3 | 3 | 3 | 3 | 5 | 6 | 5 | 5 | 5 | 5 | 3 | 3 |

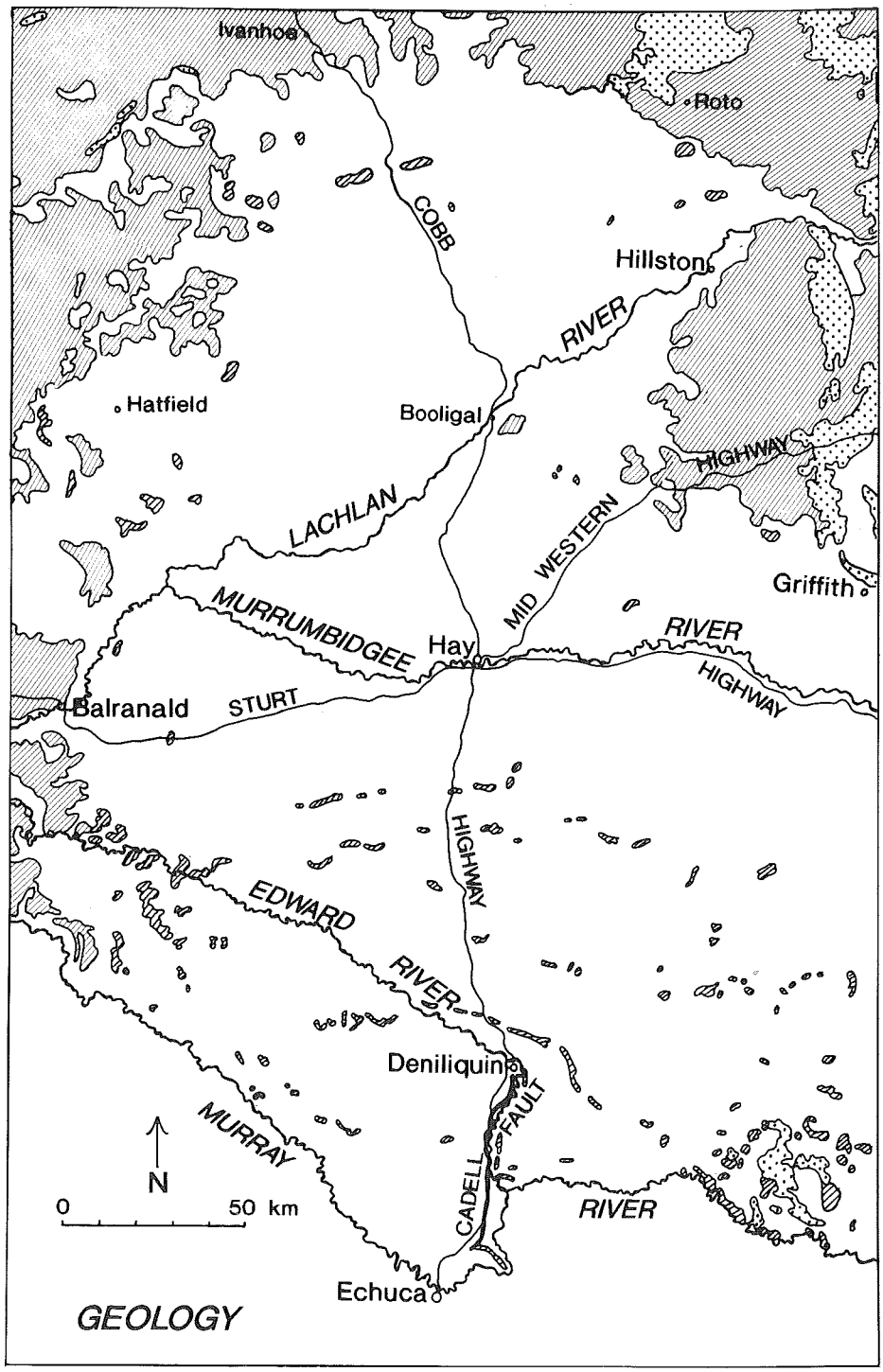


**Figure 3.** The geology of the mapped area. White unhatched areas indicate flat, alluvial and lacustrine deposits of clay, silt, sand and gravel. Hatched areas are largely aeolian, flat to gently undulating plains and dunes of red and red-brown clayey sands and loams. Spotted areas are sandstone-conglomerate sediments (slate and granite in the far south-east). Based on Goldbery and West (1968) and Offenberg (1969).

inundated by the freshwater Lake Bungunnia (Semple & Eldridge 1989, Bowler 1980).

Alluvial deposits were laid down in the eastern part of the Basin from the late Tertiary until recent times. The entire plain consists of interbedded sand and clay which was deposited by prior streams from the Palaeozoic eastern highlands. Butler (1958) proposes three main intervals of deposition, between which there were periods when the streams entrenched their beds and no deposition occurred. These streams were independent of the present day rivers and are still visible on the plain surface today (Schumm 1968). The present surface of the Plain is therefore a relict landform representing the final phase of prior stream deposition. The youngest prior streams are aged at around 36,000 years (Pels 1964b), indicating that their activity ceased in the late Pleistocene.

After prior-stream activity ended, the drainage pattern of the plains underwent major changes. Some of the major prior streams acted as drainage lines while present rivers cut across and in part along them. This coincided with a period of increased aridity (Hawkins & Walker 1956). The most recent fluvial deposit forms the floodplain of the Murrumbidgee River and filled the ancestral Murrumbidgee River cutting (Butler 1950). The interconnected basins of the Willandra Lakes System, west of the mapped area, were fed by the Willandra Billabong Creek, a distributary stream which left the Lachlan River near Hillston. This creek ceased to flow some 15 000 years ago and the lakes dried out. Willandra Creek, presently situated in the far north of the Hay Plain, formerly flowed into the Murray River but its flow was taken over by the Lachlan River. Under the present drier climate it terminates in a series of dry lakes, saltpans and depressions, the modern-day terminus being Gunnaramby Swamp just west of the mapped area.

Tectonic movements may have been responsible for the change from prior stream courses to present-day river courses. A striking feature of the southern Hay Plain is the deflection of the Murray River and the displacement of prior streams, by the Cadell Fault (Harris 1939). The Fault, visible as an uplifting of the floodplain between Echuca and Deniliquin, stopped the usual flow of the Murray River from Tocumwal westward to Barham. The river formed two new outlets, the present Murray River to the south through Echuca and the present Edward River to the north through Deniliquin. The uplift is only 20 m high and is straddled by the Cobb Highway north of Echuca. This relatively recent tectonic event is estimated to have occurred about 20 000 years ago (Bowler 1967).

## Geomorphology

The geomorphology of the Hay Plain is essentially fluvial in character, with minor aeolian and lacustrine elements (Fig. 4). Stream deposition has given the Plain its form, with erosion to a lesser extent. It is basically an inland floodplain with some low relief, dissected by rivers, creeks and ancestral and prior streams. Butler *et al.* (1973) defined it as a series of gently sloping alluvial fans and the floodplains onto which they merge. Isolated low rises to less than 100 m elevation occur throughout the area. Aeolian forces have shaped the landscape further north and west where sandplains, dunefields and low rocky outcrops arise.

### Plains

Fluvial elements have produced plains with different surface characteristics. The Hay Plain may be broadly divided into three geomorphological types based on the major floodplains: the southernmost, uplifted and heavily channelled plains of the Murray which receive the highest rainfall, the highly scalded plains of the Murrumbidgee, and the broad Lachlan River plain which receives the lowest rainfall and has many

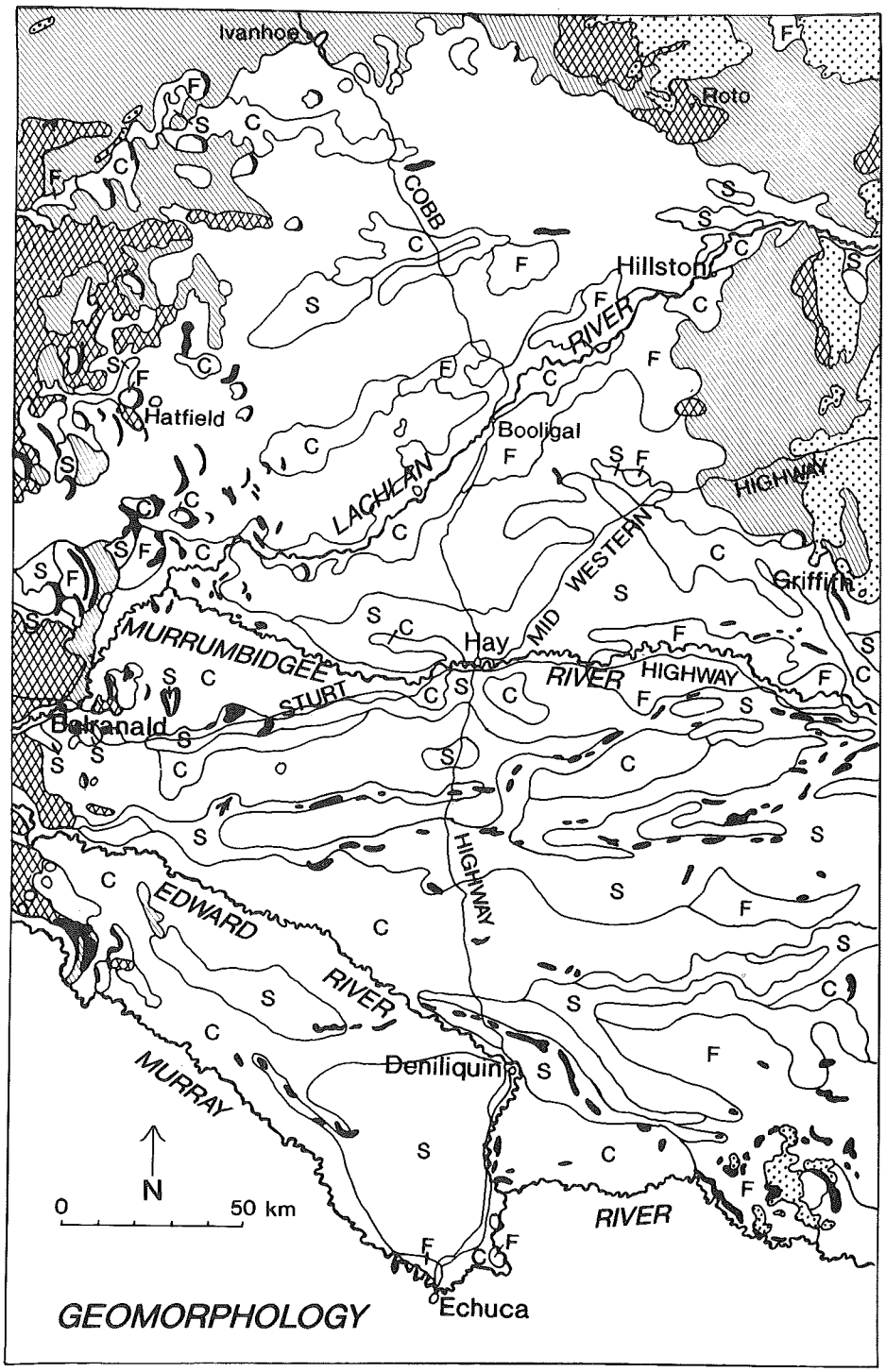


**Figure 4.** Geomorphology and landform features of the mapped area, based on Butler *et al.* (1973). Spotted areas are Palaeozoic ranges, hills and associated slopes. Double-hatched areas are dunefields. Lightly-hatched areas are aeolian plains. Black areas show source-bordering dunes, lunettes and lunette remnants. Unhatched areas indicate plains: unlabelled — plains with depressions, or lakes; C — channelled plains; S — scalded plains; F — featureless plains.

low depressions (Morgan & Terrey 1992). The Plain surface consists predominantly of clays that were deposited from prior streams when water was isolated beyond the levees on extensive floodplains (Pels 1969a). Consequent fluvial forces have produced alluvial plains with depressions, channels or little feature.

**Present rivers**

River channels such as those of the Murrumbidgee and Lachlan are deep and narrow, with steep clay banks and carry a large proportion of their sediment load in suspension. These present rivers are not old but are new eroding channels, cutting through alluvial deposits bought down by prior streams (Butler 1950). They form a branching system which eventually feeds into the Murray River (Butler *et al.* 1973). Stream flow is variable and during dry periods many of the smaller creeks dry up completely. Even major creeks and rivers, or portions of them, have been known to dry up during prolonged drought. Most rivers or creeks on the Plain terminate in lakes, saltpans or dunefields but several of them, such as the Edward and Wakool Rivers, branch off the main stream and rejoin again, forming an anabranch. Often the stream breaks up into a complex system of smaller creeks and channels as seen in the drainage system of the Lachlan River within the mapped area.

**Prior streams and ancestral rivers**

Two types of ancient stream systems have been identified on the basis of their form and age (Butler 1950). Prior streams are indicated by low, winding, sandy rises on the clay floodplain; these are elevated remnants of the old stream beds. Associated with these rises of coarse alluvium may be low, fixed sand dunes, described as source-bordering and formed by the redistribution of the coarse stream bed deposits derived from the old levees. Ancestral rivers are a younger system of remnant channels with the beds of sediment below the level of the adjacent plain. These often carry water during floods.

While current and ancestral rivers carry much of their sediment in suspension, prior streams were of a bedload type, depositing their sediments (Schumm 1968). The current bed level of prior streams is higher than the adjacent floodplain due to their once-depositional nature. Prior streams near Griffith have been aged at 36 000 years (Pels 1964b) and ancestral rivers between 30 600 and 4 200 years (Pels 1969b). Pels (1964a) also found that prior streams pre-dated the Cadell Fault and ancestral streams mostly post-dated it. Prior stream remnants today carry a different vegetation from the surrounding plain and other stream types.

**Lakes**

The dry basins of shallow lakes are a common geomorphological feature of the Hay Plain. Permanently filled natural lakes are less common, most being artificially-filled reservoirs or evaporation basins for irrigation or drainage. The lakes are generally circular, elliptical or kidney-shaped in outline with the long axis aligned north–south. The beds of dry lakes tend to have the characteristics of the adjacent plain and a dune ridge or lunette of sandy sediment overlying clay may be present along the eastern edge.

**Aeolian landforms**

Aeolian elements are not common on the Hay Plain and take the form of isolated low dunes, lake lunettes formed by the accumulation of sandy material and sandplains overlying deeper clay soils and which are often scalded. Sand dunes vary in height from 3–15 m and most are source-bordering, usually associated with prior streams and to a lesser extent with ancestral rivers (Pels 1964a, Bowler & Harford 1966).

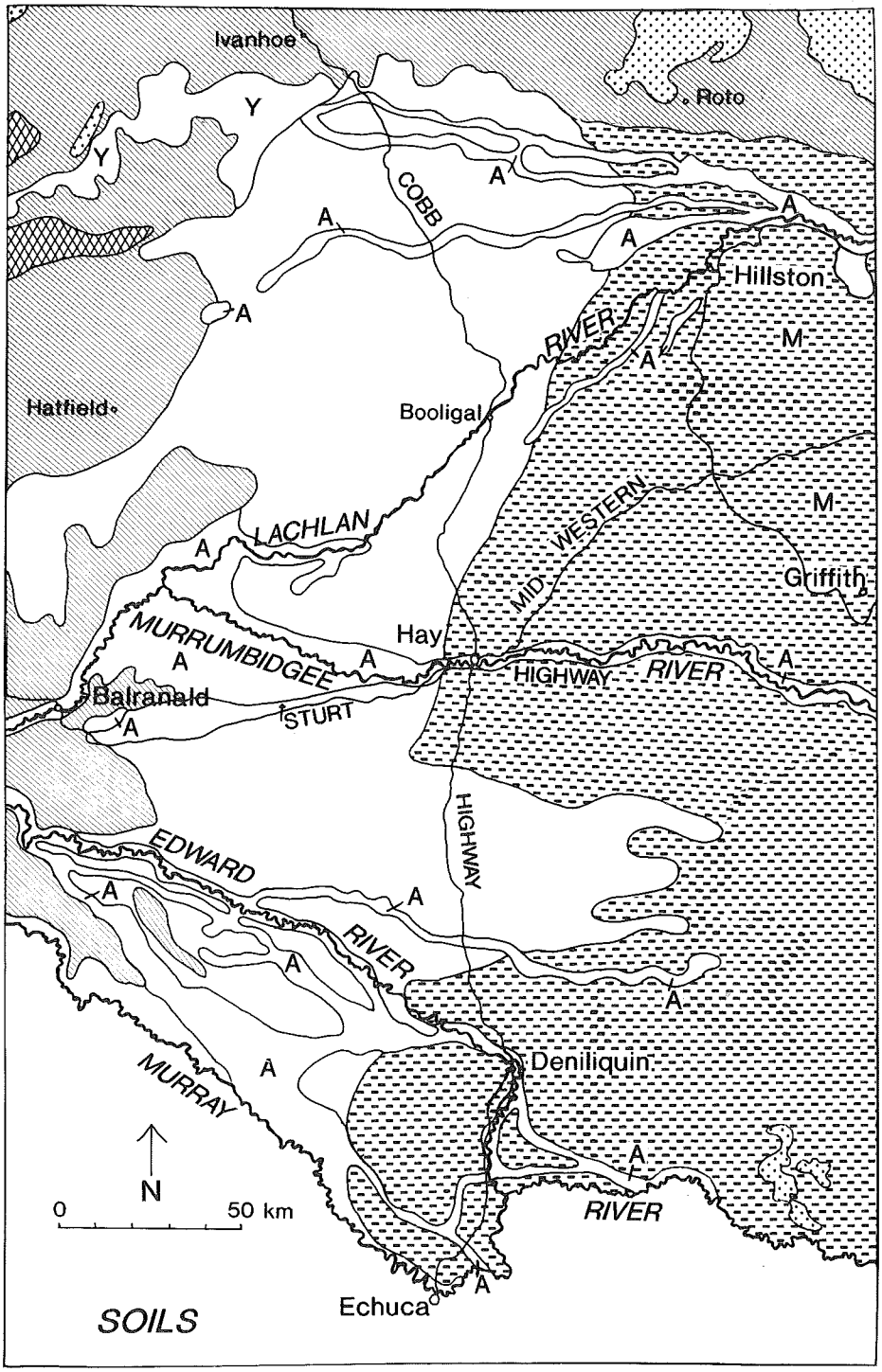


**Figure 5.** The distribution of soil types within the mapped area, based on Eldridge (1990). Unhatched areas indicate clays: unlabelled — deep, grey, cracking clays; Y — deep, yellow, cracking clays; A — ancestral streams and floodplain complex. Dashed areas are the red-brown earths group of hard, duplex soils (M — massive red earths in the east between Hillston and Griffith). Lightly-hatched areas are desert loams (calcareous earths). Double-hatched areas indicate deep, loose sands. Spotted areas are lithosols of shallow sandy soils.

Lunettes are generally crescent-shaped, following the curvature of the lake on its eastern edge (Butler *et al.* 1973). Scalding is the result of the removal of surface soil by wind, leaving bare areas of harder B-horizon soils which can vary from patches a few meters in diameter to vast areas of several square kilometres. Unvegetated, scalded areas are common on the Hay Plain.

Other aeolian sediments apart from the sand dunes and scalds occur on the Plain. Clay sheets, termed 'parna' by Butler (1956), occur over much of the Plain or interbedded with fluviatile sediments. They consist of redistributed materials derived mainly from prior stream levees and beds and are apparently more common on the eastern edge of the Hay Plain as a sheet 1–2 m thick (Schumm 1968). The source of the parna was to the west and is evidence of a period of severe aridity separating the last two phases of prior stream activity (Butler 1950).

## Soils

The predominant soils of the Hay Plain are deep, self-mulching, cracking clays (Fig. 5). consisting of grey, brown and red clays. Hard duplex soils of red-brown earths overlying grey and brown clays are seen in the north-east of the mapped area while desert loams of crusty red duplex soils are common further west and north. Isolated sandy rises and lunettes occur throughout, with deeper sandplains to low dunefields occurring at the north-west to north-east edges of the mapped area. Prior streams of coarse sand to gravel are common in the south-eastern sector of the mapped area.

Soil fertility is generally low in arid zone soils which are deficient in nitrogen and phosphorus (Leigh & Noble 1972). Soluble salts and pH increase with depth throughout the soil profile while organic matter and nitrogen levels decrease (Dalton 1988). There is a great amount of organic matter input from annual and short-lived perennial species when they die off over summer, while long-lived perennial species such as *Atriplex vesicaria* deposit organic matter into the soil year-round (Rixon 1970). Little nitrogen input is available to plants from sheep faecal pellets due to their slow and inefficient breakdown in the dry soils (Rixon 1970). Soil salinity and surface calcareousness increases across the Plain corresponding with increasing aridity (Butler *et al.* 1973).

The following soil categories are based on Eldridge (1990) while those in brackets are from Abraham (1987):

**Grey, brown and red clays** (Coarsely cracking clays)

As the most extensive group of soils found in the area, the clays occur on the beds and floodplains of the major river and creek systems, on low-lying areas of the plain and in lake beds. The grey clays occur on lower-lying areas while the brown and red clays are generally found on higher, better drained sites (Eldridge 1990). Gilgai development is often seen in clays occupying lower levels (Dalton 1988). Deep grey clays are most common in the north and west of the Hay Plain while deep yellow-grey clays are associated with the Willandra Lakes System, ancestral streams, the Lowbidgee floodplain and the Darling River. Clay soils are less susceptible to erosion than sandy or loamy soils due to their compact nature.

**Red-brown earths** (Scalded red texture-contrast soils)

These soils occur over an extensive area of the eastern and southern riverine plain, grading into areas of grey and brown clays further west. They are moderately fertile texture-contrast soils with hard setting topsoils prone to structural breakdown (Abraham 1987). They occur south-west to north-east of Deniliquin and north-east of Hay, on elevated plains and prior-stream levees. Wind erosion is prevalent on this soil

type and scalds are common, especially on the levees of prior streams. Water infiltration and holding capacities of these soils are generally high (Eldridge 1990).

**Desert loams** (Calcareous earths)

These soil types are usually found in the transition zone between the riverine and aeolian plains. They are characterised by a brown sandy loam to loam surface with a brittle crust, overlaying red to red-brown clay subsoils with an accumulation of calcium carbonate (Eldridge 1990). These soils are also susceptible to windsheeting and scalding.

**Sands**

Many isolated and semi-continuous sandhills occur throughout the mapped area. Earthy sands are found on dunes, lunettes, sandy rises and in sandy swales. Sandplains and low dunefields with deeper sands supporting mallee mark the start of the aeolian landscape in the north-west to north-east. The coarse channel sediments of prior streams comprise gravelly sand, clayey sand or light sandy clay loam. The sediments of prior stream levees grade from sandy clay loam to fine sandy clay (see red-brown earths) textures.

## Palaeovegetation

The pollen floras from inland Australia are mostly of lower Tertiary age and indicate the existence of closed forests, with abundant *Nothofagus* in pollen assemblages (Martin 1981). The arid zone flora of Australia began to develop during the Miocene, approximately 15 million years ago (Barlow 1981). There is little evidence of the development of the modern *Eucalyptus* flora or of the arid flora because of the bias of pollen preservation towards permanently wet sites (Martin 1981). It appears that it was too dry for abundant pollen preservation to the west of Narrandera. In the Murray Basin during the Eocene, about 45 million years ago, Martin (1978) found that *Nothofagus* pollen types were most abundant in the fossil record, followed by Casuarinaceae, gymnosperm, Proteaceae and Myrtaceae.

Geographic variation appears to have occurred in Tertiary floras and vegetation (Martin 1981). The disappearance of *Nothofagus* and its associated flora during the Mid-Miocene about 15 million years ago coincides with developing aridity. A gradient in the Pliocene pollen assemblages (about 5 million years before present) appears to parallel the east-west climatic gradient in western New South Wales. The change to open woodlands and forests and savannah coincides with the onset of a marked seasonal dry period.

## Vegetation

Descriptions of the Hay Plain are almost synonymous with the adage 'saltbush plains'. *Atriplex vesicaria* and *Maireana aphylla*, with *Atriplex nummularia* to a far lesser extent, are the principal species of these shrublands that dominate the landscape. Perennial saltbush shrublands extend discontinuously from the riverine plain in New South Wales to large areas of South Australia and to southern Western Australia (Dalton 1988). A network of current and ancestral rivers and creeks supports *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* woodlands while scattered low sandy rises and prior streams carry *Callitris*-dominated remnants. The perennial grasslands in the east of the Plain are indicative of greater land use in this higher rainfall area. The change from alluvial to aeolian landscapes in the north-west is marked by sandplains carrying *Casuarina pauper* and *Alectryon oleifolius* open woodlands, *Maireana pyramidata* and *Maireana sedifolia* shrublands, and mallee communities.

The vegetation of the Hay Plain was mapped by Beadle (1948) as an essentially homogeneous area of *Atriplex vesicaria*. While *Atriplex vesicaria* shrubland dominates the Plain today, much of it has been modified by intensive grazing and dieback events. The most widespread change in recent years to the low shrublands has been the replacement of *Atriplex vesicaria* by *Maireana aphylla*. The composition of these and other chenopod shrublands has been further modified with the establishment of *Sclerolaena* species, annual *Atriplex*, *Nitraria billardierei* and other species indicative of disturbance.

## Aboriginal History

The Aboriginal people have occupied the country for at least 30 000 years, with the earliest known evidence coming from Lake Mungo east of the Hay Plain (Flood 1990). Several large Aboriginal tribes lived around the rivers and on the Hay Plain itself. The Wiradjeri tribes lived on the plains east of the Darling (Mullins *et al.* 1982). The Nari-Nari, Mudi-Mudi and Gurendji occupied areas of the Murrumbidgee River between Hay and the Great Cumbung Swamp while the Yida-Yida lived near the Lachlan River north-west of Hay. Tribes along the Murray River from east to west included the Banggarang, Yota-Yota, Baraba-Baraba, Wamba-Wamba, Wadi-Wadi and Dadi-Dadi (NSW Department of Lands 1987). Charles Sturt's encounters with the Aboriginal people along the Murrumbidgee River were published in 1833, in the accounts of his expeditions.

Many plant species were used by the Aboriginal people of the area. They yielded edible tubers, fruits and seeds, wood, fibre and other materials. The ripe orange fruits of *Pittosporum phylliraeoides* were eaten and the sticky red seeds pounded into a flour. The berries of the Emu Bush (*Eremophila longifolia*), and the ripe fruits and oily seeds of the Quandong (*Santalum acuminatum*), were also eaten. The starch-rich spore capsules of *Marsilea drummondii* were a valuable food source for Aborigines, although they preferred other foods and used it more as a standby during dry periods (Mullins *et al.* 1982). The starchy pith of *Typha* species (bulrushes) was eaten as cakes and the fibre used for nets and bags. Grass seeds were gathered by the women and used for flour (Beveridge 1883).

The Aboriginal people also depended on the rivers, which would be full after winter rains, yielding fish, yabbies (freshwater crayfish), mussels, tortoises and water-fowl. Fish was the principal component of the diet for eight months in the year (Beveridge 1883). Away from the rivers, out on the plains, survival depended on water-finding skills. Soaks and wells were dug to tap underground seepage, water from rare rain showers was collected, and often the roots of *Hakea* and mallee species were tapped for their stored water. Active changes were made to the environment, with the burning of shrublands to flush out small animals and other game. Rock fishtrap complexes were also built and creeks were dammed. Temporary dwellings called mia mias were built on the open plains from mulga wood interlaced with sods of grass, although this was probably more common further west (Mullins *et al.* 1982, Beveridge 1883).

A number of Aboriginal sites have been recorded for the Hay Plain, including campsites, middens and ceremonial sites. An Aboriginal art site exists in the Booligal area and canoe trees are occasionally seen in the riverine forests. Small amounts of land are held by Aboriginal Land Councils and other bodies at sites in the area, including freehold land at Balranald and a leasehold site at Moonacullah just north of Deniliquin (New South Wales Department of Lands 1987).

## European exploration and settlement

The first attempted traverse of the Hay Plain was by John Oxley in 1817. His party crossed the Cocoparra Ranges, travelled to Rankin Springs and down the Lachlan River until they were stopped by the much-branching *Muehlenbeckia florulenta* swamps downstream of Booligal. In 1836 Thomas Mitchell succeeded in following the Lachlan to its junction with the Murrumbidgee River. Charles Sturt explored the Murrumbidgee and Lower Murray Rivers during two expeditions between 1828 and 1831 (Sturt 1833). He made many references to the Hay Plain noting that *'... nothing could exceed the apparent barrenness of these plains, or the cheerlessness of the landscape.'* On the vegetation he remarked *'... we journeyed mostly over extensive and barren plains ... covered with the salsolaceous class of plants, so common in the interior ... and were as even as a bowling green ... We passed a very large plain in the course of the day, which was bounded by forests of box, cypress, and the acacia pendula, of red sandy soil and parched appearance.'* (Sturt 1833).

Between 1835 and 1839, pastoral runs averaging 20 000 to 40 000 ha were taken up as far west as Hay (Semple 1990). They were mainly stocked with cattle and were situated along the Murray and Murrumbidgee Rivers and the Yanko and Billabong Creeks. By 1845 land had been taken up as far west as the Murray–Murrumbidgee junction with stations averaging 80 000 ha. Some of the older stations still existing today include 'Uardry' (1840), 'Deniliquin' (1842), 'Eli Elwah' (1844) and 'Nap Nap' (1845). With the discovery of gold in Victoria in the 1850s, the Hay Plain became a fattening ground for travelling stock heading for the goldfields and this coincided with the development of stock routes linking the major towns on the Plain (Dalton 1988). Sheep grazing became the dominant pastoral activity during the 1860s, with riverboats emerging as a major form of transport. Hundreds of pastoral properties and holdings now exist on the Hay Plain, with the townships of Hay and Deniliquin as major centres.

## Land Use

Sheep grazing for wool production is the main land use in dryland areas such as the Hay Plain (Semple 1990). In 1893-1895 stocking rates were about 2.5 sheep per hectare in the Deniliquin area, about the same as present stocking rates on irrigated, improved pasture. By the turn of the century, the extent of land degradation in the Western Division due to the combined effects of overstocking, droughts and rabbits was severe. This led to the appointment of a Royal Commission, which resulted in the passing of the Western Lands Act of 1901, previously administered by the Western Lands Commission (Grant 1989) and now administered by the New South Wales Department of Conservation and Land Management, Western Division. A more current sheep stocking rate on the saltbush plains is 0.4–0.8 sheep per hectare (Leigh & Noble 1972). The grasslands and saltbush plains are considered the most productive of the semi-arid grazing lands of southern Australia and the mallee lands the least productive (Semple & Eldridge 1989), although mallee communities are considered to have a high biological diversity (Calder 1990).

Cropping commenced on a small scale in the 1880s, south of Deniliquin. Most of this was dryland cropping with some irrigation at Mildura. The areas south of Hillston and Balranald were first cleared for cropping in the early 1900s. The general area of crops increased considerably after the First World War but dropped off during the Depression of the late 1920s to early 1930s. Large, state-sponsored irrigation schemes were implemented before and immediately following the Second World War. The state-sponsored Murrumbidgee Irrigation Area has been described as the richest tract of agricultural country in Australia. Other irrigation programs on the riverine plain

include the Hay, Colleambally and Tullakool Irrigation Areas. Many smaller holdings are part of private irrigation schemes. The main rural products are wool, beef, mutton, horticultural products, wine, rice, winter cereals and River Red Gum timber with increasing wheat production in dryland areas (Semple 1990). Clearing and cultivation on Western Division leasehold land are controlled by the Department of Conservation and Land Management, Western Division.

Prior streams are exploited as a source of sand and gravel for road building and numerous small pits and quarries have been opened in the major stream beds across the Plain. In recent years, existing sandhills on the Hay Plain have been developed for potato growing, although wind erosion is a big problem in these areas (Semple & Eldridge 1989). Soil loss due to land use has been high in certain pastoral situations and it is believed that much of the damage was done in the first 20 to 40 years of European settlement (Denney 1992). Rabbits were introduced into the area in the 1870s and rapidly multiplied, with almost a million killed on 'Tupra' station in 1890 (Semple 1990). They have been the cause of widespread land degradation on the Hay Plain and elsewhere in western New South Wales.

## Previous botanical surveys

### General surveys for western New South Wales

As research officer and botanist for the Soil Conservation Service at Condobolin, Noel Beadle comprehensively mapped the vegetation of western New South Wales in the late 1940s. He identified 35 plant associations and 'associes' for western New South Wales and produced a vegetation map at approximately 1:1 000 000 scale (Beadle 1948).

Stannard (1958 & 1963) conducted erosion surveys for the south-west Cobar peneplain and the central east-Darling region and included vegetation and soil maps for each of these areas. The vegetation classification was based on the work of Beadle (1948). Parts of these maps coincide with the far north-east and far north-west corners of the current survey area respectively.

The Anabranch–Mildura (Fox 1991) and Balranald–Swan Hill (Scott 1992) 1:250 000 vegetation maps have been published as part of the western component of a vegetation mapping program at the Royal Botanic Gardens in Sydney. A 1:1 000 000 vegetation map of north-western New South Wales has also been prepared (Pickard & Norris, in press).

Technical manuals, graziers' guides and literature surveys covering a wide range of vegetation types and species have been compiled by the New South Wales Soil Conservation Service (now incorporated in the Department of Conservation and Land Management); these cover the Hay Plain and western New South Wales generally.

Land Systems Maps (Walker 1991) have been published for the whole of the Western Division, including the Booligal–Hay 1:250 000 area. These maps describe the recurring patterns of vegetation, soils and topography. Various species lists have been compiled for Soil Conservation Service experimental exclosures established between 1950 and 1952 and for other study sites across the Plain, by Cunningham and Milthorpe (1981) and Semple (1986).

### Surveys covering the Hay Plain

Leigh and Mulham (1977) and Mulham and Jones (1981) compiled a comprehensive species list for the riverine plain with notes on distribution and pastoral use. Moore (1953) conducted an ecological survey and produced a vegetation map of the south-

eastern Riverina directly east of the present survey area. He discussed the concepts of climax and disclimax vegetation associations, identifying 23 communities (Moore 1953).

The riparian vegetation of the Murray River was mapped at 1:50 000 scale from Albury to Lake Alexandrina in South Australia (Margules & Partners *et al.* 1990). A total of 37 riparian communities were identified. Pressey *et al.* (1984) mapped the vegetation of the Lachlan–Murrumbidgee confluence situated in the west of the Hay Plain.

A survey of *Atriplex vesicaria* extent was conducted in 1987 by the Hay Soil Conservation Service, after widespread occurrences of dieback on the Hay Plain (Clift *et al.* 1987, Clift *et al.* 1989 and Semple 1989). The riverine plain was mapped for remnant Bladder Saltbush using data provided by local landholders (Soil Conservation Service of New South Wales unpubl.)

Sites are currently monitored throughout the Plain as part of the Rangeland Assessment Program by the New South Wales Department of Conservation and Land Management. Species have also been recorded for Willandra National Park by the New South Wales National Parks and Wildlife Service (1985–1988).

## Methods

### Mapping

The composition and extent of the present native vegetation, both remnant and modified was mapped for the Booligal–Hay and Deniliquin–Bendigo 1:250 000 map sheets (see back pocket). Black and white aerial photomosaics and photographs produced by the New South Wales Department of Lands (now the Land Information Centre of the Department of Conservation and Land Management) were used to define plant community boundaries. The photo-interpretation was checked and confirmed or modified by extensive site sampling and field traverses. Provisional vegetation maps were drafted at 1:100 000 scale and reduced to the published scale of 1:250 000. These and other sources of information used for compiling the maps are indicated in Table 2.

Some problems were encountered in interpreting the aerial photography of the Plain. Boundaries between some vegetation types, particularly shrublands and grasslands, are gradational. Mallee, riparian and other tree communities are more readily delineated on aerial photographs. Much ground truthing was thus required to define the extent of grassland and shrubland. Vegetation boundaries were often indirectly determined from the more distinct geomorphological features on the aerial images. While older photomosaics formed the basis for the mapping, contemporary vegetation was updated from recent stereo photography and LANDSAT imagery. Small remnants (smaller than 100 ha) were not mapped because of the scale employed for publication.

### Survey

The vegetation survey was conducted over three years, with nine field trips totalling 15 weeks between February 1990 and October 1992. Of these, five were undertaken during the spring, three in autumn and one trip at the end of summer. The Booligal map area was surveyed in May 1992 during drought conditions and in October 1992 after limited winter rainfall. Fig. 6 indicates site locations and major field traverses across the mapped area.

**Table 2.** Information sources and data used in compiling the Booligal–Hay and Deniliquin–Bendigo 1:250 000 vegetation maps.

| Source | Year | Data | Scale |
|---|---|---|---|
| Beadle, N.C.W. | 1948 | western NSW vegetation survey | 1:1 013 760 |
| New South Wales Department of Lands | 1960–69 | aerial photomosaics | 1:50 000 |
| Division of National Mapping (NATMAP) | 1975–88 | topographic maps | 1:50 000<br>1:100 000<br>1:250 000 |
| Pressey, R.L. *et al.* | 1984 | Cumbung Swamp vegetation survey | 1:50 000 |
| New South Wales Department of Lands | 1986–90 | stereo-paired aerial photos | 1:49 000–<br>1:86 000 |
| Soil Conservation Service of New South Wales (unpubl.) | 1987 | original maps and questionnaires from *Atriplex vesicaria* survey | 1:250 000 |
| Margules and Partners *et al.* | 1990 | Murray River riparian vegetation survey | 1:50 000 |
| Walker, P.J. (Department of Conservation and Land Management) | 1991 | Land Systems maps | 1:250 000 |
| Australian Centre for Remote Sensing | Dec. 1992 | LANDSAT TM satellite imagery | 1:250 000 |

The selection of sites was based on recognised photopatterns, accessibility and the condition of the vegetation on the ground. Additional areas of relatively undisturbed vegetation were sampled or checked on the advice of local experts. A total of 94 sites with a minimum area of 0.1 ha were fully sampled for vegetation, soil, disturbance and other environmental variables while species lists and descriptive information were collected for a further 153 sites. For the Hay and Deniliquin map areas, all species present were recorded within a sampling area of 0.2 ha (100 X 20 m). This was reduced to 0.1 ha (50 X 20 m) for the Booligal area after analysis of species area curves. Data were also collected on plant density, percentage cover, height of strata and relative strata cover. Percentage cover within the first 100 $m^2$ of the quadrat was assessed. Additional information on structure, landform, soils, disturbance and regeneration was recorded for each site. Soil samples and salinity data (using an EM-38 salinity meter) were collected for a subset of sites. Species lists were also made for numerous spot sites across the Plain.

## Structural and floristic classification of the vegetation

The site data collected were used to describe the vegetation communities floristically and structurally. The structural classifications of Specht (1981) and Walker and Hopkins (1990) were employed. Community floristic composition was based on perennial vegetation and the vegetation units named after the dominant species of the tallest stratum. Where this was inappropriate, geological references were used in the naming of the community. Associated species are listed for each vegetation unit in order of abundance. Ground-cover species are listed separately where appropriate.

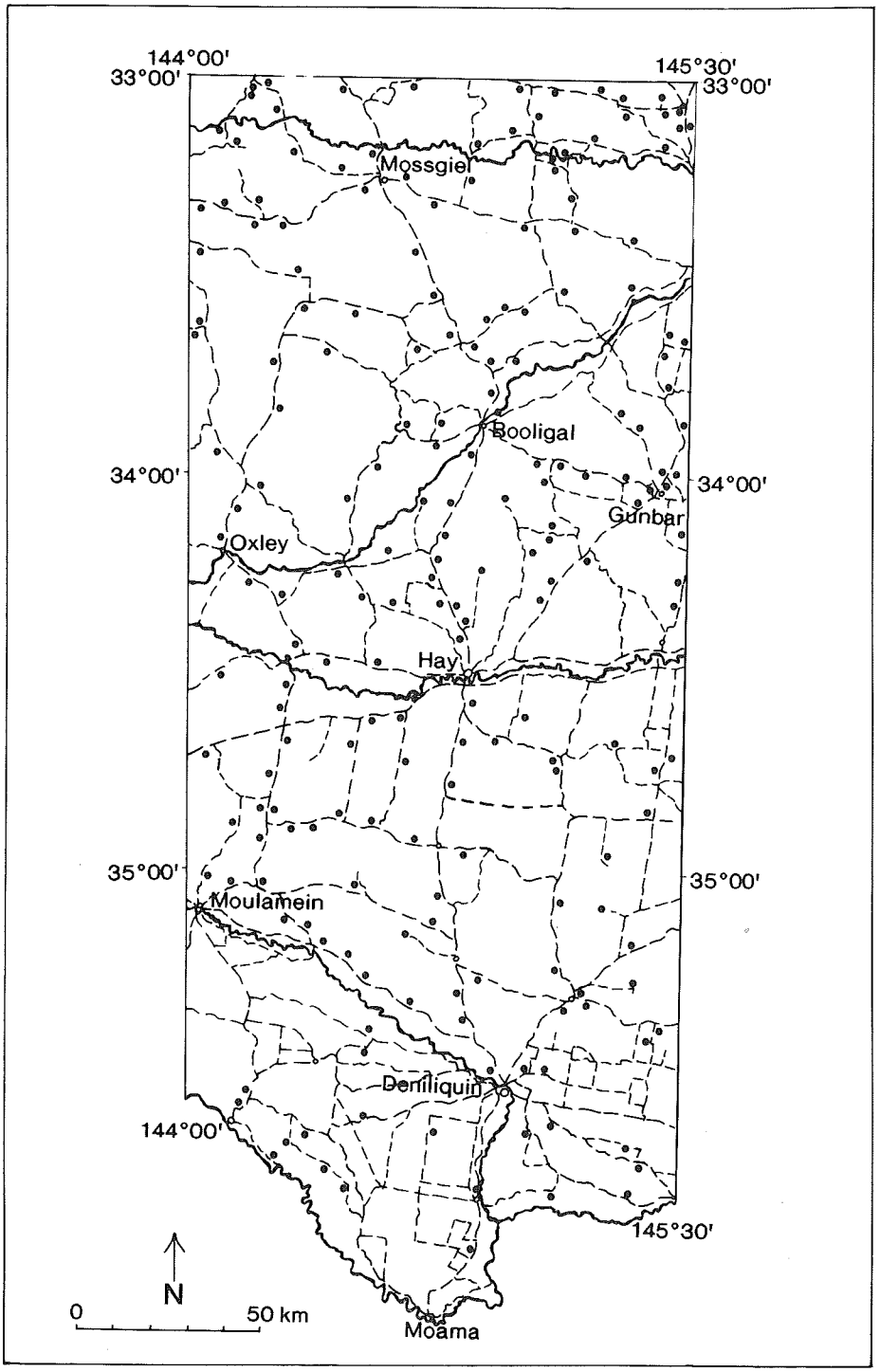


**Figure 6.** Site locations (dots) and major field traverses (dashed lines) across the mapped area (from fieldwork undertaken between February 1990 and November 1992).

The concepts of vegetation community and plant association have been variously defined. Beadle classified the vegetation of western New South Wales into major associations, each containing a number of types. The term 'type' is used to describe botanically uniform communities while an 'association' is defined as an aggregation of botanically related types (Beadle 1948). Beadle (1948) mapped the vegetation of western New South Wales at the 'association' level. In this survey, floristically uniform plant groupings are described and mapped as vegetation communities. This is equivalent to Beadle's 'type' ranking, and with the term 'association' as used by later authors (Beadle & Costin 1952, Moore 1953, Beadle 1981). The 'association' unit was redefined as a climax community in which the dominant stratum has a uniform floristic composition and structure (Beadle & Costin 1952). It should be noted that the term 'association' as used by Beadle (1948) was a more encompassing term, and is equivalent to the 'alliance' unit used in later publications to group floristically related associations (Beadle & Costin 1952, Moore 1953).

The botanical names used throughout the present survey are those currently recognised by the National Herbarium of New South Wales, and follow Harden (1990–92).

## Community descriptions

Twenty-one vegetation communities are identified on the Booligal–Hay and Deniliquin–Bendigo 1:250 000 map sheets, represented by map units 1 to 29 (Table 3). Two cleared units are also recognised. Structural types range from grassland to open forest, including woodland, mallee shrubland and chenopod shrubland. Community structure is based on Specht (1981) # and Walker and Hopkins (1990) ##. An asterisk * indicates an exotic species. (B), (H), or (D) after a species indicates whether or not it is restricted to a particular map area: Booligal, Hay and Deniliquin–Bendigo respectively.

### The vegetation communities

**Map unit 1: Riverine Forest**

**Structure:** open forest # and ##

**Main species:** *Eucalyptus camaldulensis* (River Red Gum)

**Associated species:** *Acacia stenophylla, Muehlenbeckia florulenta, Eucalyptus largiflorens, Chenopodium nitrariaceum, Acacia salicina, Eucalyptus microcarpa* (D), *Juncus ingens* (D), *Exocarpos strictus* (D), **Lycium ferocissimum.*

**Ground-cover species:** *Pratia concolor, Glinus lotoides, Oxalis perennans, Centipeda cunninghamii, Paspalidium jubiflorum, Alternanthera denticulata, Chamaesyce drummondii, Cotula australis, Marsilea drummondii, Carex appressa, Poa fordeana, Agrostis avenacea, *Cotula bipinnata, *Stellaria media* (D), **Solanum nigrum, *Sonchus oleraceus.*

**Landform:** River and creek levees and adjacent flats, channelled plains and other areas subject to frequent or periodic flooding.

**Soils:** Heavy grey, brown and red clays.

**Occurrence:** This community occurs along the major river systems of the Murray, Edward–Wakool, Murrumbidgee and Lachlan Rivers and other rivers and creeks throughout the mapped area: (Figs 7 & 8). In the drier north, creeks and rivers tend to be fringed with *Eucalyptus largiflorens* (Black Box), although *Eucalyptus camaldulensis* will occur with Black Box wherever periodic flooding occurs. Dense stands of

**Table 3.** Plant communities of the Booligal (B), Hay (H) and Deniliquin–Bendigo (D) 1:250 000 map sheets with map unit and main species. Structure is based on Specht (1981) # and Walker & Hopkins (1990) ##. Equivalent map units used by Scott (1992) for the adjacent Balranald–Swan Hill map sheet are also indicated (Bal. No.).

| No. | Plant Community | Main Species | Structure | Map | Bal. No. |
|---|---|---|---|---|---|
| **1** | Riverine Forest | *Eucalyptus camaldulensis* | open forest # & ## | BHD | 1 |
| **2** | Black Box Woodland | *Eucalyptus largiflorens* | woodland #; woodland - open woodland ## | BHD | 2 |
| **3b** | Dune-Crest Mallee | *Eucalyptus socialis, Eucalyptus dumosa, Triodia scariosa* | tall shrubland #; mallee shrubland - open mallee shrubland ## | B | 3b |
| **3d** | Sandplain Mallee | *Eucalyptus socialis, Eucalyptus dumosa* | tall shrubland #; mallee shrubland - open mallee shrubland ## | B | 3d |
| 4 | Belah–Rosewood | *Casuarina pauper, Alectryon oleifolius* subsp. *canescens* | low - low open woodland #; open woodland - isolated clumps ## | B | 4 |
| **8** | Black Bluebush | *Maireana pyramidata* | low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ## | BH | 8 |
| **8p** | Black Bluebush and Pearl Bluebush | *Maireana pyramidata, Maireana sedifolia* | low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ## | BH | 9 |
| **11** | Bladder Saltbush | *Atriplex vesicaria* | low - low open shrubland #; chenopod shrubland - open chenopod shrubland ## | BHD | 11 |
| **12** | *Sclerostegia tenuis* | *Sclerostegia tenuis, Disphyma crassifolium* subsp. *clavellatum* | low shrubland #; closed - open chenopod shrubland ## | BHD | - |
| **13** | Canegrass | *Eragrostis australasica* | tussock grassland # & ## | BHD | 13 |
| **16** | *Callitris* Mixed Woodland | *Callitris glaucophylla* | woodland - low open woodland #; woodland - isolated clumps ## | BHD | 16 |
| **17** | *Acacia melvillei* Woodland | *Acacia melvillei* | tall shrubland - low woodland #; shrubland - woodland ## | BHD | 17 |

| | | | | | |
|---|---|---|---|---|---|
| **18** | Lignum and *Chenopodium nitrariaceum* | *Muehlenbeckia florulenta*, *Chenopodium nitrariaceum* | low shrubland - open scrub #; open - closed shrubland ## | BHD | 18 |
| **19** | Old Man Saltbush | *Atriplex nummularia* | low - open shrubland #; chenopod shrubland - open chenopod shrubland ## | BHD | 19 |
| **21** | Cotton Bush | *Maireana aphylla* | low - low open shrubland #; chenopod shrubland - sparse chenopod shrubland ## | BHD | 21 |
| **22** | Dillon Bush | *Nitraria billardierei* | low - low open shrubland #; shrubland - sparse shrubland ## | BHD | 22 |
| **23** | Great Cumbung Swamp | *Phragmites australis*, *Senecio cunninghamii*, *Typha orientalis*, *Typha domingensis* | closed - open herbland/ grassland #; closed - open grassland/rushland/forbland ## | H | 23 |
| **24** | Grey Box Woodland | *Eucalyptus microcarpa*, *Allocasuarina luehmannii* | low woodland - woodland #; open woodland - woodland ## (occasionally to open forest # and ##) | D | - |
| **25** | *Acacia pendula* Woodland | *Acacia pendula* | low - low open woodland #; open woodland - woodland ## | BHD | - |
| **26** | White-top Grassland | *Danthonia caespitosa* | tussock grassland - open tussock grassland #; grassland - open grassland ## | BHD | - |
| **27** | Prior Stream Remnant Woodland | *Callitris glaucophylla*, *Hakea leucoptera*, *Hakea tephrosperma* | low open woodland #; open woodland - isolated trees ## | BHD | - |
| **28** | *Casuarina pauper*/ *Casuarina cristata* Intergrading Population | *Casuarina pauper*/ *Casuarina cristata* intergrades | low woodland - woodland #; open woodland - woodland ## | BH | - |
| **29** | Rocky Outcrop Woodland Complex | *Callitris glaucophylla*, *Eucalyptus intertexta*, *Eucalyptus vicina* | low woodland #; woodland to open woodland and open mallee woodland - shrubland ## | B | - |
| **OA** | Open Areas | various grasses, herb sand forbs | open herbfield #; grassland to forbland ## | BHD | OA |

**Figure 7.** Flooded *Eucalyptus camaldulensis* open forest at Gum Creek, Boyds Bridge, south-east of Hay, in early spring (community 1).

*Eucalyptus camaldulensis* occur along the Murray and on its adjacent floodplain, particularly in the Barmah and Millewa State Forests, which are internationally recognised wetland habitats (Finlayson & Moser 1991). A more open *Eucalyptus camaldulensis* woodland is found on the channelled floodplain of the Lachlan River south-west of Booligal.

**Condition:** Old trees thinned with selective logging, resulting in a younger age class over much of the distribution of this community; forests subject to manipulated flooding regimes with regeneration greatly affected; limited weed infestation; many areas cleared for crop growing, especially in the Murray River area.

**Notes:** *Eucalyptus camaldulensis* requires periodic flooding for seedling germination and growth (Somerville 1988) while *Eucalyptus largiflorens* tolerates less frequent flooding and occurs on slightly higher ground on the floodplain, distant from the channel. Areas of *Eucalyptus largiflorens* that dominate these terrace landform elements have been mapped as a separate community (2). Rare hybrids of *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* occur between Barham and Swan Hill.

*Eucalyptus microcarpa* (Grey Box) forms extensive stands within *Eucalyptus camaldulensis* forests in the Deniliquin area. In Werai State Forest north-west of Deniliquin, *Eucalyptus microcarpa* reaches open forest proportions. Within the Murray floodplain, higher areas of red-brown earths or sands occur, carrying much-cleared woodlands of *Callitris gracilis* subsp. *murrayensis* (Murray Cypress Pine) or *Callitris glaucophylla* (White Cypress Pine) (See Community 16). These sandhills scattered throughout the River Red Gum forest are commonly about twelve metres high and are older than the floodplain itself, having been there before the Cadell Tilt uplifting (Allen 1979). A small population of *Eucalyptus leucoxylon* subsp. *pruinosa* (unmapped) exists just north of Barham, adjacent to *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* woodland and growing on grey-brown alluvial soil.

*Eucalyptus camaldulensis* may reach heights of up to 40 m and forms the only forest structural type in the area. A shrub layer is normally absent, with leaf and branch litter dominating the ground layer. Shrubs, if present, may include *Muehlenbeckia florulenta* (Lignum), *Chenopodium nitrariaceum* and **Lycium ferocissimum*. *Muehlenbeckia florulenta* and *Eragrostis australasica* may occur in intermittently flooded channels within the floodplain while areas of semi-permanent still water support rushlands of *Typha* spp. (Fig. 22), *Phragmites australis*, *Juncus* spp. and *Eleocharis* spp. The herbaceous layer varies seasonally and, as well as the species listed, may include *Rumex*, **Medicago*, *Echium* and **Xanthium* spp. together with exotic grasses such as **Hordeum leporinum* and **Lolium perenne*. River Red Gum forests are a good example of a unispecific community. Because of the regular flooding in their habitat, all other species are drowned and only *Eucalyptus camaldulensis* can survive (Allen 1979).

Much of the River Red Gum forest on the Murray River floodplain and areas along the Murrumbidgee River are under State Forest management and have been logged and grazed to various extents. Regeneration of *Eucalyptus camaldulensis* is poor in areas where grazing is a predominant land use. Changes in flooding regimes due to river regulation have led to a decline in the quality of stands (Margules & Partners *et al.* 1990). Natural regeneration is largely dependent on flooding (Somerville 1988) and river regulation is preventing this, for example, some stands have died along the Murray River (Allen 1979). Dense areas of *Eucalyptus camaldulensis* occur along the Murray River in the Barmah, Millewa, Perricoota and Koondrook State Forests and should be targeted for conservation. These forests are also an important archaeological resource, as they include canoe trees, camp sites, middens and burial grounds. A small area of River Red Gum is conserved within Goonawarra Nature Reserve on the Lachlan River south-west of Booligal but, with the exception of Kemendoc Nature

Reserve west of the mapped area, the community remains virtually unconserved along the Murray River in New South Wales. Some small Crown Reserves conserve River Red Gum forest areas, however these are usually discontinuous and generally not actively managed.

**Map unit 2: Black Box Woodland**

**Structure:** woodland #; woodland – open woodland ##

**Main species:** *Eucalyptus largiflorens* (Black Box)

**Associated species:** *Chenopodium nitrariaceum, Rhagodia spinescens, Atriplex nummularia, Enchylaena tomentosa, Einadia nutans, Muehlenbeckia florulenta.*

**Ground-cover species:** *Chamaesyce drummondii, Atriplex semibaccata, Atriplex leptocarpa, Oxalis perennans, Boerhavia coccinea, Centipeda cunninghamii, Alternanthera denticulata, *Verbena officinalis, Calotis scapigera.*

**Landform:** Uppermost floodplain levels, periodically flooded alluvial plains, ephemeral creeks and adjacent flats, dry-lake margins, depressions, drains and channels.

**Soils:** Heavy grey and brown clays, self-mulching or compact. Black Box woodland also occurs on the sandier soils of ancient rivers and former depressions (Semple 1990).

**Occurrence:** Black Box forms extensive woodlands on the terrace landform elements adjacent to major creeks and rivers across the mapped area (Fig. 9). It is also common in depressions, along major and minor creeks (especially north of the Murrumbidgee River) and fringing dry lakes. South of Moulamein and Conargo on the Deniliquin map, *Eucalyptus largiflorens* often occurs mixed with *Eucalyptus microcarpa* (Grey Box) and less commonly *Eucalyptus melliodora* (Yellow Box), gradually being replaced by the former further south on the floodplain.

**Condition:** Some tree dieback is apparent especially in irrigated areas; weed infestation common. Understorey generally intact and sparsely grazed, except where cleared in the southern irrigation areas.

**Notes:** *Eucalyptus largiflorens* is one of the most widespread and common trees in inland New South Wales, also extending into South Australia, Victoria and extreme southern Queensland. It grows on the less frequently flooded areas of the floodplain above the level of the adjacent River Red Gum forest. It also occurs in ribbon stands along intermittent creeks, fringing lakes, or as a line of very scattered individual trees along drainage lines. *Eucalyptus largiflorens* often occurs in depressions and other areas of restricted drainage within other vegetation communities such as *Callitris glaucophylla, Acacia pendula* and mallee woodlands.

The relatively open nature of this community has allowed for the development of an understorey of variable density and composition. The main understorey species in Black Box woodlands are *Chenopodium nitrariaceum, Rhagodia spinescens* and *Enchylaena tomentosa. Chenopodium nitrariaceum* often extends out beyond the Black Box floodplain to form extensive shrublands, although much has been cleared for irrigated cropping. *Atriplex nummularia* occasionally forms a tall understorey to *Eucalyptus largiflorens*. Where the community occurs in wetter, periodically flooded areas, *Muehlenbeckia florulenta* may be the major understorey component.

Dieback of *Eucalyptus largiflorens* is a problem in heavily irrigated areas, particularly adjacent to the Murray River. In their survey of riparian vegetation, Margules and Partners *et al.* (1990) reported that trees were generally in poor condition over most

**Figure 8.** *Eucalyptus camaldulensis* forest with *Juncus ingens* understorey and ground cover of *Scleranthus minisculus* and *Stellaria media*; Edward River, Mathoura, in late winter (community 1).

**Figure 9.** Open *Eucalyptus largiflorens* woodland with grassy understorey of *Hordeum leporinum* and *Lolium perenne* on 'Bertangles', east of Hay, in early spring (community 2).

of their distribution along the whole of the Murray River, with Black Box in the far western reaches the worst affected. Soil salinisation from rising local water tables and salty groundwater inflows is considered a major problem along the river. Local cases of dieback around Deniliquin in the Edward–Wakool river system have also been reported (M. Driver, Greening Australia, pers. comm.). Salinity may be a contributing factor, although the causes of these and other dieback events in dryland areas are currently under investigation.

Logging has been a common practice in Black Box communities and the timber used for fencing. The area around Hay has been particularly affected, although small clumps have been retained in paddocks for stock shelter (Semple 1990). Sheep grazing appears to have limited regeneration of Black Box along the Murray River, while previous logging has led to a decline in mature trees of the species (Margules & Partners *et al.* 1990, Treloar 1959). A section of Willandra Creek supporting a Black Box woodland with a dense *Acacia stenophylla, Chenopodium nitrariaceum* and *Muehlenbeckia florulenta* understorey is conserved within Willandra National Park on the Booligal map area. A small area of *Eucalyptus largiflorens* associated with the Lachlan River is also conserved within Goonawarra Nature Reserve south-west of Booligal. The community is considered poorly conserved in New South Wales (Murray–Darling Basin Ministerial Council 1987).

**Map unit 3: Mallee**

**Structure:** tall shrubland to low woodland #; mallee shrubland to open mallee shrubland (rarely open mallee woodland) ##

'Whipstick' mallee is a low, stunted multi-stemmed growth form, indicating a sandy soil of low fertility and commonly occurring on the dune crests. 'Bull' mallee, a taller form with fewer stems, indicates a more fertile and less sandy soil and occurs in the heavier soils of the swales (Beadle 1948, Noble *et al.* 1980).

**Main species:** *Eucalyptus socialis* (Pointed Mallee) (B), *Eucalyptus dumosa* (Congoo Mallee) (B).

**Associated species:** *Eucalyptus gracilis* (B), *Eucalyptus leptophylla* (B), *Senna artemisioides* subsp. *filifolia, Senna artemisioides* subsp. *petiolaris, Dodonaea viscosa* subsp. *angustissima, Acacia colletioides* (B), *Eucalyptus intertexta* (B), *Eucalyptus populnea* subsp. *bimbil* (B).

*Callitris glaucophylla* and *Acacia melvillei* as well as *Casuarina pauper* with *Alectryon oleifolius* form local communities within the mallee.

The following species are associated with particular geomorphological variation within the mallee:

**3b** Dune-Crest Mallee: *Triodia scariosa* (B), *Lomandra effusa* (B), *Olearia pimeleoides* (B), *Eremophila glabra* (B), *Eremophila sturtii* (B), *Acacia wilhelmiana* (B).

**3d** Sandplain Mallee: *Maireana pyramidata, Enchylaena tomentosa, Dissocarpus paradoxus, Rhagodia spinescens.*

Note: These shrubs occur more commonly in the Sandplain Mallee in the west of the mapped area. The Sandplain Mallee of the north-east supports a different shrub layer of mostly *Senna, Dodonaea* and *Acacia* species, with a high bark litter ground component.

**Landform:** Level to undulating sandplains and irregular dunefields with low, discontinuous, linear dunes.

**Figure 10.** Mallee shrubland with *Eucalyptus socialis* and *Triodia scariosa*, on dune-crest south of Roto in mid-spring (community 3b).

**Soils:** Calcareous red earths with sandy loam to clay loam surface and red desert loams derived from aeolian materials (Scriven 1988a, Eldridge 1990).

**Occurrence:** Two disjunct areas of mallee occur on the Booligal map area. In the north-eastern sector, the mallee is characterised by sandplains and low irregular dunes with some Dune-Crest mallee (Fig.10) and interspersed with higher sandhills supporting *Callitris glaucophylla* and undulating areas of Belah–Rosewood. South of Hillston the mallee is of the 'bull'-type, with large, few-stemmed trees (Fig. 11). Due to extensive cropping in this area the mallee is very much of a remnant nature with a cleared understorey. North of Hillston and extending north and north-west to Roto and Trida railway sidings, extensive stands of whipstick mallee occur with a well-developed shrubby understorey. The second area of mallee occurs in the aeolian-alluvial geomorphological transition zone in the west. Aeolian sandplains carrying mallee with a *Maireana pyramidata* (Black Bluebush) understorey occur on the south-western edge of the Booligal map. This is primarily within Belah–Rosewood country (see Community 4) along the Clare-Oxley and Hatfield roads. Extensive dunefields supporting mallee on the dune crests and Belah–Rosewood in the swales occur further west.

**Condition:** Many areas (especially south of Hillston) severely cleared or thinned; dunes largely cleared; some soil erosion due to rabbit infestation and some scalding in open areas; areas of woody shrubs present; some areas subject to wildfire; few old stands remain, mostly of the 'whipstick' form. Dense mallee areas with intact understoreys exist along the railway lines in the north-east.

**Notes:** In New South Wales, mallee mainly occurs in the far south-west largely intact, and in a central area, much of which has been cleared for cereal growing and is now roughly bounded by Ivanhoe, Cobar and Condobolin (Scriven 1988a). *Eucalyptus socialis* and *Eucalyptus dumosa* are amongst the main species present in these mallee lands, with structural variations in different habitats (Lawrie & Stanley 1980). In the east of the mapped area, stands of *Callitris glaucophylla* and Belah–Rosewood occur intermixed with the mallee. *Eucalyptus intertexta* (Western Red Box), and *Eucalyptus populnea* subsp. *bimbil* (Bimble Box), also occur occasionally. A different mallee community exists in the west of the mapped area in the transition zone from alluvial to aeolian landforms. Here on the sandplain the mallee has a low, open, shrubby understorey of *Maireana pyramidata, Rhagodia spinescens* and *Enchylaena tomentosa. Eucalyptus socialis* and *Eucalyptus dumosa* are the main mallee species in both landform types occurring on the mapped area.

Ground litter is often high in communities that have remained unburned for some years. Chenopods form an understorey where the soils are higher in clay content, such as on sandplains and swales. *Triodia scariosa* occurs in the understorey on sandier sites such as dune crests. Large woody shrubs such as *Dodonaea, Senna* and *Acacia* species are common understorey components in the north-eastern mallee of the mapped area. To stimulate pasture growth, many graziers reduce mallee density by clearing (chaining) and burning (Semple & Eldridge 1989).

### Map unit 4: Belah–Rosewood

**Structure:** low woodland – low open woodland #; open woodland – isolated clumps ##

**Main species:** *Casuarina pauper* (Belah), *Alectryon oleifolius* subsp. *canescens* (Rosewood). *Alectryon oleifolius* subsp. *elongatus* occurs less commonly; this subspecies has a more eastern distribution and grows on heavier soils (L. Johnson pers. comm., Harden 1990–1992).

**Figure 11.** Remnant Sandplain Mallee (community 3d) of *Eucalyptus socialis*, *Eucalyptus dumosa* and *Eucalyptus gracilis*, south-west of Hillston along McKinley Road, in mid-spring.

**Figure 12.** Belah-Rosewood open woodland (community 4) with *Casuarina pauper* in the foreground and a low *Maireana pyramidata* understorey; just west of 'Belgium Park' south of Ivanhoe, at the end of autumn.

**Associated species:** *Maireana pyramidata, Geijera parviflora, Exocarpos aphyllus, Rhagodia spinescens, Acacia victoriae* (B), *Acacia melvillei, Dissocarpus paradoxus, Maireana sedifolia, Myoporum platycarpum, Maireana humillima* (B).

**Landform**: Level to undulating sandplains and aeolian dunes.

**Soils**: Calcareous earths, mainly of red to red-brown loam to loamy sand. Solonised brown soils to sandy red earths (Cunningham *et al.* 1981). Reddish-brown sands and texture-contrast (duplex) soils (Scriven 1988b). Red-brown soils with light-textured topsoil and calcareous subsoil (Wilson & Johnson 1989).

**Occurrence:** Belah–Rosewood occurs across the north and in the west to north-west of the Booligal map area (Fig. 12). The densest continuous areas of Belah–Rosewood clumps occur along the Ivanhoe–Balranald Road in the north-west of the map and east of Mossgiel along the Alma Lake and East Clare roads. An area of Belah–Rosewood with a low shrubby understorey of *Maireana brevifolia* was observed south of Conoble siding. Scattered trees of *Flindersia maculosa* were also seen within an open Belah–Rosewood community south-east of Ivanhoe. Dense *Casuarina pauper* was also observed in a distinct tier on the lower slopes of Warranary Hill, a rocky outcrop in the far north-east of the Booligal-Hay map (Community 29).

**Condition:** Scalding and soil erosion, often severe, due to rabbit infestation; many bare areas and trees generally thinned; areas of woody shrubs present; few stands with healthy understorey shrubs; heavily grazed.

**Notes:** *Casuarina pauper* and *Alectryon oleifolius* are distributed in monospecific groves within this community with little mixing of the two species. Groves or clumps of trees may be many metres apart. An open *Maireana pyramidata* understorey is common, with *Maireana sedifolia* on the calcareous soils at higher elevations. Heavy grazing of these areas has resulted in the thinning and clearing of much of the understorey and the undermining of the sandier soils by rabbits has caused further degradation. The soils are also susceptible to scalding. This community occurs on the western-most edge of the riverine plain at the transition from alluvial to aeolian landscapes.

*Callitris glaucophylla, Pittosporum phylliraeoides, Hakea leucoptera* and *Hakea tephrosperma* occupy sandier areas of higher elevation within this community. *Acacia melvillei* groves are also common on sandy-loam areas. Mallee (Community 3) may intermix with Belah–Rosewood in deeper sands at the western and far north-eastern edges of the mapped area. *Casuarina pauper* and *Alectryon oleifolius* also occur throughout the mapped area as isolated trees or small groves, especially within the mixed *Callitris*-dominated woodlands of prior streams and source-bordering dunes (Communities 16 and 27).

This community is dominated by *Casuarina pauper* which is closely related to, and of a smaller and poorer form than *Casuarina cristata*. Both species were included in Beadle's concept of *Casuarina lepidophloia* (Beadle 1948) and referred to by other authors as *Casuarina cristata* (Cunningham *et al.* 1981). *Casuarina cristata* (Belah) and *Casuarina pauper* (Black Oak) are now treated as distinct species (Wilson & Johnson 1989). An intergrading population of *Casuarina cristata* and *Casuarina pauper* occurs in the east of the mapped area (see Community 28). *Casuarina cristata* is a more central-eastern species in New South Wales and southern Queensland in contrast to the more western distribution of *Casuarina pauper*, which extends across South Australia into Western Australia (L. Johnson pers. comm.).

Tree clumps of *Casuarina pauper* and particularly of *Alectryon oleifolius* often survive by suckering. Regeneration is prevented by grazing (Semple & Eldridge 1989), while the regeneration potential of *Alectryon oleifolius* is also reduced by insect seed-embryo

predation (Wisniewski & Parsons 1986). Belah around Mildura and Ivanhoe is increasingly cut for timber and cleared for cropping, although felling is costly and difficult because of the robust nature of the trees (Semple & Eldridge 1989).

**Map unit 8: Black Bluebush**

**Structure:** low shrubland – low open shrubland #; chenopod shrubland – sparse chenopod shrubland ##

**Main species:**

**8.** *Maireana pyramidata* (Black Bluebush)

**8p.** *Maireana pyramidata, Maireana sedifolia* (Pearl Bluebush)

**Associated species:** *Maireana sedifolia, Rhagodia spinescens, Enchylaena tomentosa, Atriplex lindleyi, Dissocarpus paradoxus, Maireana georgei, Stipa nitida, Stipa scabra* subsp. *falcata, Stipa scabra* subsp. *scabra, Eragrostis dielsii,* other *Atriplex* spp. and *Sclerolaena* spp.

**Landform:** Low sandy rises, undulating plains, lunette remnants, prior stream levees.

**Soils:** Calcareous sands and loams, red-brown duplex soils with sandy topsoils and clayey subsoils. The distribution of *Maireana pyramidata* and *Maireana sedifolia* appears to be determined by soil calcareousness. Black Bluebush dominates where limestone lies at a depth of 1.2 m or more below the soil surface while soils containing shallower limestone will also support Pearl Bluebush (Beadle 1948).

**Occurrence:** This shrubland community is common in the north to north-west of the mapped area, particularly on the Booligal map area, where the country becomes undulating and duplex soils predominate (Fig. 13). Smaller rises with *Maireana pyramidata* occur throughout the mapped area, particularly on scalded prior stream levees and flats. Large and often dense areas of *Maireana pyramidata* with *Maireana sedifolia* occur north of Oxley, west of Alma Lake and south of Ivanhoe, although *Maireana sedifolia* does not usually occur as the dominant species in these localities (Fig. 14).

**Condition:** Severe to moderate soil erosion due to rabbit infestation with many bare areas; severe scalding on source-bordering dunes and lunettes; moderately grazed. Dense, relatively healthy areas exist in the north-west of the mapped area, although these may be periodically subject to caterpillar defoliation and possible dieback.

**Notes:** This community often grades into *Atriplex vesicaria* or *Atriplex nummularia* on flats and lower areas. Two condition classes of *Maireana pyramidata* were observed within the mapped area. A very open shrubland of scattered, often sparse shrubs occurs on raised scalded areas, lunettes, prior stream levees and cleared areas. Dense continuous stands, often with *Maireana sedifolia,* occur on raised areas with deeper sandy or sandy-loam soils.

*Maireana sedifolia* (Pearl Bluebush) tends to occur on calcareous soils where limestone nodules lie within 60 cm of the surface and dominates where limestone exists within the first 30 cm (Beadle 1948). *Maireana pyramidata* usually occurs on sandy soils which are alkaline but contain little lime (Dalton 1988). Pearl Bluebush was not mapped as a separate community because of its relatively small extent and has been included under this map unit. The existence of *Maireana sedifolia* within *Maireana pyramidata* shrubland is indicated (map unit 8p). Both species also occur as an understorey to Belah–Rosewood, commonly extending into adjacent areas of this woodland and occasionally into mallee. *Maireana pyramidata* is a common species on the veneer of

**Figure 13.** *Maireana pyramidata* shrubland (community 8) with a sandhill supporting *Eremophila longifolia* and *Dodonaea viscosa* subsp. *angustissima* in the background; Tchelery Woolshed west of Booroorban, at the end of summer.

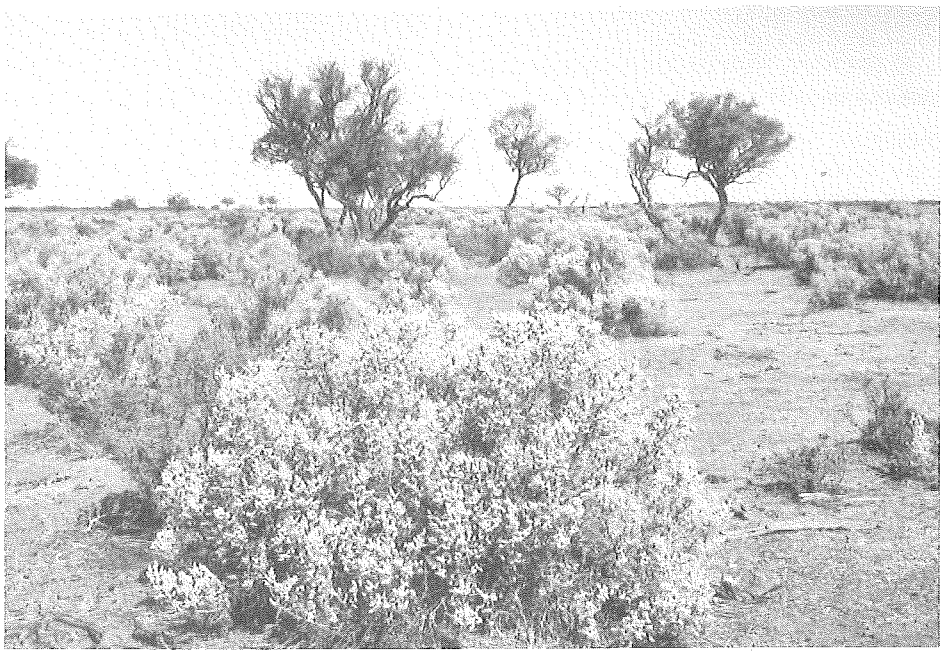

**Figure 14.** *Maireana sedifolia* shrubland (community 8p) with scattered *Casuarina pauper* and *Maireana pyramidata*, west of Alma Lake at the end of autumn.

aeolian material that indicates the transition from riverine or lacustrian landforms. *Maireana sedifolia* becomes the dominant further west where calcareous earths are more common (Beadle 1948, Fox 1991).

The coarse-textured duplex soils supporting bluebush communities are highly susceptible to wind erosion and rabbit infestation. Little clearing of bluebushes occurs in the Western Division because of their drought forage value (Semple & Eldridge 1989). Clearing of dense stands is not permitted under Cultivation Permits issued by the Western Lands Commissioner. This community remains unconserved on the Hay Plain.

### Map unit 11: Bladder Saltbush

**Structure:** low shrubland – low open shrubland #; chenopod shrubland – open chenopod shrubland ##

**Main species:** *Atriplex vesicaria* (Bladder Saltbush). Due to incomplete distributional data subspecies (Harden 1990–92) have not been recognised in the present survey.

**Associated species:** *Sclerostegia tenuis, Malacocera tricornis, Disphyma crassifolium* subsp. *clavellatum, Minuria cunninghamii, Maireana aphylla, Sclerolaena tricuspis, Sclerolaena muricata, Ixiolaena tomentosa, Eragrostis australasica, Sclerolaena brachyptera, Sclerolaena bicornis* var. *bicornis, Sclerolaena intricata, Leptorhynchos panaetioides, Calocephalus sonderi, Frankenia connata, Maireana decalvans, Dissocarpus biflorus* var. *biflorus.*

Other common associate species which vary seasonally include:

*Atriplex lindleyi, Atriplex pseudocampanulata, Rhodanthe corymbiflora, Plantago cunninghamii, Podolepis muelleri, Daucus glochidiatus, Sida trichopoda, Maireana pentagona, Sclerolaena stelligera, Brachycome lineariloba, Vittadinia cuneata* var. *cuneata, Chloris truncata, Sporobolus caroli, Agrostis avenacea.*

**Landform:** Level to depressed alluvial plains.

**Soils:** Deep, grey, self-mulching and cracking clays to red clay-loam. Grey clays, clay-loams to sandy loams overlying clay (Knowles & Condon 1951). May also occur in sandy deposits.

**Occurrence:** *Atriplex vesicaria* forms the dominant vegetation community over the mapped area (Figs. 15 & 16). It is believed to have once covered vast areas of the Hay Plain but that excessive grazing has led to its rapid decline (Beadle 1948, Knowles & Condon 1951). Several dieback events over the past decade have seen a further decline in extent of the species. Post-dieback distribution of *Atriplex vesicaria* has been mapped. The largest continuous stands occur north of Hay and west to north-west of Booligal, particularly around One Tree, Oxley, 'Freshwater' and 'Culpataro'. Only small remnant patches exist on the Deniliquin map, these being mainly north of Billabong Creek. The New South Wales Soil Conservation Service established five experimental and regeneration areas on the saltbush plains between 1950 and 1952 which remain fenced today and contain regenerated saltbush (Dalton 1988).

*Atriplex vesicaria* stands extend west to Balranald and north to about 20 km south of Ivanhoe. The area occupied by Bladder Saltbush stands on the riverine plain was estimated at approximately 1.1 million hectares, decreasing to 0.5 million hectares by the end of 1983 with subsequent dieback (Clift *et al.* 1987). Smaller areas of the community occur further north and west, for example on some of the relict lakes of the Willandra Lakes system. Some saltbush occurs in north-western Victoria as discrete areas along the Murray River (Dalton 1988). *Atriplex vesicaria* shrublands also occur on the treeless plains around the Barrier Range in north-western New South

**Figure 15.** *Disphyma crassifolium* subsp. *clavellatum* growing amongst *Atriplex vesicaria* shrubs (community 11) south-east of Booligal, in mid-spring.

Wales but, unlike those on the Hay Plain, occur on sandy to sandy loam surface soils (Beadle 1948).

**Condition:** Seriously affected by widespread dieback; moderately to heavily grazed; shrub densities reduced and many areas degraded to *Maireana aphylla* or copperburr (*Sclerolaena* spp.) shrublands.

**Notes:** The decline of the once-vast *Atriplex vesicaria* shrublands began with the opening-up of western New South Wales to pastoral activity in the mid-1800s. Overgrazing and drought has seen the elimination of the species over a wide area (Knowles & Condon 1951). In many cases it has been replaced by *Maireana aphylla, Sclerolaena* species, annual saltbush species and introduced grasses. Degraded communities within Bladder Saltbush shrubland as listed by Beadle (1948) include *Maireana aphylla, Atriplex lindleyi, Sclerolaena muricata,* annuals and *Nitraria billardierei.*

*Atriplex vesicaria* on the Hay Plain was affected by large-scale dieback from 1977 to 1983 (Clift *et al.* 1987, Clift *et al.* 1989, Semple 1989). This resulted in a 53 per cent decrease in area of the community, from 1 130 000 ha to 531 000 ha (Semple 1989). A second dieback event is presently occurring in these remnant regions (September 1991). The worst-affected areas are south-west to north-west of Booligal with stands directly west of Booligal particularly affected. The causes of these dieback events are discussed in the 'Natural modifications' section of the Discussion.

A close associate of *Atriplex vesicaria* is *Sclerostegia tenuis,* which replaces the former in depressed, saline situations (see Community 12). Large patches of *Eragrostis australasica* often occur in depressions within both these shrubland communities. Bluebush rises often grade into Bladder Saltbush shrubland at lower levels. *Atriplex vesicaria* often occurs mixed with *Atriplex nummularia* on flat to low-lying sites.

*Atriplex vesicaria* is palatable to sheep and is often the only forage plant available during drought. It is considered highly valuable from a fodder point of view and is high in protein and salt content. The woody stems are brittle and very prone to mechanical damage with overgrazing (Knowles & Condon 1951). Good regeneration of *Atriplex vesicaria* follows high autumn or winter rainfall, however the high temperatures that follow summer rainfall inhibit germination and damage the soil seed source (Knowles & Condon 1951).

**Map unit 12: *Sclerostegia tenuis***

**Structure:** low shrubland #; closed – open chenopod shrubland ##

**Main species:** *Sclerostegia tenuis* (Slender Glasswort), *Disphyma crassifolium* subsp. *clavellatum* (Round-leaf Pigface).

**Associated species:** *Atriplex vesicaria, Eragrostis australasica, Sclerolaena tricuspis, Malacocera tricornis,* annual *Atriplex* spp., *Sclerolaena muricata, Sclerolaena brachyptera, Osteocarpum acropterum* var. *deminuta, Minuria cunninghamii.*

**Landform:** Saline flats and depressions, depressed alluvial plains.

**Soils:** Clay soils in saline situations.

**Occurrence:** On depressed saline flats mostly in the west of the mapped area. Large patches occur with *Atriplex vesicaria* around Oxley and 'Corrong' on the Hay map and west of Dry Lake.

**Condition:** Some dieback apparent; moderately to heavily grazed with many areas degraded to *Maireana aphylla* or copperburr (*Sclerolaena* spp.) shrublands.

**Figure 16.** Open *Atriplex vesicaria* shrubland (community 11) south of Hay, with annual grass cover of *Hordeum leporinum* and *Lolium perenne,* in early spring.

**Figure 17.** *Atriplex nummularia* shrubland (community 19) adjacent to Black Box woodland, on 'Mywurlie' station, north-east of Hay, at the end of summer.

**Notes:** This community is closely allied to *Atriplex vesicaria* shrubland into which it generally grades. *Sclerostegia tenuis* becomes the dominant species in more saline situations and the community is particularly well-developed on the lower alluvium around Lake Victoria and other dry lakes and saltpans further west (Fox 1991). It is considered a highly salt-tolerant species, being capable of colonising highly saline environments where no other species will grow (Beadle 1948). *Sclerostegia tenuis* often forms dense mats below Black Box woodland and has decreased significantly in abundance due to grazing and trampling by stock (Cunningham *et al.* 1981).

### Map unit 13: Canegrass

**Structure:** tussock grassland # and ##

**Main species:** *Eragrostis australasica* (Canegrass)

**Associated species:** *Eleocharis pallens, Juncus flavidus, Juncus aridicola, Muehlenbeckia florulenta, Disphyma crassifolium* subsp. *clavellatum, Chenopodium nitrariaceum.*

**Landform:** Alluvial plains with depressions and other low-lying areas subject to intermittent flooding or ponding such as swamps, tabledrains and claypans.

**Soils:** Slightly saline, compact, heavy grey clays.

**Occurrence:** *Eragrostis australasica* occurs throughout the mapped area. It is particularly common in saline depressions within *Atriplex vesicaria* shrubland north of Hay, on the Lachlan River floodplain between Oxley and Booligal and in tabledrains and depressions along the major roads in low-lying and irrigated areas.

**Condition:** Some areas cleared, many degraded to copperburr (*Sclerolaena* spp.) shrubland.

**Notes:** *Eragrostis australasica* tolerates regular, but not prolonged flooding, with *Muehlenbeckia florulenta* (Lignum) occupying the wetter areas (Semple 1990). *Chenopodium nitrariaceum* and *Atriplex nummularia* may be present around the edges of Canegrass swamps.

Areas of *Eragrostis australasica* tend to be small and patchy rather than large and continuous. The species commonly occurs in depressions within the general matrix of *Atriplex vesicaria* or *Maireana aphylla* and these areas have been mapped as composite units (11/13 and 21/13). Much of the Canegrass community was not mapped due to its patchiness and relatively small extent.

### Map unit 16: *Callitris* Mixed Woodland

**Structure:** woodland – low open woodland #; woodland – isolated clumps ##

**Main species:** *Callitris glaucophylla* (White Cypress Pine). *Callitris gracilis* subsp. *murrayensis* (Murray Cypress Pine) may replace *Callitris glaucophylla* on sandhills and ridges adjacent to the Murray River on the Deniliquin–Bendigo map.

**Associated species:** *Hakea leucoptera, Hakea tephrosperma, Alectryon oleifolius* subsp. *canescens,* occasional *Alectryon oleifolius* subsp. *elongatus, Acacia melvillei, Geijera parviflora, Allocasuarina luehmannii, Acacia oswaldii, Acacia homalophylla, Pittosporum phylliraeoides, Casuarina pauper, Eremophila longifolia, Dodonaea viscosa* subsp. *angustissima, Senna artemisioides* subsp. *petiolaris, Maireana pyramidata, Acacia victoriae* (B), *Eucalyptus populnea* subsp. *bimbil* (B), *Eucalyptus intertexta* (B), *Acacia brachybotrya* (D), *Eucalyptus melliodora* (D).

**Figure 18.** *Callitris glaucophylla* mixed woodland (community 16), north of Gunbar along McKinley Road, in mid-spring.

**Landform:** Raised sandy areas such as low linear dunes, sandhills, ridges and footslopes of rocky outcrops. Old stream beds and levee banks of prior streams and source-bordering dunes formed with the redeposition of prior stream material by wind action (Butler *et al.* 1973). The remnant woodland occupying the major prior streams has been mapped as a separate map unit (see Community 27).

**Soils:** Coarse-textured red and brown earths such as sandy-loams and loams.

**Occurrence:** Isolated sandhills with *Callitris* Mixed Woodland occur throughout the mapped area (Fig. 18). Source-bordering dunes associated with prior streams and generally running in an east-west direction occur in the south of the mapped area, notably from west of Booroorban, through the Tchelery Woolsheds area to just north of Moulamein. Continuous, elevated sandridges also occur north of Conargo and Wanganella. Large areas of *Callitris glaucophylla* occur in Booroorban, Steam Plains, Puckawidgee, Edgar and Tholobin State Forests and on the properties 'Oolambeyan', 'Gum Creek', 'Steam Plains' and 'Zara'. Unusual areas of *Callitris glaucophylla* with an *Atriplex nummularia* understorey occur on 'Steam Plains' and 'Zara' properties.

Undulating country with remnant *Callitris glaucophylla* is also seen south-west to south-east of Deniliquin in primarily agricultural land, often associated with remnant Grey Box and Bulloak woodland (Community 25). *Eucalyptus melliodora*, Yellow Box, is associated with *Callitris glaucophylla* on shallow to deep sandy soils in this area, with Cypress Pine dominating on the sandhills (Moore 1953). *Callitris gracilis* subsp. *murrayensis* may replace *Callitris glaucophylla* on the sandhills and elevated plains adjacent to the Murray River (Fig. 19) and hybrids of these two species may occur. Dense stands of *Callitris glaucophylla* occur within the mallee, Belah–Rosewood and *Casuarina pauper/Casuarina cristata* intergrading population, along the eastern edge of the Booligal map. Rocky outcrops seen further north support a different Cypress Pine community, described under map unit 29.

**Condition:** Severe rabbit infestation and scalding; many areas cleared; trees generally thinned and pine selectively logged in state forests; areas of woody shrubs present; few areas with intact shrubby understoreys; understoreys generally degraded to annual grasslands; little regeneration due to grazing stock and rabbits; areas in the south largely cleared and developed for irrigation; dunes of Murray Cypress Pine within River Red Gum forests of the Murray River floodplain largely cleared.

**Notes:** Mixed woodland, dominated by *Callitris glaucophylla*, extends from Queensland, throughout the slopes and plains of New South Wales, to Victoria. Associated species vary throughout its range. It occurs throughout the Hay Plain but is seen in its greatest density further east.

This vegetation community shows the most variability of all those sampled. Trees may be widely scattered or may form more or less monospecific groves. *Callitris glaucophylla* in particular tends to occur in large stands with other species scattered or in groves in between. Grove-forming species include *Alectryon oleifolius*, *Acacia melvillei* and *Acacia homalophylla*. An understorey is rare, but where present may include *Maireana pyramidata* and *Rhagodia spinescens*. Much of the original understorey has been grazed out but it is thought that common understorey shrubs may have included species of *Dodonaea*, *Pimelea*, *Rhagodia*, *Exocarpos* and *Senna* (Noble & Mulham 1980). Generally the ground cover consists of short-lived perennial and annual grasses and herbs, many of them introduced species. The sandy soils are highly prone to wind erosion and degradation by rabbits.

Occasionally *Callitris glaucophylla* may be absent from this community, with the associated trees mentioned above dominating. *Acacia victoriae* is occasionally seen as a dominant on slight rises north of Booligal. On the Darling floodplain further west

**Figure 19.** Roadside remnant woodland of *Callitris gracilis* subsp. *murrayensis*, with *Dodonaea viscosa* subsp. *angustissima* and *Acacia brachybotrya* understorey. Sandhill north of Barham within the River Red Gum floodplain of the Murray River, at the end of winter (community 16).

**Figure 20.** *Acacia melvillei* clump (community 17) on red, duplex soil west of Alma Lake, in midspring, with ground cover of *Rhodanthe floribunda* and *Pycnosorus pleiocephalus*.

are many elevated areas of brown solonized soils which are not subject to flooding and carry open or scattered *Acacia victoriae*, sometimes with *Eremophila sturtii* (Turpentine), *Dodonaea* spp. (Hopbushes), Belah and Rosewood (Stannard 1963).

Some species such as *Dodonaea viscosa* subsp. *angustissima*, *Eremophila longifolia* and *Senna* species can form a dense, low, monospecific scrub within this community. As they reduce the grazing potential of the country, they are locally referred to as 'woody weeds'. Large areas occur along the Booroorban–Tchelery road, in Belah–Rosewood country south-west and south-east of Ivanhoe, and in the mallee between Conoble and Roto.

Early explorers remarked on the Cypress Pine during expeditions into western New South Wales: *'On our way to the river, we passed through some dense bushes of casuarinae and cypresses, to the outskirts of the plains through which the Morumbidgee winds'* (Sturt 1833). Once-vast areas of native Cypress Pine between the Murrumbidgee and Lachlan were described by a councillor in 1877 as *'... one magnificent pine forest, containing very fine trees and growing amongst them young trees which absolutely denuded the country of grass, but which, if encouraged, would have formed one of the most magnificent forests in the World ... it was destroyed lock, stock and barrel ... today nothing but stretches of land without a pine tree on them ...'* (Grant 1989). The greatest destruction of White Cypress Pine occurred between 1880 and 1910, when it was extensively cleared for wheat-growing and ringbarked to provide good grazing lands (Grant 1989). The wood was also utilised for fenceposts and other building materials.

*Callitris* Mixed Woodland is viewed as being particularly vulnerable in the context of present land use in the area. It is under serious threat from rabbits and stock; even-aged, often old stands of trees are not regenerating due to the grazing out of any seedlings produced. Soil erosion is another problem as the coarse-textured soils are undermined by rabbits and scalded due to lack of a stabilising vegetative cover. This community is not conserved within the mapped area and is considered inadequately so elsewhere.

### Map unit 17: *Acacia melvillei* Woodland

**Structure:** tall shrubland – low woodland #; shrubland to woodland ##

**Main species:** *Acacia melvillei*

**Associated species:** *Callitris glaucophylla*, *Acacia homalophylla*, *Acacia oswaldii*, *Alectryon oleifolius* subsp. *canescens*, *Casuarina pauper*.

**Landform:** Level sandplains, undulating plains and low sandy rises.

**Soils:** Red-brown clay to sandy loam.

**Occurrence:** Dense *Acacia melvillei* areas occur between Trida and Wee Elwah in the far north of the Booligal map, north of Gunbar along McKinley Road and north of Moulamein in the south-west. Significant stands were also observed around Ivanhoe, to the north of the mapped area. *Acacia melvillei* forms local communities within *Callitris* Mixed Woodlands (Community 16) of sandy rises and source-bordering dunes throughout the Hay Plain, and within the Belah–Rosewood country of the north-west (Fig. 20).

**Condition:** Severe to moderate scalding and rabbit infestation; many areas cleared; areas of woody shrubs present.

**Notes:** This community is generally small in extent or forms localised stands in Belah–Rosewood and *Callitris* Mixed Woodlands. Several larger homogeneous areas have

**Figure 21.** *Muehlenbeckia florulenta* in Fiddlers Creek south of Maude, with herbaceous banks of *Brassica rapa* subsp. *silvestris;* (community 18); early spring.

**Figure 22.** *Typha orientalis* and *Typha domingensis* reed-beds in the Lachlan River, south of Oxley, at the end of autumn.

been mapped. *Acacia melvillei* is often mistaken for the very similar species *Acacia homalophylla* which appears to be more common within other communities rather than as a dominant. The two species differ in the number and arrangement of flower heads in the inflorescence (Harden 1990–92). The populations of *Acacia melvillei* around Ivanhoe are cut for domestic firewood (Semple & Eldridge 1989).

### Map unit 18: Lignum and *Chenopodium nitrariaceum*

**Structure:** low shrubland – open scrub #; open – closed shrubland ##

**Main species:** *Muehlenbeckia florulenta* (Lignum), *Chenopodium nitrariaceum* (Nitre Goosefoot).

**Associated Species:** *Eragrostis australasica, Sclerolaena muricata, Juncus flavidus, Juncus radula* and other *Juncus* spp., *Senecio cunninghamii* var. *cunninghamii, Rumex tenax, *Rumex crispus, Atriplex suberecta.*

Species occurring in wetter areas include *Eleocharis acuta, *Alopecurus geniculatus, Marsilea drummondii* and *Limosella australis.*

**Landform:** Intermittently flooded channels, depressions, river-flats and swamps. Flooding is relatively infrequent, but often prolonged.

**Soils:** Heavy grey cracking clays.

**Occurrence:** This community occurs throughout the mapped region, in bands adjacent to major creeks and rivers and in low-lying swampy areas (Fig. 21), particularly north of Booligal and adjacent to the Murrumbidgee and Lachlan Rivers.

**Condition:** Large areas cleared for irrigation and grazing; many areas degraded to annual grasslands with *Sclerolaena* spp. (copperburrs); some cropping of depressions and lake beds cropped; some weed infestation.

**Notes:** *Chenopodium nitrariaceum* exceeds Lignum as the dominant species in this community in occasionally inundated areas with less restricted drainage. It is usually seen forming an understorey to *Eucalyptus largiflorens* and often extends out onto the floodplain beyond the woodland zone to form dense shrublands. It is also common in dry lakes and infrequently flooded depressions. *Muehlenbeckia florulenta* withstands relatively infrequent but more prolonged flooding and may form a dense, almost impenetrable scrub (Semple 1990). It favours channelled plains and depressions with impeded drainage but nearly always occurs with *Chenopodium nitrariaceum.*

Lignum swamp areas are often used for cattle grazing and much has been burned or cleared to promote annual herb and grass growth for feed (Semple 1990). This practice is particularly common in areas adjacent to the Murrumbidgee river west of Hay. This community has also been cleared for irrigation in the Deniliquin region.

Lignum areas provide important wildlife habitat, particularly for waterbirds (Semple 1990). A small area of *Eucalyptus camaldulensis, Eucalyptus largiflorens* and *Muehlenbeckia florulenta* (437 ha) is protected in Goonawarra Nature Reserve, south-west of Booligal on the Lachlan River.

### Map unit 19: Old Man Saltbush

**Structure:** low – low open shrubland #; chenopod shrubland – open chenopod shrubland ##

**Main species:** *Atriplex nummularia* (Old Man Saltbush)

**Associated Species:** *Rhagodia spinescens, Atriplex vesicaria, Enchylaena tomentosa, Einadia nutans, Eucalyptus largiflorens, Sclerostegia tenuis*, other *Atriplex* spp.

**Landform:** Level to depressed plains, low-lying areas and depressions.

**Soils:** Grey, self-mulching, cracking clays to red duplex soils with grey and brown clays. *Atriplex nummularia* grows on a wide range of soil types and at all levels of the plain (Cunningham *et al.* 1981).

**Occurrence:** This community occurs throughout the Hay Plain with a patchy distribution. Remnant areas occur around One Tree south of Oxley and west of Booligal. It is found in dry lakes in the north-west of the Booligal map, particularly south of Ivanhoe. Black Box woodlands with an understorey of *Atriplex nummularia* occur between Moulamein and Wanganella, with a particularly dense stand seen on 'Bundy'. This association is often found throughout the mapped area (Fig. 17). *Atriplex nummularia* was once a dominant understorey species to *Acacia pendula* (Beadle 1948, Moore 1953) but this association no longer exists within the mapped area.

**Condition:** Largely cleared; moderately to heavily grazed with shrubs thinned; some scalding in open areas; little regeneration due to grazing stock, rabbits, goats and kangaroos; some weed and copperburr (*Sclerolaena* spp.) infestation.

**Notes:** *Atriplex nummularia* was once one of the dominant perennial saltbush species on the Hay Plain (Moore 1953, Leigh & Wilson 1970, Leigh & Mulham 1965). Both *Atriplex vesicaria* and *Atriplex nummularia* were far more abundant before the commencement of pastoral activity in the area but their relative dominance is unknown due to the lack of old records and data. It is believed that both species grew so densely on areas of the Plain as to exclude any other perennial species (Beadle 1948). Evidence suggests that *Atriplex nummularia* was the more common species in the far south-east of the South Western Plains botanical region (Moore 1953).

The mapped areas of Old Man Saltbush are remnants of once-extensive stands that have been subjected to grazing pressure, rabbit-disturbance and clearing. The shrub is palatable to stock and rabbits and recovers well after intermittent grazing, however constant defoliation under heavy grazing pressure is detrimental (Cunningham *et al.* 1981). It was considered an important fodder species before it was grazed out (Beadle 1948). Many small remnants occur around homesteads and in small holding paddocks that saw little grazing. The larger remnant areas are delineated on the maps but many smaller patches exist, often consisting of only scattered individuals.

*Maireana pyramidata* may occur with *Atriplex nummularia* at transition zones where higher country supporting this species grades off to low-lying areas with *Atriplex nummularia*. This is often seen in undulating country such as that around Oxley and 'Wongalea' east of Gunbar.

### Map unit 21: Cotton Bush

**Structure:** low – low open shrubland #; chenopod shrubland – sparse chenopod shrubland ##

**Main species:** *Maireana aphylla* (Cotton Bush)

**Associated Species:** *Atriplex vesicaria, Sclerolaena muricata, Sclerolaena tricuspis, Nitraria billardierei, Minuria cunninghamii, Ixiolaena tomentosa, Osteocarpum acropterum* var. *deminuta, Leptorhynchos panaetioides, Atriplex lindleyi, Atriplex pseudocampanulata, Malacocera tricornis, Danthonia caespitosa, Calocephalus sonderi, Sclerolaena bicornis* var. *bicornis, Daucus glochidiatus, *Cotula bipinnata, Rhodanthe corymbiflora, Rhodanthe pygmaea,*

*Plantago cunninghamii, Podolepis muelleri, Calotis scabiosifoia* subsp. *scabiosifolia, Brachycome lineariloba.*

**Landform:** Depressed alluvial plains, usually disturbed.

**Soils:** Grey to grey-brown clays to clay-loams (Leigh & Mulham 1965).

**Occurrence:** This community is widespread over the Hay Plain and has proliferated in many areas once dominated by *Atriplex vesicaria* (Fig. 23). The largest continuous stands occur south to south-west of Hay. Dense areas occur within Willandra National Park, north-west of Hillston. *Maireana aphylla* originally occurred with *Atriplex vesicaria* in slightly depressed areas mainly in the east Darling area and excessive grazing has led to its increase with the elimination of *Atriplex vesicaria* over large areas (Beadle 1948).

**Condition:** Extensive areas degraded to annual grasslands with *Sclerolaena* spp. and *Nitraria billardierei;* weed infestation common; soils often scalded.

**Notes:** *Maireana aphylla* shrubland is usually grazed or variously disturbed and is considered to be a degraded or disclimax community from Bladder Saltbush shrubland as a result of heavy grazing (Beadle 1948). Shrublands dominated by *Nitraria billardierei, Sclerolaena muricata* and *Sclerolaena tricuspis* indicate greater disturbance. The herbaceous layer within this community consists of short-lived perennial and annual grasses and herbs, many of them introduced. The invasion by exotic pasture species such as **Avena fatua, *Hordeum leporinum, *Lolium perenne, *Phalaris paradoxa, *Phalaris minor, *Bromus madritensis, *Medicago* spp. and **Erodium* spp. has been widespread. These species are indicative of the often disturbed nature of this community.

*Maireana aphylla* distribution has increased since the *Atriplex vesicaria* dieback of 1977–1983 (Clift *et al.* 1987, Clift *et al.* 1989, Semple 1989). Post-dieback distribution of *Maireana aphylla* has been mapped.

*Maireana aphylla* and *Nitraria billardierei* tend to occur on slightly depressed areas of the Plain as they are more flood-tolerant than *Atriplex vesicaria* (Beadle 1948). *Maireana aphylla* is often associated with medium to heavy scalding and occasional individuals or patches of remnant *Atriplex vesicaria* may be seen. Shrub cover can vary considerably in this community, ranging from dense monospecific stands to scattered individuals within a matrix comprising annual and short-lived perennial grasses.

**Map unit 22: Dillon Bush**

**Structure:** low – low open shrubland #; shrubland – sparse shrubland ##

**Main species:** *Nitraria billardierei* (Dillon Bush)

**Associated Species:** *Maireana aphylla, Sclerolaena muricata, Sclerolaena tricuspis.* This community occupies disturbed areas and usually comprises a high proportion of introduced and annual species. Other associated species vary depending on the composition of the original vegetation.

**Landform:** Disturbed low-lying alluvial plains, dry lakebeds.

**Soils:** Grey to grey-brown clay and loam soils, often saline (Cunningham *et al.* 1981).

**Occurrence:** *Nitraria billardierei* tends to occur in dense continuous stands in areas of high grazing pressure, particularly adjacent to riverine and box woodlands, and in previously cropped areas. Its distribution has increased markedly with the changed land use in the area since European settlement. Severe overgrazing of the original

**Figure 23.** *Maireana aphylla* shrubland (community 21) north-west of Deniliquin, with ground cover of *Bromus diandrus* in early spring.

**Figure 24.** Roadside remnant *Eucalyptus microcarpa* (community 24) with *Acacia hakeoides* understorey; Mooney Swamp Road, north-east of Deniliquin, at the end of winter.

chenopod species has resulted in the establishment of Dillon Bush in areas once occupied by *Atriplex vesicaria* and *Atriplex nummularia* (Noble & Whalley 1978). Dillon Bush commonly occurs in lower densities within other shrubland and woodland communities. The species provides good harbour for rabbits due to its thick and spreading habit.

### Map unit 23: Great Cumbung Swamp

This community was not sampled in the current survey and information has been taken from various sources and mapped with reference to Pressey *et al.* 1984.

**Structure:** closed – open herbland/grassland #; closed – open grassland/rushland/forbland ##

**Main species:** *Phragmites australis* (Common Reed), *Senecio cunninghamii* var. *cunninghamii* (Bushy Groundsel), *Typha orientalis* and *Typha domingensis* (Cumbung or Bulrush).

**Associated Species:** **Hordeum leporinum, *Polypogon monspeliensis, *Cirsium vulgare, Pratia concolor, Marsilea drummondii, Juncus flavidus, Centipeda cunninghamii, Persicaria decipiens, Paspalum distichum, *Cotula coronopifolia, Eucalyptus camaldulensis, *Ranunculus sceleratus, Cyperus gymnocaulos, Vallisneria gigantea, *Juncus articulatus, Potamogeton crispus.*

**Landform:** Regularly inundated swamp at the confluence of the Murrumbidgee and Lachlan Rivers, with some areas of semi-permanent open water.

**Soils:** Heavy grey clays.

**Occurrence:** The Great Cumbung Swamp occurs at the far western edge of the Hay sheet. Areas of *Phragmites australis* and *Typha* spp. may occur throughout the mapped area, wherever there is relatively still, semi-permanent water or in periodically flooded situations. *Typha* spp. are particularly common in marshes, billabongs and creeks with River Red Gum forest or fringing Black Box woodland (Fig. 22).

**Condition:** River regulation resulting in a reduction in range of the community; some weed infestation.

**Notes:** Distinct zonation of the main species occurs in the Great Cumbung Swamp. *Typha* species dominate the areas of semi-permanent water with *Phragmites australis* occurring from approximately 0.3 m above the upper *Typha* limit at the periodically flooded lower banks (Pressey *et al.* 1984). *Senecio cunninghamii* var. *cunninghamii* occurs in a broad zone above, and overlapping with *Phragmites australis*. The hydrology of the swamp is influenced by the diversion of water for irrigation from the Murrumbidgee. Natural flooding occurs mainly in spring and summer. The extensive patches of semi-permanent water in the Great Cumbung Swamp can completely dry up during drought periods (Pressey *et al.* 1984).

The Lachlan–Murrumbidgee confluence encompasses other wetland communities besides the Great Cumbung Swamp. It also includes areas of *Eucalyptus largiflorens* and *Eucalyptus camaldulensis*, marshes and lakes on the main floodplain of the Murrumbidgee, and an extensive channelled Lignum area associated with the Murrumbidgee (Pressey 1988). The latter two areas are influenced by water diversions from Redbank and Maude Weirs respectively.

**Map unit 24: Grey Box Woodland**

**Structure:** low woodland – woodland #; open woodland – woodland ## (*Eucalyptus microcarpa* occasionally reaches open forest proportions # and ##)

**Main species:** *Eucalyptus microcarpa* (Grey Box) (D)

**Associated Species:** *Allocasuarina luehmannii* (Bulloak), *Eucalyptus melliodora* (Yellow Box) (D), *Acacia hakeoides, Acacia brachybotrya* (D), *Acacia acinacea* (D), *Callitris glaucophylla, Senna artemisioides* subsp. *zygophylla, Senna artemisioides* subsp. *filifolia* and *Senna artemisioides* nothosubsp. *coriacea, Acacia rigens* (D).

**Landform:** Level to undulating plains, elevated flats and rises adjacent to the Murray and Edward–Wakool river systems.

**Soils:** Red-brown earths and heavy clay to loamy alluvial soils (Cunningham *et al.* 1981). Deeper sandy soils to the south-east of Deniliquin (Moore 1953).

**Occurrence:** *Eucalyptus microcarpa* woodland occurs in the far south of the Hay Plain, restricted to the Deniliquin map sheet (Fig. 24). It is seen from east to south-west of Deniliquin, extending down to the Murray River and has its northern limit on the Plain within the Edward–Wakool river system, where it forms open forest within River Red Gum communities. *Eucalyptus microcarpa* gradually replaces *Eucalyptus largiflorens* south of Deniliquin where it occurs on higher loam soils in association with *Allocasuarina luehmannii* (Bulloak) and *Eucalyptus melliodora* (Yellow Box). Remnant areas occur just north-east of Deniliquin.

**Condition:** Largely cleared and developed for irrigation; remnant areas prone to weed and rabbit infestation; few remnants with shrubby understoreys intact; little regeneration due to clearing, stock and rabbits.

**Notes:** *Eucalyptus microcarpa* has been extensively cleared and thinned for both grazing and cropping. Around Deniliquin, this species and *Allocasuarina luehmannii* have been reduced to remnant patches of scattered trees within irrigated agricultural land. Very few areas exist with an intact shrubby understorey, most of these being roadside remnants. Small remnant stands with *Acacia* and *Senna* understoreys exist around Mathoura, north-east of Deniliquin and along Lower Thule Road east of Barham. Taller *Eucalyptus microcarpa* forest occurs with *Eucalyptus melliodora* on the heavy clays within riparian forests. In Werai State Forest north-west of Deniliquin, Aboriginal people cut the bark from the tall *Eucalyptus microcarpa* trees for canoes.

*Acacia oswaldii, Acacia salicina, Acacia rigens* and *Eremophila longifolia* have been listed by other authors as associated species (Semple 1990). In the present survey, small areas with *Acacia rigens* and *Acacia oswaldii* were seen along the railway at Burraboi north-west of Deniliquin and along Lower Thule Road east of Barham. *Acacia salicina* was not observed as an associate species.

Beadle mentions already in 1948 that few virgin stands of the woodland exist but that tree densities were once high, having been cleared for wheat growing or thinned for sheep grazing. Shrub species were already inconspicuous then but included *Acacia oswaldii, Acacia deanei, Acacia hakeoides, Acacia rigens, Hakea leucoptera, Pittosporum phylliraeoides, Eremophila longifolia* and *Dodonaea viscosa* subsp. *spatulata*. He suggests the herbaceous stratum was probably discontinuous and comprised shade-loving species like *Wahlenbergia gracilis* and *Carex inversa* and perennial grasses such as *Danthonia* spp. (Beadle 1948).

*Callitris glaucophylla* (Community 16) on sandy to loam rises occurs as a local community within *Eucalyptus microcarpa* woodland east to south-west of Deniliquin. *Allocasuarina luehmannii* and *Callitris glaucophylla* are common associates, occurring on higher

ground above the level of the *Eucalyptus microcarpa*. *Eucalyptus melliodora* is less abundant in this undulating country, observed more often with Grey Box in riparian situations.

Beadle (1948) included *Eucalyptus microcarpa* in his concept of *Eucalyptus woollsiana*, describing the association as a tall woodland with an eastern distribution from around Condobolin to south of Deniliquin. Grey Box is described as occurring either in pure stands or in association with *Callitris glaucophylla* or *Eucalyptus populnea* subsp. *bimbil* (Bimble Box), a community which is presently more common east of the Hay Plain. The soils are red-brown earths, sometimes a sandy loam but usually a loam or clay-loam overlying a clayey subsurface soil with lime occurring in varying quantities throughout the profile. Yellow Box is mentioned as an associated species while *Callitris glaucophylla* is present as a lower tree layer. *Allocasuarina luehmannii* forms local societies within Grey Box (Beadle 1948). The Grey Box Woodland of the current survey also appears to be synonymous with the *Eucalyptus woollsiana* and *Callitris glaucophylla* association identified by Moore (1953) where *Allocasuarina luehmannii* is described as a subsidiary species in the tree stratum.

### Map unit 25: *Acacia pendula* Woodland

**Structure:** low – low open woodland #; open woodland – woodland ##

**Main species:** *Acacia pendula* (Myall or Boree)

**Associated Species:** *Rhagodia spinescens, Atriplex nummularia* (largely cleared), *Danthonia caespitosa, Maireana aphylla,* annual *Atriplex* spp., annual and short-lived perennial grasses, **Medicago* spp., *Enchylaena tomentosa, Atriplex semibaccata, Maireana decalvans, Stipa nodosa.*

*Amyema quandang* subsp. *quandang* commonly occurs as a parasite on *Acacia pendula* but the mistletoe rarely kills the host (Beadle 1981).

Other common associate species which may vary seasonally or with grazing pressure include *Alternanthera denticulata, Centipeda cunninghamii, Sida* spp., *Rhodanthe corymbiflora, Maireana pentagona, Sclerolaena stelligera, Erodium* spp., *Myriocephalus rhizocephalus* subsp. *rhizocephalus*, **Cotula bipinnata, Vittadinia cuneata* var. *cuneata, Lepidium pseudohyssopifolium, Enteropogon acicularis, Ranunculus* spp.

**Landform:** Level to depressed plains. Adjacent to streams or in depressions in grasslands (Beadle 1981).

**Soils:** Grey and brown clays and more rarely on red-brown earths (Beadle 1981, Semple 1990).

**Occurrence:** *Acacia pendula* occurs mainly in the east of the Hay Plain and is seen here at the western limit of its range (Fig.25). The densest stands occur east of Hay along the Gum Creek–Conargo Road, along Wrights Lane south-east of Gunbar, east to north-east of Conargo and south of Hillston along McKinley Road. Isolated groves and scattered trees occur within *Danthonia caespitosa* (Community 26), *Eucalyptus largiflorens* (Community 2) and lower areas within *Casuarina pauper/Casuarina cristata*-intergrade woodland (Community 28) in the eastern sector of the Plain. Roadside remnants exist in agricultural country around Deniliquin and Hillston.

**Condition:** Widely cleared or thinned with extensive areas degraded to annual grasslands; moderate scalding and rabbit infestation; some areas of woody shrubs present; weeds common; few areas with shrubby understoreys; understoreys generally degraded to annual grasslands; little regeneration due to grazing.

**Figure 25.** *Acacia pendula* open woodland at the end of summer (community 25), with *Rhagodia spinescens* and grassy understorey; Jerilderie Road, south-east of Hay.

**Notes:** Widespread clearing of *Acacia pendula* for cropping, fodder and timber has resulted in a patchy remnant distribution. It commonly occurs with a very open structure and a herbaceous understorey, mostly comprising **Medicago* spp. and grasses such as *Danthonia caespitosa, Enteropogon acicularis, *Lolium perenne, *Hordeum leporinum, *Vulpia myuros* and **Bromus madritensis*. A shrubby understorey is rare or lacking. The original *Atriplex nummularia* understorey has been largely cleared. Moore (1953) noted remnants as existing in the Jerilderie area. *Atriplex vesicaria* and *Maireana aphylla* are also listed as original understorey components with the latter persisting over the two species (Beadle 1981). There are few tree associates but where present may include *Acacia salicina* and *Acacia oswaldii* (Beadle 1981).

The disappearance of the *Acacia pendula-Atriplex nummularia* alliance is attributed mainly to heavy sheep grazing followed by the severe drought of 1875 to 1877 (Moore 1953). *Acacia pendula* was felled for stock feed and regeneration was prevented by stock and rabbit grazing. The *Danthonia caespitosa* grassland areas are believed to be disclimax communities which once carried the *Acacia pendula–Atriplex nummularia* association (Beadle 1948, Moore 1953). Perennial grasslands still support a wide range of native plants including rare species such as *Swainsona plagiotropis* (see Table 5). Scattered *Acacia pendula* occurs within the mapped *Danthonia caespitosa* grasslands (see Community 26) lending support to this disclimax theory. None of this association exists within the mapped area today, with the only known stands remaining on two merino properties west of Jerilderie; 'Coonong' and 'Coree' (Moore 1953).

*Acacia pendula* woodland is a vulnerable vegetation type and is not represented in any conservation reserve in south-western New South Wales (Brickhill 1985). Unlike most *Acacia* species, *Acacia pendula* fruits and sets seed sparingly and seed germination is poor (Beadle 1981). The foliage is readily eaten by stock and any seedlings produced are prone to grazing or trampling. Rabbits may also undermine the root systems in lighter clay soils.

### Map unit 26: White-top Grassland

**Structure:** tussock grassland – open tussock grassland #; grassland – open grassland # #

**Main species:** *Danthonia caespitosa* (White-top or Ringed Wallaby Grass) predominantly, but there is usually a *Danthonia eriantha* component of about 10 per cent (S. Jacobs, Royal Botanic Gardens, pers. comm.).

**Associated Species:** *Chloris truncata* (Windmill Grass), *Enteropogon acicularis, Sporobolus caroli, Bromus arenarius, Stipa nodosa, *Hordeum leporinum, *Lolium perenne, *Lolium rigidum, *Avena fatua, *Bromus madritensis, *Vulpia myuros, *Medicago* spp., *Erodium* spp., *Rhodanthe corymbiflora, Sida trichopoda, Sida corrugata, Maireana aphylla* (occasionally).

**Landform:** Level alluvial plains.

**Soils:** Grey to brown clays or clay-loams, usually with a compacted surface (Beadle 1948).

**Occurrence:** This grassland is composed of short-lived perennial and annual grasses and occurs in the east to south-east of the Hay Plain, extending from north-east of Deniliquin to south of Gunbar. The most homogeneous areas are found south-east to north-east of Hay (Fig. 26).

**Condition:** Moderately to extensively grazed with many areas degraded to annual grasslands.

**Figure 26.** Dried-off grassland of *Danthonia caespitosa* (community 26) at the end of summer, north of Carrathool in the far east of the Hay Plain.

**Figure 27.** *Callitris glaucophylla* regenerating on prior stream (community 27), within an exclosure on 'Walgrove', south-east of Hay, at the end of summer.

**Notes:** Previous records and surveys suggest that *Danthonia caespitosa* grassland is a degraded or disclimax community that has developed under heavy grazing from climax communities dominated by *Acacia pendula–Atriplex nummularia* (Moore 1953) or *Atriplex vesicaria* (Beadle 1948). According to Beadle (1948) *Atriplex vesicaria* once occurred in areas now carrying grasslands (*Chloris–Danthonia* association) and *Maireana aphylla*. When the shrub phase is removed by grazing, perennial grasses such as *Danthonia* and *Chloris* remain; they in turn can be grazed out, leaving annual grasses and annual or short-lived spiny-fruited chenopods (S. Jacobs pers. comm.). In a study concentrating on the grasslands around Jerilderie, Narrandera and Urana to the east of the study area, Moore (1953), suggests that these grassland areas once carried *Acacia pendula* and *Atriplex nummularia* with *Atriplex vesicaria*. *Acacia pendula* remnants currently exist in the mapped grasslands, but no *Atriplex nummularia* and little *Atriplex vesicaria*.

*Danthonia caespitosa* may dominate the ground layer in *Eucalyptus largiflorens*, *Acacia pendula* and other woodland communities. Short-lived perennial and annual grasses dominate the pasture in more disturbed communities with a seasonal composition. Common species include **Hordeum leporinum*, **Lolium perenne*, **Avena fatua* and **Bromus madritensis*. At various times of the year **Medicago* spp., **Erodium* spp. and other herbs (commonly Asteraceae) are a significant component of the ground layer.

Where grazing is not too severe, *Danthonia caespitosa* will seed and recruit regularly (Cunningham *et al.* 1981). The species may be eliminated with heavy, continuous grazing and replaced with *Chloris truncata* and annual grasses. Severe grazing pressure and disturbance can lead to the removal of *Chloris truncata*, resulting in a herbfield or grassland comprising annual species (Beadle 1948).

The grassland areas south-east of Hay were affected by wildfires in November 1990. A large area of *Danthonia caespitosa* grassland was burned and much of it has not regenerated as at October 1992, but has been replaced by other grass and herb species. The grassland distribution prior to the fire has been mapped.

### Map unit 27: Prior Stream Remnant Woodland

**Structure:** low open woodland #; open woodland - isolated trees ##

**Main species:** *Callitris glaucophylla* (White Cypress Pine), *Hakea leucoptera* (Needlewood), *Hakea tephrosperma* (Hooked Needlewood).

**Associated Species:** *Pittosporum phylliraeoides*, *Alectryon oleifolius* subsp. *canescens*, occasional *Alectryon oleifolius* subsp. *elongatus*, *Rhagodia spinescens*, *Stipa scabra* subsp. *scabra*, *Aristida behriana*, *Enneapogon nigricans*, **Cucumis myriocarpus*, *Wahlenbergia stricta* subsp. *stricta*.

**Landform:** Raised beds of prior streams indicated by low, winding sandy ridges on the clay floodplain (Butler *et al.* 1973).

**Soils:** Gravel, sand and sandy-loam overlying clay (Butler 1950).

**Occurrence:** Prior streams occur mainly east to south-east of Hay within the mapped area although they are seen more frequently south and west of Griffith (Schumm 1968). Large prior streams run through 'Walgrove' property (Fig. 27), Wrights Lane and Murrumbidgee River Road north-east of Hay. Several are also seen north of Conargo.

**Condition:** Largely cleared; severe scalding and soil erosion due to rabbit infestation; little regeneration due to grazing stock and rabbits.

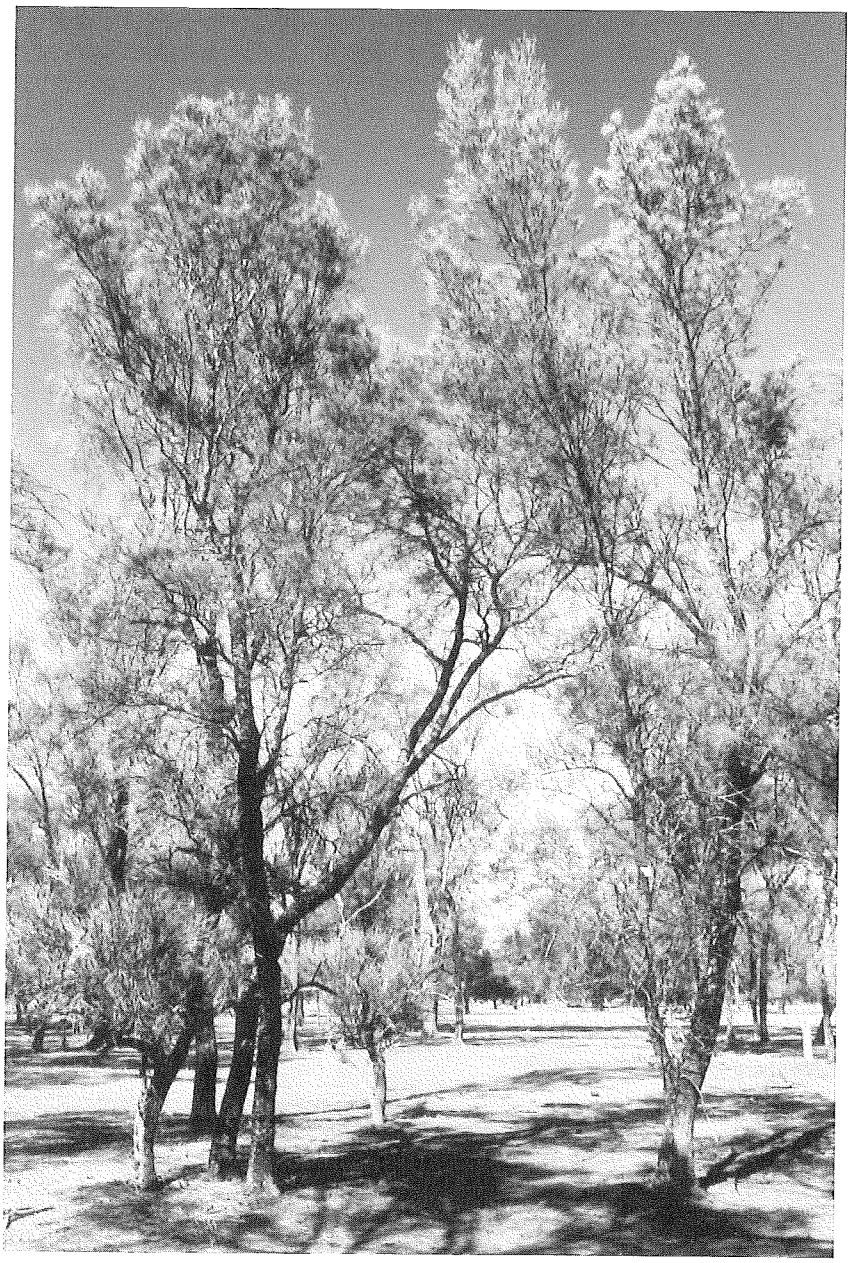

**Figure 28.** Woodland of *Casuarina pauper/Casuarina cristata* intergrades (community 28) with *Apophyllum anomalum* (Warrior Bush) in the left-foreground; north-east of Gunbar in mid-spring.

**Notes:** This vegetation community is of a very remnant nature, often reduced to just several scattered trees or a small grove. Prior streams are not always obvious on the ground and are usually visible as a line of scattered trees on a low narrow rise with adjacent scalding. Isolated groves of *Hakea* spp. or *Pittosporum phylliraeoides* may also indicate the existence of a prior stream. The stream trace is continuous and well-defined on aerial photos.

As well as *Callitris glaucophylla, Hakea* spp. and *Alectryon oleifolius*, prior streams once supported stands of *Acacia homalophylla, Casuarina pauper* and *Geijera parviflora* (Semple 1987a).

Prior streams are the last of a series of alluvial systems deposited on the Plain during late Pleistocene times and functional up till Recent times (Butler 1950). They have been mapped to include the elevated stream bed and associated scalded levees. The dunes range in height from 3 to 15 metres (Semple & Eldridge 1989).

**Map unit 28: *Casuarina pauper/Casuarina cristata* Intergrading Population**

**Structure:** low woodland – woodland #; open woodland – woodland ##

**Main species:** *Casuarina pauper/Casuarina cristata* intergrades

**Associated Species:** *Geijera parviflora* (Wilga), *Exocarpos aphyllus* (Leafless Cherry), *Apophyllum anomalum* (Warrior Bush), *Alectryon oleifolius* subsp. *canescens*, occasional *Alectryon oleifolius* subsp. *elongatus, Maireana georgei* (Satiny Bluebush), *Rhagodia spinescens, Enchylaena tomentosa, Maireana decalvans, Maireana pyramidata, Atriplex stipitata, Sclerolaena birchii, Zygophyllum glaucum.*

**Landform:** Flat to gently undulating plains, largely aeolian.

**Soils:** Texture-contrast soils of brown to red-brown sandy loam to loam, overlying red to red-brown clays.

**Occurrence:** This intergrading population occurs in a localised area between Gunbar and Hillston, along the central-eastern edge of the mapped area (Fig. 28). It extends from south-west of Gunbar through to south-west of Hillston. The densest continuous stands occur north of Gunbar on level to slightly undulating plains along McKinley, Booligal, Gunbar and Old Gunbar Roads.

**Condition:** Many areas cleared but remnants generally dense and with understorey shrubs present; some rabbit and weed infestation.

**Notes:** This community is dominated by intergrades of *Casuarina pauper* with *Casuarina cristata* (L. Johnson pers. comm.) which are taller in habit than *Casuarina pauper* and with a denser crown. *Casuarina pauper* is the co-dominant species in the Belah–Rosewood country seen further west on the deeper sandier soils of the aeolian-fluviatile transition zone (see Community 4). *Casuarina cristata* has a more eastern distribution, occurring in a north-south band from south-eastern Queensland to the south-western slopes of New South Wales (L. Johnson pers. comm., Wilson & Johnson 1989). This intergrading population falls between the distribution of *Casuarina pauper* on the deeper red-brown sands further west (see Community 4), and *Casuarina cristata* on clayey grey or brown soils containing surface calcium (Wilson & Johnson 1989). The sandsheet supporting the intergrading community overlays a clay subsurface soil.

The main associate species in this community are *Geijera parviflora, Exocarpos aphyllus* and *Apophyllum anomalum*, with Rosewood uncommon and usually restricted to small

groves or isolated trees. *Maireana georgei* (Satiny Bluebush), *Enchylaena tomentosa* and *Rhagodia spinescens* dominate the understorey in this woodland, while *Maireana pyramidata* is more prevalent in the Belah–Rosewood communities further west. A *Maireana pyramidata* association with *Maireana georgei* is said to occur mainly on soils that have not been seriously eroded (Stannard 1963). *Maireana georgei* is also noted here as having increased in number in certain sites in recent years.

This community is often somewhat mixed with a mosaic of *Callitris glaucophylla* woodland, open mallee and *Acacia pendula* woodland, especially north of Gunbar along the eastern edge of the mapped area. *Eucalyptus largiflorens* and *Acacia pendula* occur in low-lying areas whilst *Callitris glaucophylla, Hakea* species and groves of *Acacia melvillei* dominate the sandier rises within this community.

### Map unit 29: Rocky Outcrop Woodland Complex

**Structure:** low woodland #; woodland to open woodland and open mallee woodland – shrubland ##

**Main species:** *Callitris glaucophylla* (White Cypress Pine) and *Eucalyptus intertexta* (Western Red Box) (B) throughout; *Eucalyptus vicina* (B) and *Brachychiton populneus* subsp. *trilobus* (Kurrajong) (B) on the summit; *Casuarina pauper, Alectryon oleifolius* subsp. *canescens* and *Eremophila mitchellii* (Budda) (B) on the lower slopes.

**Associated Species:** *Geijera parviflora* and *Exocarpos aphyllus* on lower slopes; *Pandorea pandorana* (Inland Wonga Vine) (B), *Dodonaea lobulata* (B), *Cheilanthes austrotenuifolia* (Rock Fern) (B), *Pleurosorus subglandulosus* (B), *Thysanotus patersonii* (Twining Fringe Lily) (B) and *Arthropodium minus* to summit; *Beyeria viscosa* (B) and *Actinobole uliginosum* at summit.

**Landform:** Footslopes, ridges and crests of low rocky outcrops. Low relief erosional rocky outcrop of sandstone-conglomerate geological type (Norris & Thomas 1991). Bevelled and rounded hills with rocky cliffs of quartzite, sandstone and conglomerates (Walker 1991).

**Soils:** Brown to red-brown clay-loam to sandy loam with surface stones and gravel, overlying a sandstone-conglomerate substrate. Sandstone lithosols to red earths comprising shallow sands, loams and clay-loams, with a stony or gravelly surface (Norris & Thomas 1991).

**Occurrence:** Warranary Hill in the Warranary Range, north-west of Roto in the far north-east of the Booligal map (Fig. 30). This is the only rocky outcrop that exists within the mapped area and as such this vegetation community is not typical of the Hay Plain.

**Condition:** Moderate to severe rabbit infestation and grazing and trampling by goats.

**Notes:** There is a distinct zonal distribution of species from the footslopes to the summit of the outcrop. Mixed *Callitris glaucophylla* and Belah–Rosewood, with *Geijera parviflora* and *Exocarpos aphyllus* dominate the footslopes. A distinct *Casuarina pauper* zone occupies the lower slopes with *Dodonaea lobulata* and *Eremophila mitchellii. Callitris glaucophylla* dominates from the middle slopes to the crest, with *Eucalyptus intertexta* coming in on the upper rocky slopes and ridges. Mixed *Callitris glaucophylla* and *Eucalyptus intertexta* persist to the top where *Eucalyptus vicina* (Fig. 29) and scattered *Brachychiton populneus* appear, constituting a mixed summit woodland.

Other potential associate species within this complex were recorded for a site of similar geological type in the Keginni Range further north (Norris & Thomas 1991).

**Figure 29.** *Eucalyptus vicina* and scattered *Callitris glaucophylla* on the rocky summit of Warranary Hill (community 29), north-east of Roto in mid-spring.

**Figure 30.** Warranary Hill north-west of Roto, with *Callitris glaucophylla* from footslopes to summit, and *Casuarina pauper* on lower slopes; (community 29); mid-spring.

These include *Acacia aneura* (Mulga), *Acacia doratoxylon* (Currawang), *Acacia decora* (Western Golden Wattle) and *Cheilanthes austrotenuifolia* (Rock Fern). Other species recorded for the site by the same authors include *Pleurosorus rutifolius, Calotis cuneifolia, Calotis hispidula, Sigesbeckia australiensis, Stuartina muelleri, Geococcus pusillus, *Silene gallica, *Stellaria media, *Chenopodium murale, Fimbristylis dichotoma, Phyllanthus fuernrohrii, *Medicago laciniata, Gonocarpus elatus, Isotoma axillaris, Eucalyptus vicina, Eucalyptus morrisii, Eragrostis lacunaria, *Lamarckia aurea, Thyridolepis mitchelliana, Eriostemon linearis* and *Hybanthus monopetalus.*

Walker (1991) describes the vegetation of Warranary Hill. *Callitris glaucophylla, Eucalyptus intertexta, Acacia aneura, Senna* species and various grasses and forbs occur throughout. *Eucalyptus morrisii, Acacia doratoxylon, Eriostemon linearis* (Narrow-leaf Waxflower) and *Eremophila serrulata* (Green Fuchsia Bush) occupy the crests and upper slopes, with *Eremophila mitchelii, Eriostemon linearis* and *Pandorea pandorana* on the lower slopes. *Eucalyptus populneus* subsp. *bimbil, Acacia decora, Dodonaea viscosa* subsp. *angustissima* and *Eremophila sturtii* are seen along drainage lines.

Rocky outcrops tend to receive little grazing due to their relative inaccessibility to stock. Feral goats, however, are a major problem in rocky areas, causing much damage in high numbers by grazing and trampling native vegetation. Rabbits are also a problem in the sandier soils of the footslopes where they undermine root systems and cause massive soil erosion. Both goats and rabbits were observed on Warranary Hill.

### Open Areas (OA)

These are highly disturbed areas with a vegetation cover of annual or short-lived perennial grasses, herbs, forbs and few shrubs. Open Areas result from intense grazing, clearing and fire. Introduced pasture species usually predominate such as **Hordeum leporinum, *Lolium perenne, *Avena fatua* and **Medicago* spp. The composition of annual species changes seasonally but may also include *Erodium* spp., asteraceaeous herbs such as *Rhodanthe corymbiflora, *Cotula bipinnata* and *Podolepis muelleri,* annual saltbushes and *Swainsona* species. Weeds may also dominate the more disturbed Open Areas such as road verges and heavily used paddocks. Infestations of **Echium plantagineum* (Patterson's Curse), **Arctotheca calendula* (Capeweed) and **Brassica* spp. are particularly common on the Hay Plain.

### Cleared Areas (C)

These areas have been almost entirely cleared of natural vegetation and often cultivated for agricultural purposes. Intensive irrigation farming on the Murray River and Edward–Wakool floodplains has led to almost complete clearing of native woodlands, shrublands and grasslands in these areas. Much of the cleared country north of the Murray River contains remnant stands of *Callitris glaucophylla, Eucalyptus microcarpa* or *Acacia pendula* that have been cropped right up to the trees. Larger areas of these remnant trees have been mapped but are essentially a cleared unit. Remnants are indicated in brackets after the C symbol.

## Floristic Composition

A species list for the mapped area compiled from the current survey and published lists is given in Appendix 1. A total of 383 species from 68 families were recorded for the mapped area during the present survey. The number of species recorded for the

riverine plain as a whole rises to 977 if previous surveys are included. Leigh and Mulham (1977) reported many aquatic and escapee species not recorded for the present survey, while other surveys concentrated on particular habitats such as riparian situations (Margules & Partners *et al.* 1990). The record is dominated by species from the Poaceae (150 species or 15 %), Asteraceae (150 species or 15 %), Chenopodiaceae (83 species or 9 %) and Fabaceae (74 species or 8 %). A large proportion of species recorded are exotic: 21 per cent from the present survey, a figure which rises to 40 per cent including other records.

Several extensions of range were recorded during the survey for a number of species (Appendix 1). Four species are new records for the South Western Plains botanical subdivision while ten are unsubstantiated new records for New South Wales (Jacobs & Pickard 1981, Harden 1990–92). Twenty-seven taxa have not been recorded in any previous survey on the Hay Plain, although many of these were recorded from mallee and rocky outcrop communities atypical of the vegetation of the Plain. Fifteen of the species recorded have restricted distributions in the Western Division of New South Wales (Pressey *et al.* 1990) while eight are listed as rare, vulnerable or endangered, and one species as extinct (Briggs & Leigh 1988) (Table 5).

The composition of annual and short-lived perennial species varies from year to year and most of them are widespread and not specific to any particular community. Species turnover between seasons in arid communities is considerable, and seasonal samples only represent a fraction of the total species richness (Fox 1990). *Callitris* Mixed Woodland (Community 16) showed the highest species variability of all communities sampled on the Plain, because of the many associated trees and shrubs. Grove-forming species such as *Alectryon oleifolius, Acacia melvillei, Senna* spp. and *Dodonaea* spp. often form localised communities. Mallee areas exhibited considerable variability in understorey species associated with small-scale changes in soils and geomorphology. Many of the tree-dominated communities showed some degree of structural variability. *Eucalyptus camaldulensis* exhibits both open forest and woodland proportions while *Eucalyptus microcarpa* may attain forest dimensions within riparian situations. Mallee species that have low and multi-stemmed growth forms in mallee shrublands may elsewhere be tall and single-stemmed, forming woodlands.

## Discussion

### Distribution of the vegetation communities

The major cause of variation in vegetation type is an interaction between soil moisture and rainfall, in particular depth of wetting (Noy-Meir 1974). With the move from sandy to clayey soils the moisture regime changes from one of deeper, easily available moisture to shallow, marginal moisture. The associated vegetation communities have adapted to each of these regimes. Most annual species die once the temporary topsoil water is depleted, but as long as it persists, the faster root and shoot growth of annual species gives them the competitive advantage over the perennials. As the depth of wetting increases, the competitive advantage shifts from shallow-rooted to deep-rooted species.

Soil fertility, particularly in phosphate, may be a secondary factor determining vegetation composition (Noy-Meir 1974). *Maireana sedifolia* dominates on calcareous soils where limestone nodules exist within the first 30 cm of the surface (Beadle 1948). *Atriplex vesicaria* grows in grey clays which are mildly alkaline and contain calcium carbonate (Beadle 1981).

**Fluvial influences**

The alluvial landscape dominates the Hay Plain, with some minor lacustrian elements. The characteristic vegetation communities are the various chenopod shrublands, notably *Atriplex vesicaria* shrubland, as well as the *Eucalyptus camaldulensis* and *Eucalyptus largiflorens* woodlands that fringe the rivers and creeks and extend out across the lower floodplains.

The grey clay soils of the Plain support different vegetation communities at different levels. The lowest, most water-retaining floodplains and depressions carry *Muehlenbeckia florulenta* scrub, *Eragrostis australasica, Eucalyptus camaldulensis* forest and other species tolerant of regular inundation. *Eucalyptus largiflorens* woodlands and *Chenopodium nitrariaceum* shrublands are found at slightly higher levels on the floodplain. The slightly elevated brown clay plains adjacent to the Murray River south of Deniliquin carry *Eucalyptus microcarpa* and *Allocasuarina luehmannii* remnants. These were some of the first areas to be cleared and cropped due to the fertile soils and their proximity to an irrigation source. Relatively large and dense areas of River Red Gum forest occupy the wide floodplains directly adjacent to the Murray River.

Saltbush (*Atriplex*-dominated) shrublands occur on the level, slightly saline plains and exist within the mapped area at their eastern and southern limits. Areas that receive water run-on usually have deeply cracking clays which give deep rooting species like *Atriplex nummularia* a moisture advantage (Dalton 1988). Remnant shrublands of this species are thus found on lower lying areas of the Plain. More compact clays which have a shallower wetting profile give shallow rooting perennial species such as *Atriplex vesicaria* the competitive advantage. *Atriplex vesicaria* and *Maireana aphylla* shrublands dominate the vast level plains, with *Sclerostegia tenuis* growing in more saline situations. These communities show varying degrees of degradation and most comprise often large areas of species indicative of disturbance such as *Nitraria billardierei, Sclerolaena muricata* and *Sclerolaena tricuspis*. The area supporting *Atriplex vesicaria* was certainly much greater prior to grazing, which has allowed the spread of more competitive species such as *Maireana aphylla* where the saltbush has been removed or thinned.

*Acacia pendula* woodland is also found on alluvial plains, occupying level to depressed grey clay plains or red-brown earths at slightly higher levels on the floodplain. It occurs within the mapped area at its western limit in south-western New South Wales. In this lower rainfall zone it occurs on heavier clay soils which retain moisture better while further east the surface soils supporting *Acacia pendula* are loamier (Moore 1953). Heavily grazed areas in the east of the mapped area which once supported *Atriplex vesicaria, Acacia pendula* and *Atriplex nummularia* are now disclimax perennial grasslands or, where grazing pressure continues to be high, annual grasslands comprising introduced pasture species (Moore 1953, Beadle 1948, Wilson & Graetz 1979).

Prior stream remnants which take the form of low oval-shaped dunes and old raised stream beds, provide minor topographic relief to the alluvial landscape. The coarser textured soils of these landforms carry mixed *Callitris*-dominated woodlands and *Maireana pyramidata* shrublands and are highly vulnerable to degradation due to the erodible nature of the soils. Rabbits are a particular problem in these sandier areas as the soil provides much better burrowing conditions, compared to the more compact clays of the surrounding plains.

**Aeolian influences**

The aeolian sandsheets predominating in the west and north of the Hay Plain mark the transition from fluvial to aeolian landscapes. Major changes in the vegetation

occur here, as Belah–Rosewood open woodland and mallee and bluebush shrublands replace the low, uniform chenopod shrublands and grasslands of the alluvial plain. Aeolian forces also shape minor elements on the alluvial plain itself. An indicator of aeolian influences and sandier soils on the alluvial plain is the presence of *Callitris glaucophylla, Hakea* species and other mixed woodland species (Beadle 1948). While their presence may indicate the existence of a prior stream bed, larger rises supporting these species may be source-bordering dunes comprising the coarser soils of prior streams redeposited by wind action (Butler *et al.* 1973). *Callitris glaucophylla* occurs extensively on deeper, sandy soils and on rocky outcrops further north to north-east. Lunettes and scalded plains supporting bluebush shrublands are also geomorphological features with aeolian origins. The soils of aeolian landforms tend to be coarse-textured and are susceptible to erosion once the fixing vegetation cover is removed (Semple & Eldridge 1989).

Small areas of mallee encroach on the mapped area and are primarily of the sandplain type with a shrubby understorey, although some dune-crest mallee carrying *Triodia scariosa* occurs in the north-east. Much of this mallee is of the multi-stemmed 'whipstick' form indicating lower soil fertility and a history of regular burning (Beadle 1948, Noble *et al.* 1980). Remnants of large, old trees of the 'bull' mallee form are seen in heavily cleared areas along the north-eastern and western edges of the mapped area. Dunefields supporting mallee vegetation are more typical of the aeolian country to the west and north-east of the Hay Plain.

More typical of the aeolian landscape within the mapped area are open woodlands of *Casuarina pauper* (Belah) and *Alectryon oleifolius* (Rosewood) and *Maireana*-dominated shrublands. These dominate the sandsheets in the north to north-east of the Plain. *Maireana pyramidata* shrubland is a common community on the transition zone between aeolian country and alluvial plains and on the source-bordering dunes associated with prior streams. The duplex soils have a sandy topsoil 0.3 to 1 m thick, overlying an alluvial clay base (Semple & Eldridge 1989). Where limestone exists close to the soil surface *Maireana sedifolia* (Pearl Bluebush) dominates, and it becomes the dominant bluebush in the more calcareous earths further north and west (Beadle 1948). On the aeolian sandplains, in areas with low to medium grazing pressure, *Maireana pyramidata* forms the understorey to Belah and Rosewood. Belah–Rosewood is cleared preferentially to mallee and is prone to invasion by woody shrubs such as *Dodonaea viscosa* subsp. *angustissima* and *Senna* species.

Both mallee and Belah–Rosewood occur more extensively north of the mapped area with Belah–Rosewood dominating to the north-west and mallee to the north-east. *Acacia melvillei* is an important component of the aeolian landscape and commonly occurs in groves on sandier sites within Belah–Rosewood areas. Across the Hay Plain, groves of either Belah, Rosewood or both species occur within mixed woodlands on low sandy rises. Of particular interest in the central east of the mapped area is a sandsheet comprising duplex red-brown earth overlying clay supporting an intergrading population of *Casuarina pauper* with *Casuarina cristata* (Community 28).

## Seasonal variability of the vegetation

The composition of annual and short-lived perennial grasses and herbs in open understoreys and pastures, varies considerably from season to season. Most of the winter and spring herbage comprises escaped pasture and other exotic species which are widespread throughout most vegetation communities. **Hordeum leporinum* (Barley Grass) is the most widespread and abundant grass species, especially after autumn rains but **Lolium perenne*, **Avena fatua*, **Bromus madritensis* and **Phalaris* species may become local dominants. *Medicago* species are also extremely abundant and wide-

spread with burrs persisting throughout the driest periods. Both introduced and native species of *Erodium* are also common. Native annual species are also present in the flux of grasses and herbs that occurs after autumn and winter rains. *Rhodanthe corymbiflora, Rhodanthe floribunda, Podolepis muelleri, Daucus glochidiatus, Brachycome lineariloba, Pycnosorus pleiocephalus, Daucus glochidiatus, Swainsona procumbens,* and species of *Vittadinia, Wahlenbergia, Ptilotus* and *Goodenia* are some of the more showy species. Annual saltbushes such as *Atriplex lindleyi, Atriplex conduplicata, Atriplex pseudocampanulata* and *Atriplex leptophylla* are also a common component of the springtime herb layer in many communities.

The availability of water is the major climatic limit to plant growth on the Hay Plain. Temperature is also important in that it directly affects evaporation and transpiration. Winter is generally the period most favourable for plant growth, more so in the south where annual rainfalls are higher and more reliable. Most annual species grow in the winter months under these more favourable moisture regimes while summer growing and long-lived perennial species have developed strategies to either tolerate or avoid drought. Perennial *Atriplex* species require relatively little moisture for continued survival and growth. The high concentration of soluble salts in the plants and fine leaf hairs facilitate water absorption and prevent water loss during dry periods (Knowles & Condon 1951). Annual and short-lived perennial species are able to evade the hotter months and drought by completing their life cycle after one reasonably heavy fall of rain. Perennial shrubs such as *Atriplex vesicaria, Atriplex nummularia, Chenopodium nitrariaceum* and *Maireana aphylla* depend to a large extent on winter rains for germination and establishment (Dalton 1988).

The abundant annuals produced during winter, as well as some perennial grasses, die off in late spring to persist as dried stubble or surface litter. The perennial bushes remain green throughout the year, although portions may die back or shed leaves in excessively dry and hot summers to conserve moisture (Knowles & Condon 1951). Perennial grasses such as *Danthonia caespitosa* also produce a flush of growth with winter rains. They are better equipped to take advantage of unseasonal rainfall events than annual grass and herb species because they can regenerate vegetatively as well as from seed. They will however, dry off during the average hot summer (Dalton 1988). Competition may give annual species a seasonal advantage over perennial ones. After winter rainfall, fast-growing annual species rapidly exploit the readily available surface moisture, while during summer perennial species have the advantage of being able to tap deeper water supplies in the soil (Noy-Meir 1974).

## Modifications to the natural vegetation due to land use

Rapid change to the natural vegetation of the Hay Plain came about with the introduction of sheep grazing and other farming practices. The spread of rabbits has also had highly destructive effects on the landscape.

### Pre-European vegetation

The composition of the original saltbush vegetation on the Hay Plain prior to European impact has been debated. Some authors believe *Atriplex vesicaria* was the dominant species, others *Atriplex nummularia.* Most of the evidence suggests that *Atriplex vesicaria* was the more common and it is regarded in this and other publications as the original climax community (Beadle 1948, Knowles & Condon 1951). Beadle (1948) indicates that *Atriplex nummularia* was more abundant south of the Murrumbidgee River and in the eastern sector of the Plain. *Atriplex nummularia* shrublands are presently restricted to small remnant patches across the riverine plain while *Atriplex vesicaria* is much more widespread and abundant.

Moore (1953) presents evidence to show that the grasslands in the Narrandera, Urana and Jerilderie areas (in the south-east of the riverine plain) are disclimax or degraded communities once occupied by *Acacia pendula* and *Atriplex nummularia*. The original vegetation was an open woodland comprising trees of up to 10 m high with a well-developed shrub stratum which varied towards an *Atriplex nummularia* shrubland where the *Acacia* became infrequent. Associated shrubs included *Rhagodia spinescens, Enchylaena tomentosa, Maireana aphylla* and the poorly developed herb layer consisted mainly of *Danthonia* species, *Stipa falcata, Atriplex semibaccata, Maireana excavata* and various asteraceous herbs (Moore 1953). Similarly, much of the *Danthonia* grassland mapped in the current survey and by Beadle in 1948 has resulted from the clearing and grazing of the original communities.

Interestingly 'Coree', a property east of the current study, contains a significant area of *Atriplex vesicaria*, possibly occurring here at its south-eastern limit in Australia (Moore 1953). *Atriplex vesicaria* may have been much more common in these areas but was also grazed out. Moore (1953) also states that the original woodlands in the south-eastern riverine plain were open communities with a well-developed herbaceous stratum dominated by *Themeda australis*.

**Grazing disturbance**

The modification to the natural vegetation by sheep and cattle grazing on the Hay Plain has been immense. As the dominant land use, sheep grazing is concentrated on the rangelands, while cropping prevails closer to rivers and other water sources for irrigation. Not a single paddock appears to have escaped stock disturbance of one sort or another. The least disturbed areas of native vegetation exist in exclosures, home paddocks and reserves where stock have been excluded. A 43 ha exclosure seen in 1990 on 'Waterloo' south-east of Hay, has remained ungrazed for approximately 25 years and displayed great native species diversity and density of vegetation. Some of these sites however, especially those with loamy to sandy texture-contrast soils, may show significant degradation caused by rabbits and other feral animals.

The effects of grazing on native vegetation can range from complete clearing of perennials and their replacement by other species, to minor defoliation of perennial shrubs, trees and grasses. Grazing of seedlings also directly prevents regeneration in many communities. Some communities are partially modified by the thinning of the perennial vegetation when browsed by stock, which allows opportunistic species to become established. This is often seen in paddocks that are rotationally but intensively grazed in the short term. Species especially palatable to stock may be completely denuded and destroyed if stock rates are high and grazing pressure intensive. *Atriplex vesicaria, Atriplex nummularia, Maireana pyramidata* and *Maireana aphylla* are removed by inappropriate grazing, particularly with continuous heavy grazing (Beadle 1948, Leigh & Mulham 1965). These species may be replaced by opportunistic or exotic plants such as *Sclerolaena* species, thistles and introduced grasses. Some shrubland areas have been so heavily grazed that the original species have been entirely replaced by dense shrublands of *Nitraria billardierei, Sclerolaena muricata* and *Sclerolaena tricuspis* or by a suite of exotic annual grasses. Within most vegetation communities, particularly those with a more open structure, introduced annual and short-lived perennial grasses constitute the ground cover between scattered trees and shrubs. Invasion by other pasture species such as *Medicago* spp. and by various asteraceaeous herbs is also common. The ecological degradation of original plant communities to areas containing entirely disturbance-indicator species or annuals is a common result of grazing and clearing pressure on the Hay Plain.

It appears that sheep are highly selective even under conditions of low pasture availability (Leigh & Mulham 1966a, 1966b & 1967, Robards *et al.* 1967). In grazing trials the diet composition rarely conformed with that of the perennial pasture, a large proportion consisting of annual species such as **Hordeum leporinum* and **Medicago polymorpha*. Only in the summer when these are not available, were the dominant perennials grazed, as well as dry material such as medic burrs. In summer when very little other material was available, *Atriplex vesicaria* made up 90 per cent of the diet (Leigh & Mulham 1967). Within a *Maireana aphylla* shrubland, this species and medic burrs were favoured in summer. In winter there is a greater proportion of annual forage produced in the *Maireana aphylla* shrubland than in the *Atriplex vesicaria* shrubland (Leigh & Mulham 1966b). Grazing by native mammals appears to have a less damaging affect on chenopod shrublands. In areas where kangaroos congregate in large numbers they can remove all herbage in a similar manner to sheep. In contrast, however, they usually have little apparent effect on chenopod shrublands or tree seedlings (Wilson *et al.* 1984). Surveys have shown that kangaroos consume more grass than sheep (Wilson & Harrington 1984) and that red kangaroo populations are higher in mulga and box woodlands and *Danthonia* grasslands than in saltbush areas (Dalton 1988). Local variations in numbers are controlled by available herbage and shelter and population explosions during times of drought may have a negative effect on the already stressed vegetation.

While not observed during the present survey, some authors suggest that infrequent or short intensive periods of grazing actually increase shrub vigour and density. Osborn *et al.* (1932) and Knowles and Condon (1951) suggest that grazing by stock may have a pruning effect on *Atriplex vesicaria* promoting vigorous growth and compact bushes. If grazing was too heavy, however, shrubs started to deteriorate to the point of complete destruction under extreme conditions. Heavy intermittent grazing has been reported to improve the vigour of *Atriplex vesicaria* as well as seedling establishment (Ratcliffe 1936, Leigh & Mulham 1966a). It has also been suggested that this species may exhibit adverse symptoms in the absence of grazing, such as producing a large, scrappy form (Clift *et al.* 1987). Clift (1989) suggested that ungrazed or lightly grazed stands were often the first to experience dieback and were subsequently the slowest to regenerate. Other authors conclude that light grazing is more harmful to the vigour of *Atriplex vesicaria* communities than heavy or no grazing (Osborn *et al.* 1932). Similarly, infrequent or short intensive periods of grazing may actually increase plant species diversity within a community, a phenomenon occasionally observed along stockroutes within *Atriplex vesicaria* shrubland. These modifications to the vegetation are seen from the pastoral viewpoint of maximising grazing productivity. In terms of habitat sustainability such results may be degradational.

Modification of the original understorey due to grazing pressure is also common. An example of this is the *Acacia pendula* and *Atriplex nummularia* alliance described by Beadle (1948) and Moore (1953) which no longer exists today. The disappearance of the community is attributed to sheep grazing, bushfires, the severe drought of 1875-1877, the felling of *Acacia pendula* for stock feed and the use of the timber for firewood (Moore 1953). *Atriplex nummularia* is eaten readily by stock (Cunningham *et al.* 1981) and has been completely cleared as the understorey component of *Acacia pendula* woodland communities, to be replaced by perennial native and annual exotic grasses. Other vegetation communities have had their understoreys severely or completely cleared by direct grazing or trampling. Many *Eucalyptus largiflorens* and most *Callitris* woodlands have lost their original shrubby understoreys to grazing, with a replacement ground cover of annual and short-lived perennial grasses and herbs.

The shrubland and grassland communities on the Hay Plain may be regarded as various stages in a succession after grazing disturbance. A climax vegetation commu-

nity is one which is in equilibrium with its environment and is essentially a stable community over a relatively long period (Moore 1953). A community in disclimax phase has undergone changes of varying degrees as a direct result of land use practices such as grazing, clearing and burning. The grassland communities of the Hay Plain are considered to be disclimax communities with various degrees of degeneration in evidence (Moore 1953, Wilson & Graetz 1979). In any part of south-western New South Wales, *Danthonia* and *Stipa* species are not found as dominants except under grazing while *Chloris* species dominate only in areas subject to heavy or severe grazing (Moore 1953).

The successionary process can be also be seen in scald reclamation patterns where over the years the scalds become revegetated with the surrounding dominant matrix of vegetation via a number of intermediary communities. In the short term, the larger scalds appear to be colonised by species that are disturbance indicators such as *Nitraria billardierei* and *Sclerolaena* species, *Maireana aphylla*, annual and short-lived perennial grasses such as **Hordeum leporinum* and **Lolium perenne* and annual herbage, particularly medic and other pasture species. The course of degeneration from healthy, dense Bladder Saltbush shrubland to bare scalded areas under grazing pressure can be followed. *Atriplex vesicaria* is initially replaced with *Maireana aphylla*, followed by *Sclerolaena* species and annual saltbushes, annual herbs and grasses and finally *Nitraria billardierei*. Scalding occurs after extreme grazing has eliminated even the relatively unpalatable *Nitraria billardierei* (Dalton 1988, Beadle 1948). Various states of ecological degradation can be monitored via these species.

Regeneration of many species is directly prevented by sheep grazing. Many shrubby understorey species are removed and any regeneration is prevented by persistent grazing. Trees of *Callitris glaucophylla* are not regenerating due to grazing pressure and older stands will ultimately die out. Regeneration of this species is rarely observed in the presence of stock and rabbits (Semple 1987b) while grazing herbivores also severely limit regeneration of *Casuarina pauper* and *Alectryon oleifolius* (Chesterfield & Parsons 1985). Protection from grazing promotes regeneration of key community species as well as the shrubby understorey.

Trampling by stock may also have a deleterious effect on vegetation leading ultimately to erosion. This occurs mostly in places of concentrated stock gathering such as watering points. Osborn *et al.* (1932) suggest that occasional trampling has the effect of planting seed, resulting in the overcrowding of bushes in an *Atriplex vesicaria* shrubland.

Saltbush and bluebush shrublands are considered to be of low resilience due to their susceptibility to overgrazing and the instability of the soils with vegetation removal (Graetz & Wilson 1984). Despite some recovery of *Atriplex vesicaria* after the dieback event of 1977–1983, many areas on the Hay Plain have still not recovered. Twenty-eight per cent of the country which previously carried healthy saltbush is still in a degraded state, particularly those areas south of Hay and between the Lachlan and Murrumbidgee Rivers (Clift *et al.* 1989, Semple 1989). Grazing pressure and mismanagement of regenerating stands appears to be the cause.

**Clearing and cropping**

Clearing for agriculture has the most extreme effect on the natural vegetation in that it is removed completely and regeneration is prevented. Irrigated crop growing is a major farming industry on the arable lands adjacent to major rivers and creeks. Within the mapped area, the floodplain country of the Murray River has been extensively cleared and cropped, primarily for rice, fruit and wheat. Few intact areas of native vegetation remain, most existing as remnant trees within cropped paddocks. The less

extensive floodplains of the Murrumbidgee and Lachlan Rivers further north have been irrigated and cropped to a lesser extent. Some cropping is carried out in the dry lake basins north-west of Booligal and south of Ivanhoe, mostly after infrequent flooding events.

**Logging**

Many areas of the Hay Plain that were once wooded or forested have been cleared or thinned. *Callitris glaucophylla* was used for building and fencing and has been cleared considerably. *Acacia pendula* has been similarly cleared in the east of the Plain. River Red Gum timber is also highly valued, for heavy building work, railway sleepers, fencing and furniture making; logging of this species is the major activity in the State Forests on the Murray and Murrumbidgee Rivers. Charcoal production using River Red Gum logs and offcuts is an old industry maintained today at Mathoura. The original composition of these communities is also modified by logging, and many woodland and open forest areas are consequently prone to weed invasion. Timber-cutting in the Barmah–Millewa forests on the Murray River has altered their structure, from predominantly large old trees with patches of younger trees to young trees with few of the original forest giants (Somerville 1988).

**Salinity**

The removal, recycling and regulation of ground water is disrupted with the removal of vegetation. Without plant cover to regulate it, the water table rises, bringing dissolved salts to the soil surface and resulting in soil salinity. Surface salinity is a particular problem in areas of heavy irrigation and other situations where there is a high influx of water and little vegetation cover. Existing vegetation can also die off with increasing soil salinity, to be replaced by more salt-tolerant species. In extreme cases the result is a saltpan on which few plants can grow. Salinisation is a problem in some irrigated areas along the Murray River and appears to be more severe in the intensively irrigated areas across the river in Victoria. However in the Tullakool Irrigation Area near Wakool, rising salinity has necessitated the installation of a subsurface drainage system and evaporation ponds.

**Erosion**

Soil erosion is exacerbated with the removal of vegetation. Scalding, the removal of the top soil horizon by wind action, is commonly seen on the Hay Plain. Duplex and deeper sandy soils are particularly scald-prone, as the sandy to loamy surface soil is removed, exposing the heavier clay B-horizon. Abraham (1987) notes that the red-brown earths occurring in the eastern Hay Plain are texture-contrast soils with hard-setting loamy topsoils which are not as susceptible to scalding as the sandier topsoils occurring as sandsheets further west. Source-bordering dunes, lunettes and low sandy rises are also susceptible to windsheeting (the removal of thin surface layers of soil by wind) and drift (the removal and accumulation of sand either on the eroded surface or against adjacent obstructions) (Dalton 1988, Condon & Stannard 1957).

The regeneration of scalded areas is limited by high exposure of the surface soil to temperature, evaporation and wind movement, and by the low water infiltration rates and limited seed source in the soil (Beadle 1948b). Abraham (1987) believes that the rate of scald revegetation is slowing down, and that many remaining scalds are unlikely to revegetate naturally as their sloping surfaces do not hold water as efficiently as the already reclaimed flat surfaces. *Atriplex vesicaria* is reported to be the most successful native shrub for sowing onto scalded and degraded land, followed by *Atriplex nummularia* to a lesser extent (Muirhead & Jones 1966, Alchin 1974). Germination rates are low and seeding rates therefore need to be high.

Erosion is exacerbated by the presence of rabbits which disturb the soil, often on a massive scale. Huge warrens were observed in many sandy sites on the Plain, often exposing the root systems of existing trees. Sheep and cattle remove existing vegetation by grazing and cause soil erosion by trampling. Gully erosion due to water runoff is not common on the Hay Plain but was observed in several heavily irrigated sites in the south.

**Feral herbivores**

Of all the animals introduced to inland Australia rabbits have had the greatest impact on the environment. Grazing by rabbits, particularly of seedlings, contributes to the overall land degradation by preventing regeneration of community dominants. *Callitris* woodlands on prior stream ridges and low dunes and the Belah–Rosewood sandplains have been most affected by rabbit invasion. Away from the sandier habitats, *Atriplex nummularia* and *Nitraria billardierei* shrublands on the alluvial plains provide excellent shelter for rabbits (Dalton 1988). The eastern area of the Hay Plain, bounded by Booroorban, Four Corners and Carrathool has been described by local sources as the most rabbit-infested area of the Plain (Dalton 1988).

Pigs, goats and foxes continue to be a problem in western New South Wales. Feral pigs are common in the swamp and floodplain areas of the Lachlan–Murrumbidgee confluence but are not so prevalent on the saltbush plains (Dalton 1988). Goats are a serious problem in rocky habitats and groups were observed on Warranary Hill within the study area, where the vegetation is noticeably cropped and there is some soil erosion.

**Introduced plants**

A major modification to the natural vegetation has been the introduction and establishment of exotic species and non-local native taxa. Many of these plants, particularly the introduced pastoral species and weeds, have become a prominent part of the landscape, usually dominating the winter pasture and ground layer within many vegetation communities. Introduced pasture species such as **Hordeum leporinum*, **Lolium perenne*, **Avena fatua*, **Medicago* and *Erodium* species have become so established as to dominate the herbaceous layer of most communities on the Plain. In the current survey, 21 per cent of the species recorded are introduced taxa (Appendix 1). Semple (1987a) found that a third of the species present within an ungrazed prior stream site were naturalised. The high proportion of naturalised taxa has serious implications for natural vegetation management on the Hay Plain.

Common woody species that have become naturalised include **Lycium ferocissimum* and **Nicotiana glauca*. Common herbs and forbs that have become pests in many areas of the Plain include **Xanthium spinosum*, **Echium plantagineum*, **Cirsium vulgare*, **Sonchus oleraceus*, **Arctotheca calendula*, **Heliotropium europaeum*, **Brassica rapa* and **Sisymbrium* species. Weed species may cause particular problems with revegetation projects and rehabilitation of natural vegetation. Vigilant weeding programs need to be carried out in such cases, where weeds impede desired plant growth. These species, carried in by rivers or introduced with domestic stock or cropping, continue to be dispersed by animals, winds and vehicles (Beadle 1981).

*Nitraria billardierei*, a native species, has successfully colonised many cleared and disturbed areas on the Hay Plain. Native woody shrubs such as *Dodonaea viscosa* subsp. *angustissima* and *Senna* species often colonise disturbed areas on sandy soils in dense monospecific thickets and are considered weeds by graziers as they reduce the grazing potential of the land. *Callitris glaucophylla*, relatively rare on the Hay Plain, is regarded as a woody weed in some parts of the western slopes and the Pilliga region because of its dense regrowth in these areas. Historical records indicate that natural

fluctuations occur in the densities of native woody species. Denney (1992) suggests that the woody weed outbreaks are a successional stage that, if left alone, will slowly change towards the original woodland-grassland vegetation.

## Natural modifications

### Dieback events

The most recent and devastating modification to the vegetation on the Hay Plain has been the widespread dieback of *Atriplex vesicaria*. Between 1977 and 1983 dieback resulted in a decrease in the area of *Atriplex vesicaria* shrubland on the Plain by 53 per cent (Clift *et al.* 1987). It has since been replaced by shrublands of *Sclerolaena muricata*, *Sclerolaena tricuspis*, *Maireana aphylla* and annual or short-lived perennial grasses. Localised dieback of *Maireana pyramidata*, *Maireana sedifolia*, *Maireana aphylla* and *Atriplex nummularia* also occurred in some areas. At the time, many believed the future presence of *Atriplex vesicaria* on the Plain was in doubt, such was the severity of the dieback. The saltbush recovered somewhat with general regeneration from seedlings and reshooting after early summer rains in 1984, but did not completely regenerate in all areas, especially south of Hay (Clift *et al.* 1989, Semple 1989).

Dieback is believed to be a product of exceptional rainfall (Semple 1989). Shrubs send out shallow, short-lived feeding roots which prove inadequate during ensuing dry spells for plant survival. A lack of effective summer rain coupled with the above-average winter rain may promote strong competition from annual grasses and forbs which deplete the surface soil moisture. Other effects of above-average rainfall may be the disruption of normal *Atriplex vesicaria* growth, the strong competition between shrubs as well as from annuals and the proliferation of wilt-inducing pathogens. Caterpillars and weevil larvae (borers) are thought to contribute to saltbush death by defoliating the shrubs (Semple 1989). They are more likely to be secondary invaders as the low numbers seen were not consistent with defoliation and it seems that the caterpillar plagues coincided with, rather than initiated the dieback. Subsequent maintenance of the pre-existing grazing pressure in these areas is also detrimental to saltbush regeneration.

### Fire

Aboriginal people regularly burned the grassland of the plains to promote the growth of young grasses and seeds, both to collect and to attract game (Mullins *et al.* 1982). The incidence of naturally occurring wildfires in the area is unknown although lightning strikes could certainly cause ignitions in woodland areas of the Plain. *Atriplex vesicaria* and *Atriplex nummularia* are naturally resistant to fire (Leigh & Mulham 1965), although they may be destroyed if sufficient fuel has built up between the shrubs in the form of dried grasses and litter. The regeneration of these species after fire is slow, especially if the seed source has also been destroyed (Hodgkinson 1983, Hodgkinson *et al.* 1984). *Maireana aphylla* and *Maireana pyramidata* are not as adversely affected by fire although their densities may be reduced after wildfire (Leigh & Noble 1981).

Grassland areas south-east of Hay were affected by fire in November 1990 which was ignited from the Sturt Highway. Widespread fires in 1991 also burned a huge area north-east of Booligal to Willandra Creek. Few shrublands remain in the eastern half of the map due to the combined effects of clearing, grazing and fires. Trees appear to have survived these fire events better and coppice growth was observed north-east of Booligal. The mallee in the north-east of the mapped area has a history of regular burning. Fires occurred in the Roto–Hillston region in 1940 and 1956 to 1957 (Denney 1992) and parts of the mallee country in the Cobar Shire, situated north of Roto, were

burnt during the wildfires of 1974–75 (Noble *et al.* 1980). Much of the mallee here is of the 'whipstick' form, which is highly combustible. *Triodia*, commonly associated with whipstick mallee on the dune-crests, is also extremely flammable due to its high litter accumulation (Noble *et al.* 1980).

### Drought

Drought is normally declared when at least 50 per cent of properties over a widespread area contain insufficient water or feed to sustain stock (Dalton 1988). The famous droughts of 1883–1885 and 1890–1894 resulted in substantial degeneration of saltbush and grassland pastures. Drought conditions bring additional grazing pressure and place stress on the natural vegetation. The felling of trees and lopping of foliage from various species such as *Casuarina pauper*, *Alectryon oleifolius*, *Geijera parviflora* and *Acacia pendula* for stock feed is a common practice during drought (Grant 1989).

*Atriplex vesicaria* has a high drought resistance, having the ability to absorb moisture through the leaves from rainfall and dew, due to the high concentrations of soluble salts in the leaves (Knowles & Condon 1951). Very fine hairs on the leaves assist in water absorption and collapse during dry periods to form a protective, water-retaining covering. The plant can also rapidly produce feeding roots following good rains and, if severe drought conditions prevail, it sheds leaves. Seemingly dead, defoliated bushes, often reduced to black sticks, may be in a condition that minimises water loss (Knowles & Condon 1951).

### Flooding and high rainfall

Flooding events are essential for the survival of several major species on the Plain. *Eucalyptus camaldulensis* requires regular inundation for seed dispersal and establishment as does *Eucalyptus largiflorens* to a lesser extent. Lignum (*Muehlenbeckia florulenta*) grows rapidly during wet periods while *Chenopodium nitrariaceum* and *Eragrostis australasica* are also adapted to periods of inundation (Cunningham *et al.* 1981). Flooding influences the distribution of such communities by facilitating seed dispersal and initial establishment. The natural hydrology of the major rivers has been changed with river regulation practices and floods are not as common now as they would be naturally (Dalton 1988). The removal of vegetation cover and subsequent increase in erosion has increased the sediment loads in many rivers (Schumm 1968).

It has been suggested that the abnormally high rainfall years of 1973 and 1974 indirectly contributed to the widespread dieback of *Atriplex vesicaria* from 1977 to 1983 (see 'Dieback events' in this section). *Atriplex nummularia* is well-adapted to low-lying areas that receive extra run-on and can withstand long periods of inundation, even germinating in waterlogged soil. Plants of *Atriplex vesicaria* are not as flood-tolerant although the seeds are not affected and are the main means of regeneration after a flood (Dalton 1988).

## Conservation of vegetation

The vegetation of western New South Wales is very poorly conserved, considering that many plant communities are threatened due to continuing land use practices (Benson 1989, 1991). Only about two per cent of the Western Plains is conserved in national parks or nature reserves (Benson 1988). The flora in agricultural zones is the most poorly conserved. Vegetation groups which have the poorest conservation status in New South Wales include inland *Acacia* shrublands and *Casuarina* woodlands, chenopod shrublands of the southern plains, box woodlands and communities of inland watercourses and floodplains (Benson 1989, 1991). The Hay Plain comprises a

significant area of chenopod shrublands, semi-arid woodlands and riverine forest, constituting the heart of the Murray–Darling catchment area. Few of the vegetation communities representative of the Hay Plain are protected in reserves.

Willandra National Park (19 386 ha) and Goonawarra Nature Reserve (437 ha) are the only formal reserves within the mapped area (excluding Sandune Pine Flora Reserve, a relatively small reserve managed by the Forestry Commission, on the Murray River) representing a conserved proportion of only 0.45 per cent. The variety of vegetation communities within these reserves is limited and they do not adequately represent the botanical biodiversity of the Hay Plain. Willandra National Park was to have realised the conservation of riverine plain *Atriplex vesicaria*, but after 20 years of grazing protection it comprises mostly modified *Maireana aphylla* shrubland and open grassland. In the intensively irrigated areas south of Deniliquin, few areas remain in which the original vegetation still survives. There is an urgent need to protect key sites for preservation.

## Significant vegetation communities

The most vulnerable communities on the Hay Plain presently are those growing on the sandy duplex soils of low rises, prior streams and sandplains. These soils are highly erosion-prone due to the combined effects of vegetation removal by overgrazing and undermining by rabbits. In a priority-order of vegetation communities for conservation in the southern Riverina, Brickhill (1985) lists *Callitris*-dominated and *Acacia pendula* communities as top-priority. Table 4 indicates the threats to and present conservation status of vegetation communities occurring on the Hay Plain.

*Callitris glaucophylla* Mixed Woodland (Community 16) and Prior Stream Remnant Woodland (Community 27) are vulnerable communities of particular concern. They suffer from removal of understorey species and the prevention of seedling establishment due to grazing and trampling by stock, undermining by rabbits and erosion due to vegetation loss. Notable sites include 'Steam Plains' and 'Zara' north of Deniliquin (Brickhill 1985), 'Oolambeyan' south-east of Hay, and the Booroorban, Tholobin, Puckawidgee and Edgar State Forests. The 'Steam Plains' and 'Zara' areas also contain unusual and rare understoreys of *Atriplex nummularia*. As well as being logged, the State Forest areas are often leased out to landholders and suffer intensive grazing pressure with little or no regeneration of tree species. The Tholobin State Forest is particularly degraded, with rabbit infestation, heavy logging and overgrazing. Immediate acquisition some of these sites will prevent the loss of these remnant old woodlands in future years. Fencing off some of these areas from stock and rabbits would allow natural regeneration of the pine and re-establishment of the shrubby understorey. The 'Zara' sandhills, which have been fenced-off in the past and are in a relatively natural condition, and sites within the Steam Plains, Puckawidgee and Edgar State Forests could be targeted for regeneration. The relative rarity of *Callitris* Mixed Woodland on the Hay Plain today and the degraded state of prior streams give these communities particular conservation significance.

The higher, red-earth floodplain country between Deniliquin and the Murray River also remains unconserved. This area contains remnants of *Eucalyptus microcarpa* woodland with *Allocasuarina luehmannii* and *Eucalyptus melliodora* (Community 24) and areas of *Callitris glaucophylla* woodland (Community 16). It has been almost entirely cleared for irrigation with cropping up to and below the trees. Small roadside remnants remain, some with well-developed shrubby understoreys of local *Acacia* and *Senna* species and their acquisition for formal reservation is particularly urgent. Areas of *Eucalyptus microcarpa*, *Eucalyptus melliodora* and *Callitris glaucophylla* are listed as high priority communities for conservation, with proposed sites at Wahgunyah and

**Table 4.** Present conservation status of and threats to vegetation communities occurring within the Booligal, Hay and Deniliquin-Bendigo 1:250 000 map areas (adapted from Brickhill 1985, Benson 1989 and Morgan & Terrey 1992).

| Community | Threats | Effects | Conservation Status |
|---|---|---|---|
| **1** Riverine Forest | forestry activities, river regulation, irrigation, clearing for cropping, grazing, recreational activities | minor reduction in range and populations, younger age class over much of its distribution | Inadequately conserved, vulnerable; some conserved in Goonawarra Nature Reserve (437 ha) along the Lachlan River but conservation status extremely poor along Murray and Murrumbidgee Rivers, the former containing the largest stands in Australia. |
| **2** Black Box Woodland | grazing and cropping | major reduction in range and populations, major alteration of understorey, older age class over much of its distribution | Inadequately conserved but not threatened in the forseeable future; some conserved in Goonawarra Nature Reserve and Willandra National Park. |
| **3** Mallee | grazing, cropping, significant changes in fire regime, rabbit invasion | major reduction in range and populations, major alteration of understorey | Adequately conserved in Nombinnie, Round Hill and Yathong Nature Reserves, and Mallee Cliffs National Park, outside the mapped area and not threatened in the forseeable future. |
| **4** Belah-Rosewood | grazing, rabbit invasion, cropping | major reduction in range and populations, major alteration of understorey, little regeneration, older age class over much of its distribution | Inadequately conserved, vulnerable; very widespread and not conserved over its range. |
| **8** Black Bluebush | grazing, rabbit invasion | minor reduction in range and populations | Poorly conserved but not threatened in the forseeable future. Pearl Bluebush poorly conserved and vulnerable. |
| **11** Bladder Saltbush | grazing, cropping, dieback events | major reduction in range and populations | Poorly and inadequately conserved, vulnerable; none conserved on the Hay Plain |

Table 4 (continued)

| Community | Threats | Effects | Conservation Status |
|---|---|---|---|
| **12** *Sclerostegia tenuis* | grazing, cropping, dieback events | major reduction in range and populations | Not conserved, vulnerable. |
| **13** Canegrass | grazing, irrigation dryland cropping | minor reduction in range and populations | Inadequately conserved, vulnerable. |
| **16** *Callitris* Mixed Woodland | grazing, rabbit invasion, cropping, some logging | major reduction in range and populations, major clearing and alteration of understorey, little regeneration, older age class over much of its distribution, soil erosion | Inadequately conserved, vulnerable; some areas endangered on the Hay Plain under current threats. |
| **17** *Acacia melvillei* Woodland | grazing, rabbit invasion, cropping, some cutting for domestic firewood | minor reduction in range and populations | Not conserved over its range, vulnerable. |
| **18** Lignum and *Chenopodium nitrariaceum* | irrigation and drainage, clearing for cropping and grazing | major reduction in range and populations | Inadequately conserved, vulnerable; some conserved within Goonawarra Nature reserve. Currently being cleared along the Murrumbidgee River for irrigation. |
| **19** Old Man Saltbush | grazing | major reduction in range and populations | Not conserved, endangered; extinct in some regions and relatively rare on the Hay Plain. |
| **21** Cotton Bush | grazing | overall increase in range and populations on the Hay Plain with Bladder Saltbush dieback | Vulnerable to overgrazing; conserved within Willandra National Park (19 386 ha), most of which comprises this shrubland. |

| Community | Threats | Effects | Conservation Status |
|---|---|---|---|
| **23** Great Cumbung Swamp | irrigation and drainage, resulting from river regulation, grazing | minor reduction in range and populations | Inadequately conserved but not threatened in the forseeable future. |
| **24** Grey Box Woodland | grazing and clearing for cropping | major reduction in range and populations, major clearing of understorey, little to no regeneration, older age class over much of its distribution | Not conserved, vulnerable to endangered; intact communities, especially with Yellow Box, rare on the Hay Plain. Some *Allocasuarina luehmannii* conserved off the mapped area but inadequately so. |
| **25** *Acacia pendula* Woodland | grazing, cropping and some lopping for fodder | major reduction in range and populations, major alteration and clearing of understorey | Not conserved, endangered by clearing; intact Old Man Saltbush understorey extremely rare. |
| **26** White-top Grassland | grazing and cropping | major reduction in range and populations | Not conserved but not threatened in the forseeable future. |
| **27** Prior Stream Remnant Woodland | grazing, rabbit invasion, cropping | major reduction in range and populations, major alteration of understorey, little regeneration, soil erosion | Not conserved, vulnerable; some areas endangered on the Hay Plain under current threats. |
| **28** *Casuarina pauper/ Casuarina cristata* Intergrading Population | grazing, cropping, some rabbit invasion | minor reduction in range and populations, major alteration of understorey | Not conserved, vulnerable; possibly cleared for cropping east of the mapped area. |
| **29** Rocky Outcrop Woodland Complex | grazing, clearing, feral animals, significant changes in fire regime | minor reduction in range and populations, major alteration of understorey | Not conserved but not threatened in the foreseeable future. |

Buckingbong State Forests, to the east of the mapped area (Brickhill 1985). Also unreserved are the small isolated sandhills of the Murray floodplain supporting *Callitris gracilis* subsp. *murrayensis* (Murray Cypress Pine). Small, unmapped and rare remnants of shrubs such as *Melaleuca lanceolata* and *Acacia rigens* occur around Deniliquin. Any small vegetation remnants in areas of intensive land use must be assumed to have a high conservation value (Morgan & Terrey 1992).

The conservation status of *Atriplex vesicaria* (Community 11) and other chenopod shrublands on the Hay Plain is considered extremely poor (Benson 1988). Large areas have been reduced to ephemeral grasslands with *Sclerolaena* species, or to *Maireana aphylla* shrublands, particularly around the Lachlan River in the north-east of the mapped area and south of Hay. The majority of the 19 386 ha of Willandra National Park is not considered representative of the vegetation on the Plain since no *Atriplex vesicaria* has been recorded there and has not returned after 20 years of grazing protection. The Park was established within highly disturbed and modified vegetation which was expected to return to a species mix close to that which existed before grazing (Lunnon 1988). The properties presently surrounding the Park contain mostly open annual grasses and herbfields where grazing pressure continues to be high. The present survey has indicated that the best areas of *Atriplex vesicaria* remain in little-disturbed sites such as exclosures and on areas only periodically and lightly grazed, such as certain stockroutes. The most extensive tracts occur north to northwest of Hay and west of Booligal; however these have declined considerably both in area and condition over the past 15 years, as a consequence of dieback events. Beadle (1948) mapped *Atriplex vesicaria* as far south as the Edward River with patchy areas further south. Small stands remaining between Moulamein and Wanganella represent the southern limit of its distribution on the Hay Plain. Any native shrublands south of this limit have been completely cleared, making the preservation of the southern-most remnants all the more significant. Further investigation into the causes of dieback is essential for the future survival and management of this community. The procurement of a more representative reserve, entirely protected from grazing and within the existing area of *Atriplex vesicaria* is needed to ensure the preservation of this important shrubland.

Remnant areas of *Atriplex nummularia* shrubland (Community 19) occur throughout the Hay Plain but its distribution is very patchy. Once much more extensive, it has been reduced to small relict areas, often around homesteads and in small holding paddocks. The shrub is also found as an understorey to Black Box, at sites between Moulamein and Wanganella and north-east of Hay, and on 'Steam Plains' with *Callitris glaucophylla*. The 'Steam Plains' site has been listed as the best remaining stand of this community and nominated as a proposed conservation reserve (Brickhill 1985). As a relatively rare type of native shrubland on the Hay Plain today, the protection of these remnants is highly desirable.

*Acacia pendula* is also inadequately represented in the conserved estate. Regeneration in the field is sporadic and young plants are often damaged by grazing, since the foliage is palatable to stock (Beadle 1981). Intact woodlands now only occur as isolated remnants, having been largely altered to short-lived perennial or annual grasslands. *Acacia pendula* requires detailed survey as a matter of priority to determine the options available for conserving representative areas (Morgan & Terrey 1992). A survey of *Acacia pendula* and *Acacia homalophylla* distribution in western New South Wales is currently underway (M. Fox in prep.).

The long-term future of tree species in the lower rainfall zone of the Hay Plain is also of great concern. Belah–Rosewood (Community 4) is very poorly protected throughout its range (Benson 1988) and remains unprotected within the mapped area. Graz-

ing seriously limits the regeneration of *Casuarina pauper* and *Alectryon oleifolius* to the extent that the future of these species on pastoral land is regarded as severely threatened in the long-term (Chesterfield & Parsons 1985). *Alectryon oleifolius* in particular is highly palatable to grazing stock, rabbits and goats, and regenerates by suckers; seedlings are rarely found. *Casuarina pauper* regenerates by limited seedling production and suckering appears insufficient to perpetuate stands of the species (Chesterfield & Parsons 1985). A reduction in grazing pressure will also be necessary to protect the erosion-prone soils.

The conservation status of riparian and floodplain ecosystems of the Murray, Murrumbidgee and Lachlan River systems is extremely poor. There appears to be an urgent need to establish a reserve in the *Eucalyptus camaldulensis* forests of the Murray River which, except for Kemendoc Nature Reserve west of the mapped area, remain virtually unconserved in New South Wales. The largest stands of this species in Australia occur in the southern Riverina (Brickhill 1985). *Eucalyptus camaldulensis* is considered well conserved in Victoria in such reserves as Hattah–Kulkyne National Park (Murray–Darling Basin Ministerial Council 1987). Many of the most significant stands of the species in New South Wales are in State Forests and the continued logging is compromising the selection of representative conservation areas. At present no substantial River Red Gum forest is adequately conserved in New South Wales (Morgan & Terrey 1992). The forests of the Barmah–Millewah area form the only tall open forest on the western slopes and plains and remain unconserved. There is no doubt that the management of these forests for timber production very often has a detrimental effect on nature conservation (Somerville 1988). The flora reserves gazetted by the Forestry Commission are considered inadequate and the conservation of *Eucalyptus camaldulensis* in secure reserves free from all logging and grazing should be high on the conservation agenda (Somerville 1988).

The Black Box vegetation of the Murrumbidgee River is represented near Balranald in Yanga Nature Reserve but further representation in the east is desirable. The Murrumbidgee River is highly regulated within the mapped area and few suitable sites exist. Localities such as Darlington Point east of the mapped area could be targeted for conservation. Kinchega National Park south-east of Broken Hill reserves *Eucalyptus largiflorens* and some *Eucalyptus camaldulensis* on the Darling River (Benson 1988). One of the biggest threats to inland river systems is their contamination by chemicals and salts, and nutrient enrichment from fertilisers and livestock droppings that result in algal blooms. Changed flooding regimes due to river regulation have also affected regeneration of many River Red Gum and Black Box communities.

Other important unprotected vegetation occurs as ephemeral wetlands. Areas of *Muehlenbeckia florulenta* and *Eragrostis australasica* provide habitat for thousands of waterbirds when flooded (Pressey 1988). The Booligal wetland complex is associated with the Lachlan River downstream of Booligal and encompasses the Merrowie, Merrimajeel and Muggabah Creek anabranches. The channels and lake basins contain extensive stands of *Muehlenbeckia florulenta*, *Eucalyptus largiflorens* and *Eucalyptus camaldulensis*. Although containing these species, Goonawarra Nature Reserve is considered only marginal to, and not representative of, the Booligal wetlands (Pressey 1988). The Great Cumbung Swamp of the Lachlan–Murrumbidgee confluence is not protected at all by reserves. Inland reed swamps are commonly burnt to promote new green growth for stock while large areas of Lignum are presently being cleared for irrigation development on the lower Murrumbidgee within the mapped area (Pressey 1988). Other threats to wetland areas include the hydrological changes imposed by dams and weirs, sheep and cattle grazing (which commonly prevents the regeneration of Black Box and River Red Gum), logging, and lake-bed cropping which can cause salinity problems where irrigated (Pressey 1988).

**Table 5.** Species of particular conservation significance recorded for the Booligal–Hay and Deniliquin–Bendigo 1:250 000 map sheets. (A) Species nationally listed as rare or threatened (Briggs & Leigh 1988) and (B) species with restricted distributions in the Western Division of New South Wales (Pressey *et al.* 1990).

**Risk Codes** (Briggs & Leigh 1988)
**2** Maximum geographic range of less than 100 km. **3** Range over 100 km but restricted to highly specific and localised habitats. **X** Species not recorded for at least 50 years and presumed extinct. **E** Endangered species at risk of disappearing within one or two decades under present land use. **V** Vulnerable species not presently endangered but at risk of disappearing over a longer period (20-50 years). **Ca** Adequately reserved with a total conserved population of 1000 plants or more. **Ci** Inadequately reserved with a total conserved population of less than 1000 plants.

**Category and Priority Codes** (Pressey *et al.* 1990)
**Category 1** Species occurring only in the Western Division with a restricted distribution. **Category 2** Species occurring only in New South Wales with a restricted distribution within and outside the Western Division **Category 3** Species with a restricted distribution in the Western Division and also occurring interstate with **A** a small range and/or few records or **B** a wide range and/or many records. **Category 4** Species with disjunct occurrences in the Western Division with **A** the main population interstate and **B** the main population in New South Wales. **Priority 1** Protection measures in the Western Division will completely determine the survival of the taxon nationally. **Priority 3** Conservation of these taxa in the Western Division will influence their overall survival. **Priority 4** Protection in the Western Division is desirable to conserve the genetic variation within the ranges of these taxa.

| (A) Taxa | Risk Code | Habitat |
|---|---|---|
| AMARANTHACEAE<br>*Ptilotus extenuatus* Benl. | 2X | Known from only two collections, one made in 1818 with no precise locality recorded and one from 'Zara' station north-west of Deniliquin in 1919. Despite numerous searches, it has not been collected for the past 73 years and is believed to have been grazed-out by domestic stock and rabbits (Briggs & Leigh 1988). |
| ASTERACEAE<br>*Brachycome papillosa* G.L. Davis | 3V | *Maireana aphylla* shrubland within Willandra National Park (present survey). Also recorded from *Atriplex vesicaria* communities on clay soils (Community 11) (Semple 1986, Leigh & Mulham 1977). |
| BRASSICACEAE<br>*Lepidium monoplocoides* F. Muell. | 3ECi | *Maireana pyramidata* shrubland (Community 8, present survey). Also recorded by Leigh & Mulham (1977) and Margules & Partners *et al.* (1990). |
| CHENOPODIACEAE<br>*Maireana cheelii* (R.H. Anderson) P.G. Wilson | 3V | *Atriplex vesicaria* shrubland (Community 11) (Semple 1986, Leigh & Mulham 1977). |

| | | |
|---|---|---|
| CYPERACEAE<br>*Eleocharis obicis*<br>L.A.S. Johnson and O.D. Evans | 3V | Depressions with *Eragrostis australasica* (present survey, Community 13) but also recorded from *Atriplex vesicaria* (Community 11) and *Atriplex nummularia* (Community 19) shrublands (Cunningham & Milthorpe 1981) |
| ERIOCAULACEAE<br>*Eriocaulon australasicum*<br>(F. Muell.) Korn | 2VCa | Recorded as a collection in 1853 from 'wet places along the Murray towards junction of Murrumbidgee' (Mulham & Jones 1981). |
| FABACEAE-FABOIDEAE<br>*Swainsona murrayana*<br>Wawra | 3V | *Atriplex vesicaria* (Community 11), *Acacia pendula* (Community 25) and *Maireana aphylla* (Community 21) communities, the latter in Willandra National Park (present survey). |
| *Swainsona plagiotropis*<br>F. Muell. | 3ECi | Roadsides, rail reserves, stock routes and areas of lightly grazed unimproved pasture, in *Danthonia* spp./ *Enteropogon acicularis/Stipa* spp. grassland communities. Found on the plains country around Jerilderie and on the Murray Valley plains south of Echuca in Victoria. One site for the species is reserved in Wharparilla Flora Reserve near Echuca in Victoria, however the population presently comprises only two individuals (Appleby *et al.* 1991). Most of the *Swainsona plagiotropis* sites in the Jerilderie area also have populations of *Swainsona murrayana*. Although not recorded from the mapped area, this species is considered significant for the Hay Plain in its wider context. |

| **(B) Taxa** | **Cat./Prior.** | **Habitat** |
|---|---|---|
| AIZOACEAE<br>*Zaleya galericulata*<br>subsp. *australis*<br>(Melville) Hj. Eichler | 3B/4 | Recorded from a *Maireana pyramidata* shrubland (Community 8) during the present survey. |
| ASTERACEAE<br>*Brachycome exilis* Sond. | 3B/4 | A *Maireana pyramidata* community (Community 8) on a sand ridge (Leigh & Mulham 1977). |
| BRASSICACEAE<br>*Cuphonotus humistratus*<br>(F. Muell.) O.E. Schultz | 2/3 | *Atriplex vesicaria* and *Maireana aphylla* communities (Communities 11 and 21) (Semple 1986). |
| *Menkea australis* Lehm. | 3B/4 | Widespread in northern districts of the riverine plain where it may be locally common (Leigh & Mulham 1977). |
| *Pachymitus cardaminoides*<br>(F.Muell.) O.E. Schultz | 3B/4 | Recorded from 'Zara', north-west of Deniliquin in 1903 and probably overlooked since then (Mulham & Jones 1981). |

**Table 5** (continued)

| B) Taxa | Cat./Prior. | Habitat |
|---|---|---|
| *Rorippa eustylis* (F. Muell.) L.A.S. Johnson | 3B/4 | A *Eucalyptus camaldulensis* community (Community 1) (Margules & Partners *et al.* 1990) and a swampy area on a river flat near Deniliquin (Mulham & Jones 1981). |
| *Stenopetalum velutinum* F. Muell. | 3B/4 | Recorded from Wanganella in 1903 (Leigh & Mulham 1977). |
| CHENOPODIACEAE | | |
| *Dysphania littoralis* R.Br. | 4A/4 | *Eucalyptus camaldulensis* woodlands in moist low-lying areas (Community 1) (Mulham & Jones 1981). |
| *Sclerolaena limbata* (J.M. Black) Ulbr. | 3B/4 | *Atriplex vesicaria* shrubland (Community 11) (present survey). |
| FABACEAE-FABOIDEAE | | |
| *Swainsona reticulata* J. Black | 4B/4 | Confined to clay and clay-loam soils in the southern and eastern districts of the riverine plain (Leigh & Mulham 1977). |
| *Swainsona sericea* (A. Lee) H. Eichler | 4B/4 | Confined to clay and clay-loam soils in the southern and eastern districts of the riverine plain (Leigh & Mulham 1977). |
| FABACEAE-MIMOSOIDEAE | | |
| *Acacia pycnantha* Benth. | 4B/4 | Isolated occurrences in the Tocumwal-Berrigan area (Leigh & Mulham 1977), possibly just within the extreme south-eastern corner of the mapped area. |
| MYRTACEAE | | |
| *Eucalyptus porosa* F. Muell. ex Miq. | 3B/4 | A single tree was recorded from *Eucalyptus largiflorens* woodland (Community 2) in an exclosure protected from grazing (present survey). Also recorded from the Moulamein district (Leigh & Mulham 1977). |
| POLYGONACEAE | | |
| *Muehlenbeckia diclina* (F. Muell.) Druce | 3B/4 | Recorded from 'Manfred', south-west of Ivanhoe (Leigh & Mulham 1977) which is outside the mapped area but still on the riverine plain. |
| PORTULACACEAE | | |
| *Calandrinia volubilis* Benth. | 3A/3 | *Atriplex vesicaria* communities (Community 11) (Leigh & Mulham 1977, Semple 1986). |

The conservation status of some of the other communities mapped appears to be satisfactory. The central western mallee communities are well represented in a number of nature reserves to the north-east of the mapped area, including Yathong, Round Hill and Nombinnie Nature Reserves. The acquisition of Nombinnie along with Yathong Nature Reserve has consolidated the conservation of the *Eucalyptus socialis–E. dumosa–E. gracilis* association (Benson 1988). The southern mallee outlier, however, between Griffith and Hillston is almost completely cleared and cultivated. Clearing for grazing and cropping has also reduced the distribution of some mallee communities in their eastern most occurrences (Benson 1989). Conservation recommendations for remnant mallee areas include maintaining roadside and fenceline corridors for habitat and erosion control and fencing to exclude stock (Morgan & Terrey 1992). *Eucalyptus intertexta*, a component of the Warranary Hill Woodland Complex (Community 29) in the far north-east of the mapped area is very poorly conserved (Benson 1988). Some *Maireana pyramidata* and *Maireana sedifolia* is conserved within Kinchega and Mungo National Parks although these species remain unconserved on the Hay Plain.

## Conservation of species

The conservation status of species on the Hay Plain and south-western New South Wales generally is poor. Forty-four per cent of all vulnerable plants in New South Wales occur on the western slopes and plains (Benson 1989, 1991). This is due to the widespread environmental modification since European settlement and because there are relatively few reserves in these areas compared to the eastern part of the state. Five species that once existed on the Western Plains botanical subdivisions are now extinct while at least ten now only occur interstate (Benson 1989). Seven rare species have been recorded from the Hay Plain while one species, *Ptilotus extenuatus*, is presumed extinct (Briggs & Leigh 1988). Species of particular conservation significance within the mapped areas are listed in Table 5.

More knowledge of the population biology of these restricted, threatened and rare species is needed, starting with surveying their distributions and protecting populations in reserves where possible.

## Conservation recommendations

The clearing of land for irrigation and cropping and the prevention of regeneration of native species due to grazing pressure are the major factors contributing to vegetation loss on the Hay Plain. In such an altered area, any relatively intact remnants of natural vegetation need to be carefully managed. No further clearing should be permitted without regional assessment. The regeneration of perennial species is essential to achieve landscape stability within the pastoral areas (Morgan & Terrey 1992).

It is clear that high stocking rates and grazing pressure from other introduced and native herbivores will continue to be most detrimental to the survival of the remaining natural vegetation. The prevention of regeneration in many communities by grazing pressure has serious ramifications for their future survival. To ensure the long-term stability of the vegetation and soil, management should aim to utilise the annual element of the pasture, while maintaining the perennial component (Dalton 1988). Continuing irrigation practices and tree clearing may leave riparian and floodplain vegetation vulnerable to dieback from rising salinity.

Options for conserving native vegetation range from the gazetting of fully managed national parks and nature reserves in appropriate areas, to the more immediate action of vegetation retention and protection by individual land managers through

altered management practices. Because of the remnant nature of native vegetation on the Hay Plain today, carefully chosen and managed reserves should be incorporated into any future land management plans for the area. Conservation programs will require the acquisition and establishment of reserves in which there is complete eradication of all stock and feral herbivores, and control of native herbivores. The concept of individual custodianship of natural resources may be the key to the future survival of remnant vegetation communities and habitats in much of south-western New South Wales.

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**APPENDIX 1**

Species list for communities identified on the Booligal, Hay and Deniliquin–Bendigo 1:250 000 map sheets. Key to communities on pages 22–23.

**Key**

a Leigh, J.H. and Mulham, W.E. (1977) Vascular plants of the Riverine Plain of New South Wales with notes on distribution and pastoral use. *Telopea* 1(4): 225–293 and Mulham, W.E. and Jones, D.E. (1981) Vascular plants of the Riverine Plain of New South Wales – supplementary list. *Telopea* 2(2): 197–213.

b Cunningham, G.M. and Milthorpe, P.L. (1981) The vascular plants of five exclosures in western New South Wales. *Cunninghamia* 1(1): 23–34. *(Soil Conservation Service of New South Wales experimental exclosures 'Trida', 'Micabil', 'Sayers Lake' and 'Booberoi').*

c Semple, W.S. (1986) Plant species lists from four exclosure sites in the Hay district of south-western New South Wales. *Cunninghamia* 1(4): 491–502. *(Soil Conservation Service of New South Wales experimental exclosures 'Jim Barren', 'One Tree', 'Paradise' and 'Tchelery').*

d 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.* (NSW National Parks & Wildlife Service). *(Great Cumbung Swamp area).*

e Margules and Partners Pty Ltd, P. & J. Smith Ecological Consultants and Department of Conservation Forests and Lands Victoria (1990) *Riparian vegetation of the River Murray* (Murray-Darling Basin Commission). *(Murray River Section 4).*

[] synonymous names
* exotic
\# extension of known range in NSW (specimen held National Herbarium of NSW).
! new record for NSW (unsubstantiated).
@ ROTAP listed (Briggs & Leigh 1988).
% western division plants with restricted distribution (Pressey *et al.* 1990).

| **Botanical Name** | **Community** | | | | | **Other Records** |
|---|---|---|---|---|---|---|
| | **Forest** | **Woodland** | **Mallee** | **Shrubland** | **Grassland** | |
| **PTERIDOPHYTES** | | | | | | |
| **Aspleniaceae** | | | | | | |
| *Pleurosorus subglandulosus* | | 29 | | | | |
| **Azollaceae** | | | | | | |
| *Azolla filiculoides* | | | | | | de |
| *A. filiculoides* var. *rubra* | | | | | | a |
| *A. pinnata* | | | | | | d |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Dennstaedtiaceae** | | | | | | |
| *Pteridium esculentum* | | 16 | | | | |
| **Isoetaceae** | | | | | | |
| *Isoetes muelleri* | | | | | | a |
| **Marsileaceae** | | | | | | |
| *Marsilea angustifolia* | | | | | | a |
| *M. drummondii* | 1 | 2 25 28 | | 11 12 18 21 | 13 23 26 | d |
| **Ophioglossaceae** | | | | | | |
| *Ophioglossum lusitanicum* | | | | | | |
| **Pteridaceae** | | | | | | |
| *Pteris tremula* | | | | | | a |
| **Sinopteridaceae** | | | | | | |
| *Cheilanthes austrotenuifolia* [*C. sieberi* subsp. *tenuifolia*] | | 29 | | | | |
| *C. sieberi* subsp. *sieberi* [*C. tenuifolia* subsp. *sieberi*] | | | | | | a |
| **GYMNOSPERMS** | | | | | | |
| **Cupressaceae** | | | | | | |
| *Callitris glaucophylla* | | 4 16 17 24 27 29 | 3d | 8 11 | | |
| *C. gracilis* subsp. *murrayensis* [*C. preissii* subsp. *murrayensis*] | | 16 24 | | | | e |
| **ANGIOSPERMS-DICOTYLEDONS** | | | | | | |
| **Aizoaceae** | | | | | | |
| *Disphyma crassifolium* subsp. *clavellatum* [*D. clavellatum*] | | | | 8 11 12 21 | 13 | |
| **Galenia pubescens* | | | | | | a |
| *Glinus lotoides* | 1 | 2 28 | | | | |
| **Mesembryanthemum crystallinum* | | 2 | | 8 | | |
| **M. nodiflorum* | | | | | | a |
| *Sarcozona praecox* | | | | | | ac |
| *Tetragonia tetragonoides* | | | | | | abc |
| %*Zaleya galericulata* subsp. *australis* | | | | 8 | | |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Amaranthaceae** | | | | | |
| **Alternanthera angustifolia* | | | | | ab |
| *A. denticulata* | 1 | 2 25 28 | | 11 18 | |
| *A. nodiflora* | | 2 | | | |
| **A. pungens* | | | | | a |
| **Amaranthus albus* | | | | | a |
| **A. hybridus* | | | | | a |
| *A. macrocarpus* | 1 | 2 28 | | | |
| **A. retroflexus* | | | | | a |
| **A. viridus* | | | | | a |
| *Ptilotus atriplicifolius* var. *atriplicifolius* | | | | | a |
| *P. erubescens* | | | | | a |
| *P. gaudichaudii* var. *parviflorus* | | 4 16 | | | |
| *P. macrocephalus* | | | | | a |
| *P. nobilis* | | 25 | | | |
| *P. polystachyus* var. *polystachyus* | | 25 | | | |
| *P. semilanatus* | | | | | a |
| *P. spathulatus* | | 4 16 25 29 | | | |
| **Anacardiaceae** | | | | | |
| **Schinus areira* | | | | | ad |
| **Apiaceae** | | | | | |
| **Ammi majus* | | | | | a |
| **Apium leptophyllum* | | | | | a |
| *Daucus glochidiatus* | | 25 27 28 | | 8 11 12 21 | |
| *Eryngium plantagineum* | | | | 21 | |
| *E. rostratum* | | | | | a |
| **Foeniculum vulgare* | | | | | a |
| *Hydrocotyle laxiflora* | | | | | a |
| **Asteraceae** | | | | | |
| **Acroptilon repens* | | | | | a |
| *Actinobole uliginosum* | | 4 16 29 | 3b | | |
| *Angianthus brachypappus* | | | | 19 | |
| *A. tomentosus* | | | | | b |

| | | | | | |
|---|---|---|---|---|---|
| **Arctium minus* | | | | | a |
| **Arctotheca calendula* | 1 | 2 24 25 | 11 18 21 22 | | |
| **Artemisia arborescens* | | 24 | | | |
| **Aster subulatus* | | | | | abe |
| **Bidens pilosa* | | | 21 | | |
| **B. subalternans* | | | | | a |
| *Brachycome basaltica* var. *gracilis* | | | | | ad |
| *B.* species *B* | | | | | ac |
| *B. ciliaris* var. *ciliaris* | | 29 | | | |
| *B. ciliaris* var. *lanuginosa* | | | | | b |
| *B. curvicarpa* | | | | | ac |
| *%B. exilis* | | | | | a |
| *B. goniocarpa* | | | | | ab |
| *B. heterodonta* var. *heterodonta* | | | | | ab |
| *B. lineariloba* | | 25 29 | 8 11 21 | | |
| *@B. papillosa* | | | 21 | | ac |
| *B. readeri* | | | | | a |
| *Bracteantha bracteata* [*Helichrysum bracteatum*] | | | | | e |
| **Calendula palaestina* | | | | | a |
| *Calocephalus citreus* | | | | | ab |
| *C. sonderi* | | 4 16 | 8 11 12 19 21 22 | 13 26 | |
| *Calotis anthemoides* | | 25 | | | |
| *C. cuneifolia* | | | | | a |
| *C. cymbacantha* | | | | | b |
| *C. hispidula* | 1 | 4 16 25 29 | | | |
| *C. lappulacea* | | | | | a |
| *C. plumulifera* | | | | | b |
| *C. scabiosifolia* var. *integrifolia* | | | | | b |
| *C. scabiosifolia* var. *scabiosifolia* | | 25 | 11 21 | | |
| *C. scapigera* | | 2 | | | |
| **Carduus pycnocephalus* | | | | | a |
| **C. tenuiflorus* | | | | | ace |
| **Carthamus lanatus* | | | | | abc |
| *Cassinia arcuata* | | | | | a |
| **Centaurea calcitrapa* | | | | | a |
| **C. melitensis* | | 2 | 21 | | |
| *Centipeda cunninghamii* | 1 | 2 25 28 | 8 18 | 23 | d |
| *C. minima* | | | | | abde |
| *C. thespidioides* | | | | | abc |
| **Chondrilla juncea* | 1 | | | | |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Asteraceae (cont'd)** | | | | | |
| **Chrysanthemoides monilifera* | | | | | a |
| *Chrysocephalum apiculatum* [*Helichrysum apiculatum*] | | 25 | 3b | 21 22 | |
| *Chthonocephalus pseudevax* | | | | | ab |
| **Cichorium intybus* | | | | | a |
| **Cirsium vulgare* | 1 | 2 16 25 27 | | 11 18 21 | 13 23 d |
| **Conyza albida* | | | | | acd |
| **C. bonariensis* | 1 | | | | |
| *Cotula australis* | 1 | 25 | | | |
| **C. bipinnata* | 1 | 25 | | 11 19 21 22 | |
| **C. coronopifolia* | | | | | 23 |
| *!Craspedia glauca* | | | | | e |
| *!C. uniflora* | | | | | a |
| *C. variabilis* | | 29 | | | |
| *Cymbonotus lawsonianus* | | | | | e |
| *C. preissianus* | | | | | a |
| **Cynara cardunculus* | | | | | a |
| *Eclipta platyglossa* | | 2 28 | | | |
| *Epaltes australis* | | | | | ae |
| *E. cunninghamii* | | | | | ab |
| *Eriochlamys behrii* | | | | | ac |
| **Gnaphalium coarctatum* | | | | | a |
| *G. gymnocephalum* | | | | | ae |
| *G. sphaericum* | | | | | bce |
| *Gnephosis arachnoidea* | | | | | b |
| **Hedypnois rhagadioloides* subsp. *cretica* | | 4 16 25 | | 21 | |
| *Helichrysum leucopsideum* | | | | | e |
| *H. rutidolepis* | | | | | a |
| *!H. semipapposum* | | | | | a |
| *Hyalosperma glutinosum* subsp. *glutinosum* [*Helipterum hyalospermum*] | | | | | ac |
| *H. praecox* [*Helipterum praecox*] | | | | | ac |
| *H. semisterile* [*Helipterum jessenii*] | | 25 | 3b | | |

| | | | | | |
|---|---|---|---|---|---|
| **Hypochaeris glabra* | | 25 29 | | 11 21 | |
| **H. radicata* | | 4 16 | | 21 | |
| *Isoetopsis graminifolia* | | | | | ab |
| *Ixiolaena leptolepis* | | | | 8 11 21 | |
| *I. tomentosa* | | 2 16 24 25 | | 11 21 22 | 13 |
| **Lactuca saligna* | | | | | ae |
| **L. serriola* | | | | | bce |
| **Leontodon taraxacoides* | | | | | ae |
| *#Leptorhynchos elongatus* | | 25 | | | |
| *L. panaetioides* | | 24 | | 11 21 | |
| *L. squamatus* | | | | | a |
| *Leucochrysum molle* [*Helipterum molle*] | | | | 21 | |
| *Microseris lanceolata* | | | | | ac |
| *Millotia myosotidifolia* | | 29 | | | |
| **M. perpusilla* | | | | | a |
| *Minuria cunninghamii* | | | 3d | 8 11 12 19 21 22 | |
| *M. denticulata* | | | | | abc |
| *M. integerrima* | | | | | abc |
| *M. leptophylla* | | 25 29 | | | |
| *Myriocephalus rhizocephalus* | | 25 | 3d | 18 19 21 | |
| *M. stuartii* | | | | | c |
| *Olearia pimeleoides* | | | 3b 3d | | |
| **Onopordum acanthium* | | | | | a |
| **O. acaulon* | | | | | ac |
| **Picris echioides* | | | | | ace |
| **P. hieracioides* | | | | | d |
| *Podolepis canescens* | | | | | a |
| *P. muelleri* | | | | 11 21 | |
| **Podospermum resedifolium* [**Scorzonera laciniata*] | | | | 11 | |
| *Pogonolepis muelleriana* | | | | | ab |
| *P. stricta* | | | | | c |
| *Pseudognaphalium luteo-album* | 1 | | | | |
| *Pycnosorus chrysanthus* [*Craspedia chrysantha*] | | | | | ab |
| *P. globosus* [*Craspedia globosa*] | | | | | ac |
| *P. pleiocephalus* [*Craspedia pleiocephala*] | | 4 16 25 29 | | 8 21 | |

| Botanical Name | Community | | | | | Other Records |
|---|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland | |
| **Asteraceae (cont'd)** | | | | | | |
| **Reichardia tingitana* | | | | | | a |
| *Rhodanthe corymbiflora* [*Helipterum corymbiflorum*] | | 2 4 16 25 29 | | 8 11 18 19 21 22 | 26 | |
| *R. diffusa* [*Helipterum diffusum*] | | | | | | c |
| *R. floribunda* [*Helipterum floribundum*] | | 4 16 25 29 | | 8 11 21 | | |
| *R. moschata* [*Helipterum moschatum*] | | | | | | abc |
| *R. polygalifolia* [*Helipterum polygalifolium*] | | | | | | ab |
| *R. pygmaea* [*Helipterum pygmaeum*] | | 4 16 25 | | 11 21 | | |
| *R. stuartiana* [*Helipterum stuartianum*] | | | | | | a |
| *R. uniflora* | | 4 16 | | | | |
| **Scolymus hispanicus* | | | | | | a |
| *Senecio cunninghamii* var. *cunninghamii* | | | | 18 | 23 | d |
| *S. glossanthus* | | 25 | | 11 21 | | |
| *S. hispidulus* var. *dissectus* | | | | | | a |
| *S. lautus* subsp. *dissectifolius* | | | | 11 21 | | |
| *S. linearifolius* | | | | | | a |
| *S. platylepis* | | | | | | a |
| *S. quadridentatus* | 1 | 2 | | 21 | | |
| *S. runcinifolius* | 1 | | | 18 21 | | |
| *Sigesbeckia orientalis* subsp. *orientalis* | | | | | | a |
| **Silybum marianum* | | | | | | a |
| *Solenogyne bellioides* | | | | | | a |
| *S. dominii* | | | | | | a |
| **Sonchus asper* subsp. *glaucescens* | | | | | | d |
| *!S. hydrophilus* | | | | | | e |
| **S. oleraceus* | 1 | 2 25 28 29 | | 11 21 | 26 | |
| *Stuartina muelleri* | | | | | | ab |
| **Taraxacum officinale* | | | | | | a |
| **Tragopogon porrifolius* | | | | | | a |
| *Triptilodiscus pygmaeus* [*Helipterum australe*] | | 25 29 | | | | |

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|---|---|---|---|---|---|
| [*Helipterum australe*] | | | | | 3 |
| **Urospermum picroides* | | | | | c |
| *Vittadinia cervicularis* var. *cervicularis* | | | | | be |
| *V. condyloides* | | | | | c |
| *V. cuneata* var. *cuneata* | | 25 | 11 | | |
| *V. cuneata* var. *hirsuta* | | 25 | | | |
| *V. dissecta* | | | | | e |
| *V. gracilis* | | 2 16 27 28 | | 26 | |
| *V. pterochaeta* | | 25 | | | |
| *V. tenuissima* | | | | | a |
| **Xanthium ambrosioides* | | | | | a |
| **X. occidentale* | 1 | | | | ad |
| **X. orientale* | | | | | a |
| **X. spinosum* | 1 | 25 28 | 8 12 18 19 | 13 | |
| **Bignoniaceae** | | | | | |
| *Pandorea pandorana* | | 29 | | | |
| **Boraginaceae** | | | | | |
| **Amsinckia intermedia* | | | | | a |
| **Anchusa arvensis* | | | | | a |
| **Buglossoides arvensis* | | | | | a |
| *Cynoglossum australe* | | | | | a |
| *C. suaveolens* | | | | | a |
| **Echium plantagineum* | 1 | 2 4 16 24 25 27 28 | 8 11 18 21 22 | 26 | |
| **Heliotropium curassavicum* | | | | | a |
| **H. europaeum* | 1 | 16 25 27 | 8 21 | | |
| **H. supinum* | | 2 | | | |
| *Omphalolappula concava* | | 25 | 8 | | |
| *Plagiobothrys elachanthus* | | | | | a |
| *P. plurisepaleus* | | | | | bc |
| **Brassicaceae** | | | | | |
| **Alyssum linifolium* | | 25 | 8 | | |
| *Arabidella eremigena* | | | | | a |
| *A. nasturtium* | | | | | ac |
| *A. trisecta* | | | | | b |
| **Brassica juncea* | | | | | a |
| **B. rapa* subsp. *silvestris* | | 3b | 21 | 26 | |
| **B. tournefortii* | | 4 16 | | | |
| **Capsella bursa-pastoris* | | | | | ace |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Cardaria draba* | | | | | a |
| **Carrichtera annua* | | 29 | | 11 18 19 | |
| **Coronopus didymus* | | | | | a |
| *%Cuphonotus humistratus* | | | | | bc |
| **Diplotaxis tenuifolia* | | | | | a |
| *Geococcus pusillus* | | | | | a |
| *Harmsiodoxa blennodioides* | | 29 | | | |
| *H. brevipes* var. *brevipes* | | | | | c |
| **Hirschfeldia incana* | | | | | a |
| **Lepidium africanum* | | 25 | | | |
| *L. fasciculatum* | | 28 | | | |
| *@L. monoplocoides* | | | | 8 | ae |
| *L. papillosum* | | 29 | | | |
| *L. pseudohyssopifolium* | | 2 16 25 27 | | 21 | |
| *!L. rotundum* | | | | | b |
| *L. sagittulatum* | | | | | bc |
| *%Menkea australis* | | | | | ac |
| *%Pachymitus cardaminoides* | | | | | a |
| *Phlegmatospermum cochlearinum* | | | | | ab |
| **Rapistrum rugosum* | 1 | | | | |
| **Raphanus raphanistrum* | | | | | a |
| *%Rorippa eustylis* | | | | | ae |
| *R. laciniata* | | | | | ade |
| **R. palustris* | | | | | ae |
| **Sinapis alba* | | | | | a |
| **Sisymbrium altissimum* | | | | | b |
| **S. erysimoides* | 1 | 28 | | 19 21 | |
| **S. irio* | 1 | 25 | | | |
| **S. officinale* | | | | | a |
| **S. orientale* | | 25 29 | | | |
| *Stenopetalum lineare* | | | | | e |
| *%S. velutinum* | | | | | a |
| **Callitrichaceae** | | | | | |
| *Callitriche cyclocarpa* | | | | | e |
| *C. sonderi* | | | | | e |
| **C. stagnalis* | | | | | ae |

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|---|---|---|---|---|---|
| **Campanulaceae** | | | | | |
| *Wahlenbergia communis* | | | | | abce |
| *W. fluminalis* | | | | | acde |
| *W. gracilenta* | | | | | c |
| *W. gracilis* | 1 | 25 | | | abce |
| *W. luteola* | | 25 | | | |
| *W. stricta* subsp. *alterna* | | 4 | | | |
| *W. stricta* subsp. *stricta* | | 4 16 27 29 | | 11 | |
| **Cannabaceae** | | | | | |
| **Cannabis sativa* | | | | | a |
| **Capparidaceae** | | | | | |
| *Apophyllum anomalum* | | 28 | | | |
| **Caryophyllaceae** | | | | | |
| **Cerastium glomeratum* | | | | | ae |
| **Moenchia erecta* | | | | | a |
| **Petrorhagia velutina* | | | | | ae |
| **Polycarpon tetraphyllum* | | | | | a |
| *Scleranthus minusculus* | 1 | | | | |
| **Silene gallica* | | | | | a |
| **Spergula pentandra* | | | | | a |
| **Spergularia diandra* | | | | | ac |
| **S. rubra* | | 2 4 16 25 28 | 3d | 8 11 18 21 22 | |
| *Stellaria angustifolia* | | | | | ae |
| **S. media* | 1 | | | | |
| **Vaccaria pyramidata* | | | | | a |
| **Casuarinaceae** | | | | | |
| *Allocasuarina luehmannii* | | 16 17 24 | | | |
| *Casuarina cristata* | | 16 | | | |
| *C. obesa* | | | | | e |
| *C. pauper* | | 4 16 17 28 29 | 3d | 8p | |
| *C. pauper*/*C. cristata* intergrades | | 28 | | | |
| **Chenopodiaceae** | | | | | |
| *Atriplex angulata* | | | | | ab |
| *A. conduplicata* | | | | 8 | |
| *A. eardleyae* | | 16 27 28 | | 21 | |
| *A. holocarpa* | | | | 11 | |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Chenopodiaceae (cont'd)** | | | | | |
| *Atriplex infrequens* | | | | | b |
| *A. intermedia* | | | | | b |
| *A. leptocarpa* | | 2 16 25 27 | | 8 11 12 18 21 | |
| *A. lindleyi* | | 2 28 | | 8 8p 11 12 18 19 21 | 13 |
| *A. nummularia* | | 2 16 25 27 | | 8 11 19 | 13 |
| *A. pseudocampanulata* | | 2 16 | | 8 11 12 18 19 21 | 13 |
| *A. pumilio* | | | | | d |
| *A. semibaccata* | | 2 16 25 27 28 | | 8 11 12 18 21 | |
| *A. spinibractea* | | | | | a |
| *A. spongiosa* | | | | | ab |
| *A. stipitata* | | 25 28 | 3d | 11 | |
| *A. suberecta* | | 2 | | 18 | |
| *A. vesicaria* | | 2 4 25 28 | | 8 8p 11 12 19 21 22 | 13 |
| **Chenopodium album* | | | | | a |
| **C. ambrosioides* | | | | | a |
| *C. auricomum* | | | | | a |
| *C. carinatum* | | | | | a |
| *C. cristatum* | | | | | c |
| *C. curvispicatum* [*Rhagodia gaudichaudiana*] | | 16 | | 11 | |
| *C. desertorum* subsp. *microphyllum* | | | | | a |
| *C. melanocarpum* | | | | | ab |
| **C. multifidum* | | | | | a |
| **C. murale* | | 2 | | | |
| *C. nitrariaceum* | 1 | 2 16 27 28 | | 8 11 12 18 19 | 13 26 |
| *C. pumilio* | 1 | 2 | | 8 | |
| *Dissocarpus biflorus* var. *biflorus* | | 4 | 3d | 8 11 19 | 13 |
| *D. biflorus* var. *cephalocarpus* | | | | | b |
| *D. paradoxus* | | 4 27 | 3d | 8 8p 11 19 21 | 26 |
| %*Dysphania littoralis* | | | | | a |
| *Einadia hastata* | | | | | ae |
| *E. nutans* | 1 | 2 16 25 27 28 29 | | 8 11 12 19 21 | 13 |
| *E. polygonoides* | | | | | a |
| *E. trigonos* | | | | | a |
| *Enchylaena tomentosa* | | 2 4 16 25 27 28 | 3d | 8 11 19 | |

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|---|---|---|---|---|---|
| *Maireana aphylla* | | 4 16 25 27 | | 8 11 19 21 22 | 13 26 |
| *M. appressa* | | | | 8 | |
| *M. brevifolia* | | 4 16 | | | |
| @*M. cheelii* | | | | | ac |
| *M. coronata* | | 25 | | | |
| *M. decalvans* | | 2 16 25 27 28 | | 8 11 21 | 26 |
| *M. enchylaenoides* | | | | | ae |
| *M. excavata* | | | | | a |
| *M. georgei* | | 28 | | 8 21 | |
| *M. humillima* | | 4 16 | | | |
| *M. lobiflora* | | 25 | | | |
| *M. microcarpa* | | | | | ac |
| *M. microphylla* | | | | | ab |
| *M. pentagona* | | 2 16 25 27 | | 11 21 22 | 26 |
| *M. pyramidata* | | 2 4 16 27 28 | 3d | 8 8p 11 12 19 | |
| *M. sclerolaenoides* | | 25 27 | | | |
| *M. sedifolia* | | 4 27 | 3d | 8 8p | |
| #*M. turbinata* | | 25 | | 8 | |
| *Malacocera tricornis* | | 2 16 27 | | 8 8p 11 12 18 19 21 | 13 |
| *Osteocarpum acropterum* var. *deminuta* [*Babbagia acroptera*] | | 28 | | 8 8p 11 12 21 | |
| !*O. saluginosum* [*Threlkeldia saluginosa*] | | | | | ab |
| *Rhagodia spinescens* | 1 | 2 4 16 17 25 27 28 | 3d | 8 8p 11 12 19 21 | 13 26 |
| *R. ulicina* | | | | | a |
| *Salsola kali* | | 2 16 27 28 | | 8 11 19 21 | 26 |
| *Scleroblitum atriplicinum* | | | | | ac |
| *Sclerolaena articulata* | | | | | b |
| *S. bicornis* var. *bicornis* | | 2 28 | 3b 3d | 8 11 12 19 21 | |
| *S. bicornis* var. *horrida* | | 25 | | | |
| *S. birchii* | | 28 | | | |
| *S. brachyptera* | | 16 25 27 28 | | 8 8p 11 12 19 21 22 | |
| *S. calcarata* | | | | | b |
| *S. decurrens* | | | | | ab |
| *S. diacantha* | | | | 21 | |
| *S. divaricata* | | | | 8 11 21 | |
| *S. eriacantha* | | | | | b |
| *S. intricata* | | 2 | | 8 11 12 | |
| *S. lanicuspis* | | | | | ab |
| %*S. limbata* | | | | 11 | |

| Botanical Name | Community | | | | | Other Records |
|---|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland | |
| **Chenopodiaceae (cont'd)** | | | | | | |
| *Sclerolaena muricata* | 1 | 2 16 24 25 27 28 | | 11 12 18 19 21 22 | 13 26 | |
| *S. muricata* var. *muricata* | | | | 11 21 | | |
| *S. muricata* var. *semiglabra* | | 16 24 25 | | | | |
| *S. muricata* var. *villosa* | | 2 | | 11 21 | | |
| *S. obliquicuspis* | | | | | | bd |
| *S. parallelicuspis* | | | | | | a |
| *S. patenticuspis* | | | | | | bc |
| *S. stelligera* | | 16 25 27 | 3d | 11 12 18 21 | 26 | |
| *S. tricuspis* | | 2 16 25 27 28 | | 8 8p 11 12 18 19 21 22 | 13 | |
| *S. uniflora* | | | | | | b |
| *S. ventricosa* | | | | | | b |
| *Sclerostegia tenuis* | | | | 11 12 19 | 13 | |
| **Clusiaceae** | | | | | | |
| *Hypericum gramineum* | | | | | | e |
| *H. japonicum* | | | | | | a |
| **H. perforatum* | | | | | | a |
| **Convolvulaceae** | | | | | | |
| *Calystegia sepium* | | | | | | a |
| **Convolvulus arvensis* | | 2 27 | | 8 | | |
| *C. erubescens* | 1 | 25 28 | | 8 11 12 18 21 | 13 | |
| *Cressa cretica* | | | | 11 | | |
| *Evolvulus alsinoides* | | 2 | | | | |
| *Wilsonia rotundifolia* | | | | | | a |
| **Crassulaceae** | | | | | | |
| *Crassula colorata* var. *acuminata* | | 16 25 29 | | 8 11 19 21 | | |
| *C. helmsii* | | | | | | a |
| *C. decumbens* var. *decumbens* | | 4 16 25 29 | 3d | | | |
| *C. peduncularis* | | | | | | ae |
| *C. sieberiana* | | | | | | abce |
| **Cucurbitaceae** | | | | | | |
| **Citrullus lanatus* var. *lanatus* | | | | | | abc |
| **Cucumis myriocarpus* | | 25 27 28 | | 19 | 26 | |

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|---|---|---|---|---|---|---|
| *Ecballium elaterium* | | | | | | a |
| *Zehneria micrantha* | | | | | | a |
| **Dilleniaceae** | | | | | | |
| *Hibbertia obtusifolia* | | | | | | a |
| **Droseraceae** | | | | | | |
| *Drosera glanduligera* | | | | | | a |
| *D. peltata* | | | | | | a |
| **Elatinaceae** | | | | | | |
| *Bergia trimera* | | | | | | a |
| *Elatine gratioloides* | | | | | | a |
| **Euphorbiaceae** | | | | | | |
| *Beyeria viscosa* | | 29 | | | | |
| *Chamaesyce dallachyana* | | | | | | d |
| *C. drummondii* | 1 | 2 16 25 27 28 | | 21 | 26 | |
| *Chrozophora tinctoria | | | | | | a |
| *E. eremophila* | | | | | | abc |
| *E. peplus | | | | | | a |
| *E. planiticola* | | 27 | | 21 | 26 | |
| *Phyllanthus lacunarius* | | | | | | a |
| **Fabaceae-Caesalpinoideae** | | | | | | |
| *Senna artemisioides* subsp. *circinnata* [*Cassia circinnata*] | | | | | | a |
| *S. artemisioides* nothosubsp. *coriacea* [*Cassia eremophila* var. *coriacea*] | | 24 | | | | |
| *S. artemisioides* subsp. *filifolia* [*Cassia eremophila* var. *eremophila*] | | 4 24 | 3d | | | |
| *S. artemisioides* subsp. *petiolaris* [*Cassia eremophila* var. *platypoda*] | | 16 | 3d | | | |
| *S. artemisioides* subsp. *zygophylla* [*Cassia eremophila* var. *zygophylla*] | | 16 24 25 | | | | |
| *S. barclayana* | | | | | | a |
| **Fabaceae-Faboideae** | | | | | | |
| *Alhagi maurorum* | | | | | | a |
| *Bossiaea buxifolia* | | | | | | a |
| *Chamaecytisus palmensis | | | | | | a |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland | |
| **Fabaceae-Faboideae (cont'd)** | | | | | | |
| *Daviesia mimosoides* | | | | | | a |
| *Dillwynia cinerascens* | 1 | | | | | |
| *D. sericea* | | | | | | a |
| *Eutaxia diffusa* | | | | | | a |
| *E. microphylla* | | | | | | ae |
| **Genista linifolia* | | | | | | a |
| *Glycine clandestina* | | | | | | a |
| *G. tabacina* | | | | | | a |
| *Glycyrrhiza acanthocarpa* | | | | | | ae |
| *Lotus australis* | | | | | | a |
| **L. corniculatis* | | | | | | a |
| *L. cruentus* | | | | | | abc |
| **Medicago laciniata* | | 29 | | | | |
| **M. minima* | | 29 | | | | |
| **M. polymorpha* | 1 | 2 16 24 25 27 | | 8 11 18 21 | 26 | |
| **M. praecox* | 1 | 2 4 16 24 25 | | 8 11 12 19 21 22 | 13 26 | |
| **M. sativa* | | | | | | ab |
| **M. truncatula* | | 2 4 16 24 25 28 | | 8 11 21 | 26 | |
| !**Melilotus alba* | | | | | | a |
| **M. indica* | | | | | | ad |
| **Prosopis glandulosa* var. *glandulosa* | | | | | | a |
| **P. juliflora* | | | | | | a |
| *Psoralea cinerea* | | | | | | a |
| *P. tenax* | | | | | | ae |
| *Pultenaea largiflorens* | | | | | | a |
| *Swainsona burkittii* | | | | | | b |
| @*S. murrayana* | | 25 | | 11 21 | | ab |
| !%*S. reticulata* [*S. oroboides* subsp. *reticulata*] | | | | | | a |
| *S. phacoides* | | | | | | ae |
| @*S. plagiotropis* | | | | | | a |
| *S. procumbens* | | 25 | | 11 21 | | |
| %*S. sericea* [*S. oroboides* subsp. *sericea*] | | | | | | a |
| *S. swainsonioides* | | | | | | ab |

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|---|---|---|---|---|---|---|
| *Templetonia egena* | | | | | | a |
| **Trifolium angustifolium* | | | | | | ae |
| **T. arvense* | 1 | | | | | |
| **T. campestre* | | | | | | ae |
| **T. cernuum* | | | | | | ae |
| **T. dubium* | | | | | | e |
| **T. glomeratum* | | | | | | abce |
| **T. repens* | | | | | | e |
| **T. striatum* | | 25 29 | | | | |
| **T. subterraneum* | | 25 | | 18 | | |
| **T. tomentosum* | | | | | | abce |
| **Vicia hirsuta* | | | | | | ae |
| **V. monantha* subsp. *triflora* | | | | | | ab |
| **V. sativa* subsp. *sativa* | | | | | | ae |
| | | | | | | |
| **Fabaceae-Mimosoideae** | | | | | | |
| *Acacia acinacea* | 1 | 16 24 | | | | |
| *A. aneura* | | | | | | a |
| *A. brachybotrya* | | 16 24 | | | | |
| *A. colletioides* | | | 3d | | | |
| *A. dealbata* | 1 | | | | | e |
| *A. deanei* | | | | | | a |
| *A. decora* | | | | | | a |
| **A. farnesiana* | | | | | | a |
| *A. hakeoides* | | 16 24 28 | | | | |
| *A. homalophylla* | | 16 17 | | | | |
| *A. implexa* | | | | | | a |
| *A. ligulata* | | 4 16 27 | | | 26 | |
| *A. lineata* | | | | | | a |
| *A. loderi* | | | | | | ab |
| *A. melvillei* | | 4 16 17 | 3d | 11 | | |
| *A. montana* | | | | | | a |
| *A. oswaldii* | | 16 17 24 28 | | | | |
| *A. pendula* | | 16 17 25 27 28 | | 21 | 26 | |
| %*A. pycnantha* | | | | | | a |
| *A. rigens* | | 2 16 24 | | | | |
| *A. salicina* | 1 | 2 16 | | | | |
| *A. stenophylla* | 1 | 2 | | | | |
| *A. victoriae* | | 4 16 | 3d | | | |
| *A. wilhelmiana* | | | 3b 3d | | | |

| Botanical Name | Community | | | | | Other Records |
|---|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland | |
| **Frankeniaceae** | | | | | | |
| *Frankenia connata* | | | | 11 21 | | |
| *F. crispa* | | | | | | b |
| *F. latior* | | | | | | a |
| *F. serpyllifolia* | | | | | | b |
| **Fumariaceae** | | | | | | |
| **Fumaria bastardii* | | | | | | a |
| **F. capreolata* subsp. *capreolata* | | | | | | ae |
| **F. densiflora* | | | | | | a |
| **F. muralis* subsp. *muralis* | | | | | | ae |
| **Gentianaceae** | | | | | | |
| *Centaurium spicatum* | | | | | | abc |
| **C. tenuiflorum* | | | | | | b |
| **Cicendia quadrangularis* | | | | | | a |
| *Sebaea ovata* | | | | | | a |
| **Geraniaceae** | | | | | | |
| **Erodium botrys* | | 25 | | | | |
| **E. brachycarpum* | | | | | | a |
| **E. cicutarium* | | 2 24 25 | | 8 11 19 21 | 26 | |
| *E. crinitum* | 1 | 2 4 16 25 28 29 | 3b | 11 12 18 21 | 13 26 | |
| *E. cynogorum* subsp. *glandulosum* | | | | | | b |
| **E. malacoides* | | | | 21 | | |
| **E. moschatum* | | 2 25 | | 11 19 21 | 26 | |
| *Geranium retrorsum* | | | | | | ae |
| *G. solanderi* var. *solanderi* | 1 | | | 21 | 26 | |
| **Goodeniaceae** | | | | | | |
| *Goodenia cycloptera* | | | | | | b |
| *G. fascicularis* | | 25 | | 11 | | |
| *G. glauca* | | | | | | acde |
| *G. gracilis* | | | | 11 | | |
| *G. heteromera* | | | | | | ab |

| | | | | | |
|---|---|---|---|---|---|
| *G. pinnatifida* | | 4 16 25 29 | 21 | | |
| *G. pusilliflora* | | 4 16 25 29 | 8 11 21 | | |
| !*G. subintegra* | | | | | a |
| *Velleia paradoxa* | | 4 29 | | | |
| **Haloragaceae** | | | | | |
| *Haloragis aspera* | | 2 | | | |
| *H. glauca* | | 25 | | | |
| *H. heterophylla* | | | | | ab |
| *Myriophyllum crispatum* | | | | | ade |
| *M. verrucosum* | | | | | ade |
| **Lamiaceae** | | | | | |
| *Ajuga australis* | | | | | a |
| **Lamium amplexicaule* | | | | | ae |
| **Marrubium vulgare* | | 2 24 25 27 | | 26 | |
| *Mentha australis* | | 2 | | | |
| *M. diemenica* | | | | | a |
| **M. pulegium* | | | | | a |
| *M. satureoides* | | | | | a |
| **Salvia reflexa* | | | | | a |
| **S. verbenaca* | | | | | a |
| **Stachys arvensis* | | | | | ad |
| *Teucrium racemosum* | | 2 27 28 | | | |
| **Linaceae** | | | | | |
| *Linum marginale* | | | | | ab |
| **L. usitatissimum* | | | | | a |
| **Lobeliaceae** | | | | | |
| *Isotoma fluviatilis* | | | | | a |
| !*Lobelia pratioides* | | | | | e |
| *Pratia concolor* | 1 | 2 25 | | 23 | d |
| *P. darlingensis* | | | | | a |
| **Loranthaceae** | | | | | |
| *Amyema linophyllum* subsp. *orientale* | | | | | ae |
| *A. miquelii* | | | | | ae |
| *A. miraculosum* subsp. *boormanii* | | 16 28 | | | |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Loranthaceae (cont'd)** | | | | | |
| *Amyema linophyllum. pendulum* | 1 | | | | |
| *A. preissii* | | 2 16 | | | |
| *A. quandang* var. *quandang* | | 25 28 | | | |
| *Lysiana exocarpi* subsp. *exocarpi* | | 2 16 | | | |
| #*L. exocarpi* subsp. *tenuis* | | | 3d | | |
| **Lythraceae** | | | | | |
| *Ammannia multiflora* | | | | | a |
| *Lythrum hyssopifolia* | | 28 | | | |
| *L. salicaria* | | | | | a |
| **Malvaceae** | | | | | |
| *Abutilon halophilum* | | 27 | | 11 | |
| *A. otocarpum* | | | | | c |
| *A. theophrasti* | | | | | a |
| *Hibiscus brachysiphonius* | | | | | b |
| *H. trionum* | | | | | ac |
| *Lavatera plebeia* | | 27 | | | 26 |
| **Malva parviflora* | 1 | 25 27 | | 11 12 21 | 13 26 |
| *Malvastrum americanum* | | | | | b |
| *Sida ammophila* | | 2 27 | | 11 | 26 |
| *S. corrugata* | | 2 16 25 27 28 29 | | 8 8p 11 19 21 | 26 |
| *S. cunninghamii* | | 4 16 29 | | | |
| *S. fibulifera* | 1 | | | | |
| *S. intricata* | | 25 27 | | 21 | 26 |
| *S. subspicata* | | | | | a |
| *S. trichopoda* | 1 | 2 16 25 27 | | 11 21 | 26 |
| **Martyniaceae** | | | | | |
| **Ibicella lutea* | | | | | a |
| **Proboscidea louisianica* | | | | | a |
| **Menyanthaceae** | | | | | |
| *Nymphoides crenata* | | | | | ade |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Myoporaceae** | | | | | | |
| *Eremophila bignoniiflora* | | | | | | b |
| *E. debilis* | | 24 | | | | |
| *E. deserti* | | | | | | a |
| *E. divaricata* | | | | | | a |
| *E. glabra* | | | 3b 3d | | | |
| *E. longifolia* | 1 | 16 25 28 | | 8 | | |
| *E. maculata* | | | | | | a |
| *E. mitchellii* | | 29 | | | | |
| *E. sturtii* | | | 3b | | | |
| *Myoporum montanum* | | | | | | a |
| *M. platycarpum* | | 4 | 3d | | | |
| **Myrtaceae** | | | | | | |
| *Callistemon brachyandrus* | | | | | | a |
| *C. sieberi* | | | | | | a |
| *Calytrix tetragona* | | | | | | a |
| *Eucalyptus camaldulensis* | 1 | 2 | | | 23 | d |
| *E. camaldulensis/E. largiflorens* hybrids | 1 | | | | | |
| *E. dumosa* | | | 3b 3d | | | |
| *E. gracilis* | | | 3b 3d | | | |
| *E. intertexta* | | 16 29 | 3d | | | |
| *E. largiflorens* | 1 | 2 16 24 | 3d | 18 19 | | |
| *E. leucoxylon* subsp. *pruinosa* | | | | | | a |
| *E. leptophylla* | | | 3b 3d | | | |
| *E. melliodora* | | 2 16 24 | | | | |
| *E. microcarpa* | 1 | 2 16 24 | | | | |
| *E. oleosa* | | | 3d | | | |
| *E. populnea* subsp. *bimbil* | | 2 4 16 28 | 3d | | | |
| %*E. porosa* | | 2 | | | | a |
| *E. socialis* | | | 3b 3d | | | |
| *E. vicina* | | 29 | | | | |
| #*Melaleuca lanceolata* subsp. *lanceolata* | | 2 16 | | | | |
| **Nitrariaceae** | | | | | | |
| *Nitraria billardierei* | 1 | 2 16 25 | | 8 11 12 19 21 22 | 13 | |
| **Nyctaginaceae** | | | | | | |
| *Boerhavia coccinea* | | 2 16 25 27 | | 11 21 | 26 | |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Oleaceae** | | | | | |
| *Jasminum lineare* | | 16 | | | |
| **Onagraceae** | | | | | |
| *Epilobium billardierianum* subsp. *cinereum* | | | | | ace |
| *E. hirtigerum* | | | | | de |
| **Ludwigia peploides* subsp. *montevidensis* | | | | | d |
| **Oenothera affinis* | | | | | a |
| **O. stricta* subsp. *stricta* | | | | | a |
| **Oxalidaceae** | | | | | |
| *Oxalis corniculata s.lat.* | | | | | bc |
| *O. perennans* | 1 | 2 16 25 27 28 | | 8 11 12 18 19 21 | 13 26 |
| **O. pes-caprae* | | 24 | | | |
| **Papaveraceae** | | | | | |
| **Argemone ochroleuca* subsp. *ochroleuca* | | | | | a |
| **Papaver hybridum* | | | | 8 | |
| **P. somniferum* subsp. *setigerum* | | | | | a |
| **Pittosporaceae** | | | | | |
| *Bursaria spinosa* | | 24 | | | |
| *Pittosporum phylliraeoides* | | 4 16 27 29 | 3d | | |
| **Plantaginaceae** | | | | | |
| *Plantago cunninghamii* | | | | 11 21 | |
| **P. coronopus* subsp. *commutata* | | | | | a |
| *P. debilis* | | | | 8 | |
| *P. drummondii* | | 25 | | | |
| *P. gaudichaudii* | | | | | a |
| **P. lanceolata* | | | | | ae |
| *P. turrifera* | | | | | abc |
| *P. varia* | | | | | a |
| **Plumbaginaceae** | | | | | |
| **Limonium sinuatum* | | | | | a |

| | | | | | |
|---|---|---|---|---|---|
| **Polygonaceae** | | | | | |
| **Acetosa vesicaria* | | | | | a |
| **Acetosella vulgaris* | | | | | a |
| **Emex australis* | | | | | a |
| *Muehlenbeckia florulenta* | 1 | 2 25 | 18 | 13 | |
| *%M. diclina* | | | | | a |
| *M. horrida* | | | | | acd |
| *Persicaria decipiens* | | | | 23 | ade |
| *P. hydropiper* | | | | | a |
| *P. lapathifolia* | | | | | a |
| *P. orientalis* | | | | | ad |
| *P. prostrata* | | | | | ade |
| **Polygonum arenastrum* | | | | | a |
| **P. aviculare* | | 28 | | | |
| *P. decipiens* | | 2 | | | |
| *P. plebeium* | | | | | ade |
| *Rumex bidens* | | | | | a |
| *R. brownii* | 1 | | | | |
| **R. crispus* | | 2 | 18 21 | | d |
| *R. crystallinus* | | | | | abe |
| *R. dumosus* | | | | | ac |
| **R. pulcher* subsp. *pulcher* | | | | | a |
| *R. tenax* | 1 | 2 25 27 28 | 11 12 18 21 | 13 26 | |
| **Portulacaceae** | | | | | |
| *Calandrinia balonensis* | | | | | b |
| *C. calyptrata* | | | | | e |
| *C. eremaea* | | 25 | 11 | | |
| **C. menziesii* | | | | | a |
| *C. pumila* | | | | | c |
| *%C. volubilis* | | | | | ac |
| *Portulaca oleracea* | | 27 | | 26 | |
| **Primulaceae** | | | | | |
| **Anagallis arvensis* | | 25 28 29 | | | |
| **Proteaceae** | | | | | |
| *Banksia marginata* | | | | | a |
| *Hakea leucoptera* | | 16 24 27 | 8 | | |
| *H. tephrosperma* | | 16 27 28 | 8 | 26 | |

| Botanical Name | Community | | | | Other Records | |
|---|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland | |
| **Ranunculaceae** | | | | | | |
| *Clematis microphylla* var. *microphylla* | | 16 | | | | |
| **Myosurus minimus* var. *australis* | 1 | | | | | |
| *Ranunculus inundatus* | | | | | | ade |
| *R. lappaceus* | | | | | | ade |
| **R. muricatus* | | | | | | a |
| *R. pentandrus* var. *platycarpus* | 1 | 2 25 | | 11 18 19 | | |
| *R. pumilio* var. *politus* | | 25 | | | | |
| *R. pumilio* var. *pumilio* | 1 | | | | | |
| **R. sceleratus* | | | | | 23 | ade |
| *R. sessiliflorus* var. *sessiliflorus* | | | | | | e |
| *R. undosus* | | | | | | ade |
| **Resedaceae** | | | | | | |
| **Reseda luteola* | | | | | | a |
| **Rosaceae** | | | | | | |
| *Acaena novae-zelandiae* | | | | | | a |
| *Aphanes australiana* | | | | | | a |
| **Rosa canina* | | | | | | a |
| **R. rubiginosa* | | | | | | ae |
| **Sanguisorba minor* subsp. *muricata* | | | | | | a |
| **Rubiaceae** | | | | | | |
| *Asperula conferta* | | 25 | | | | |
| *A. cunninghamii* | | | | | | b |
| *A. gemella* | | 25 | | 18 | | |
| **Galium aparine* | | | | | | ae |
| **G. murale* | | | | | | a |
| **Rutaceae** | | | | | | |
| *Flindersia maculosa* | | 4 | | | | |
| *Geijera parviflora* | | 4 16 28 29 | 3d | | | |

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|---|---|---|---|---|---|
| **Salicaceae** | | | | | |
| **Salix babylonica* | | | | | e |
| **Santalaceae** | | | | | |
| *Exocarpos aphyllus* | | 4 16 17 25 28 29 | 3d | 19 | |
| *E. cupressiformis* | | | | | a |
| *E. strictus* | 1 | | | | |
| *Santalum acuminatum* | | 2 16 | | | |
| *S. lanceolatum* | | 16 | | | |
| **Sapindaceae** | | | | | |
| *Alectryon oleifolius* subsp. *canescens* | | 4 16 17 27 28 29 | 3d | 8 8p 21 | |
| *A. oleifolius* subsp. *elongatus* | | 16 27 | | | |
| *Dodonaea bursariifolia* | | | | | b |
| *D. lobulata* | | 29 | | | |
| *D. viscosa* subsp. *angustissima* | | 4 16 25 27 28 | 3b 3d | | |
| *D. viscosa* subsp. *cuneata* | | | | | a |
| **Scrophulariaceae** | | | | | |
| *Glossostigma diandrum* | | | | | a |
| *Gratiola pedunculata* | | | | | ad |
| *G. pubescens* | | | | | a |
| **Kickxia sieberi* | | | | | a |
| *Limosella australis* | | 25 | | 18 | |
| *L. curdieana* | | | | | ac |
| *Mimulus gracilis* | | | | 18 | |
| *M. prostratus* | | | | | a |
| **Parentucellia latifolia* | | 25 | | | |
| *Peplidium foecundum* | | | | | a |
| *Stemodia florulenta* | | | | 18 | |
| [*Morgania floribunda*] | | | | | |
| *S. glabella* | | | | | a |
| [*Morgania glabra*] | | | | | |
| **Verbascum thapsus* subsp. *thaspus* | | | | | a |
| **V. virgatum* | | | | | a |
| **Veronica arvensis* | | | | | b |
| **V. catenata* | | | | | a |
| *V. pleibeia* | | | | | a |
| **V. peregrina* | | 25 | | | |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Solanaceae** | | | | | |
| **Datura ferox* | | | | | a |
| *D. inoxia* | | | | | a |
| **D. stramonium* | | | | | a |
| **D. wrightii* | | | | | a |
| *Lycium australe* | | | | | b |
| **L. ferocissimum* | 1 | 2 16 25 27 28 | | 8 11 18 19 21 | 26 |
| **Nicotiana glauca* | | | | 18 | |
| *N. goodspeedii* | | | | | b |
| *N. simulans* | | 29 | | | |
| *N. velutina* | | | | | b |
| **Solanum elaeagnifolium* | | | | | ab |
| *S. ellipticum* | | | | | a |
| *S. esuriale* | 1 | 2 16 25 27 28 | | 8 11 12 18 21 | 13 26 |
| **S. linnaeanum* | | | | | a |
| **S. nigrum* | 1 | 2 28 | | 18 | |
| **S. pseudocapsicum* | | | | | a |
| *S. rostratum* | | | | | a |
| *S. simile* | | | | | a |
| **S. triflorum* | | | | | a |
| **Stackhousiaceae** | | | | | |
| *Stackhousia monogyna* | | | | | a |
| **Sterculiaceae** | | | | | |
| *Brachychiton populneus* subsp. *trilobus* | | 29 | | | |
| **Stylidiaceae** | | | | | |
| *Levenhookia dubia* | | | | | a |
| **Thymelaeaceae** | | | | | |
| *Pimelea curviflora* | | | | | a |
| *P. microcephala* subsp. *microcephala* | | | | | a |
| *P. trichostachya* | | | | | b |
| *P. stricta* | | | | | a |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Urticaceae** | | | | | | |
| *Parietaria debilis* | | 27 29 | | | | |
| *Urtica incisa* | | | | | | ac |
| **U. urens* | | | | | | abcde |
| **Verbenaceae** | | | | | | |
| **Phyla nodiflora* | | | | | | ae |
| **Verbena bonariensis* | | | | | | ab |
| **V. officinalis* | | 2 28 | | | | |
| **V. supina* | | | | 18 | | |
| **Violaceae** | | | | | | |
| *Viola betonicifolia* | | | | | | a |
| **Zygophyllaceae** | | | | | | |
| **Tribulus terrestris* | | 2 27 | | | 26 | |
| *Zygophyllum ammophilum* | | | | | | a |
| *Z. apiculatum* | 1 | | | | | |
| *Z. glaucum* | | 28 | | | | |
| *Z. iodocarpum* | | | 3d | | | |
| *Z. ovatum* | | | | | | b |
| **ANGIOSPERMS-MONOCOTYLEDONS** | | | | | | |
| **Alismataceae** | | | | | | |
| *Damasonium minus* | | 2 | | | | |
| **Sagittaria graminea* var. *platyphylla* | | | | | | a |
| **S. montevidensis* | | | | | | a |
| **S. sagittifolia* | | | | | | a |
| **Alliaceae** | | | | | | |
| **Allium triquetrum* | | | | | | a |
| **Nothoscordum borbonicum* | | | | | | a |
| **Amaryllidaceae** | | | | | | |
| *Calostemma purpureum* | | | | | | ab |
| *Crinum flaccidum* | 1 | | | | | |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Anthericaceae** | | | | | |
| *Arthropodium milleflorum* | | | | | a |
| *A. minus* | | 29 | | | |
| *Dichopogon fimbriatus* | | | | | a |
| *Thysanotus baueri* | | | | | bcd |
| *T. patersonii* | | 29 | | | |
| *T. tuberosus* | | | | | b |
| *Tricoryne elatior* | | | | | a |
| **Asparagaceae** | | | | | |
| **Asparagus officinalis* | | | | | ae |
| **Myrsiphyllum asparagoides* [**Asparagus asparagoides*] | | | | | a |
| **Asphodelaceae** | | | | | |
| **Asphodelus fistulosus* | | | | | a |
| *Bulbine alata* | | | | | b |
| *B. bulbosa* | | 25 | | | |
| *B. semibarbata* | | 25 29 | | 8 | |
| **Colchicaceae** | | | | | |
| *Wurmbea dioica* subsp. *dioica* | | 25 | | | |
| **Cyperaceae** | | | | | |
| *Bolboschoenus fluviatilis* [*Scirpus fluviatilis*] | | | | | a |
| *Carex appressa* | 1 | | | | |
| *C. bichenoviana* | | | | | a |
| *C. inversa* | | 25 | | | |
| *C. tereticaulis* | | | | | a |
| *Cyperus bifax* | | | | | a |
| *C. concinnus* | | | | | a |
| *C. difformis* | | | | | a |
| **C. eragrostis* | | | | | ae |
| *C. exaltatus* | | | | | ae |
| *C. gunnii* | | | | | e |

| | | | | |
|---|---|---|---|---|
| *C. gymnocaulos* | | | 23 | ade |
| *C. pygmaeus* | | | | ae |
| *C. victoriensis* | | | | a |
| *Eleocharis acuta* | | 18 | 23 | d |
| @*E. obicis* | | 18 | 13 | b |
| *E. pallens* | 2 25 | 12 | 13 26 | |
| *E. plana* | | | | b |
| *E. pusilla* | | | | ade |
| *E. sphacelata* | | | | ad |
| *Fimbristylis aestivalis* | | | | a |
| *F. dichotoma* | | | | ab |
| *F. velata* | | | | a |
| *Isolepis australiensis* [*Scirpus australiensis*] | | | | a |
| *I. congrua* [*Scirpus congruus*] | | | | a |
| *I. hookeriana* [*Scirpus hookeranus*] | | | | a |
| **I. hystrix* [**Scirpus hystrix*] | | | | a |
| *I. victoriensis* [*Scirpus victoriensis*] | | | | a |
| *Lipocarpha microcephala* | | | | a |
| *Schoenus apogon* | | | | a |
| **Eriocaulaceae** | | | | |
| @*Eriocaulon australasicum* | | | | a |
| **Hydatellaceae** | | | | |
| *Trithuria submersa* | | | | a |
| **Hydrocharitaceae** | | | | |
| **Egeria densa* | | | | a |
| **Elodea canadensis* | | | | a |
| *Hydrilla verticillata* | | | | a |
| *Ottelia ovalifolia* | | | | a |
| *Vallisneria gigantea* | | | 23 | ad |
| **Hypoxidaceae** | | | | |
| *Hypoxis glabella* var. *glabella* | 25 | 12 19 21 | | |
| *H. hygrometrica* | | | | c |

| Botanical Name | Community | | | | Other Records |
|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland |
| **Iridaceae** | | | | | |
| **Gynandriris setifolia* | | | | | a |
| **Homeria flaccida* | | | | | a |
| **Romulea flava* | | | | | a |
| **R. minutiflora* | | 25 | | | |
| **R. rosea* var. *australis* | | 25 | | | |
| **Juncaceae** | | | | | |
| **Juncus acutus* | | | | | ae |
| *J. amabilis* | | | | | ae |
| *J. aridicola* | 1 | | | | 13 |
| **J. articulatus* | | | | | 23 ade |
| *J. bufonius* | | | | | abc |
| **J. capitatus* | | | | | a |
| *J. flavidus* | | 25 | | 12 18 21 | 13 23 d |
| *J. holoschoenus* | | | | | a |
| *J. homalocaulis* | | | | | a |
| *J. ingens* | 1 | | | | |
| *J. pallidus* | | | | | a |
| *J. radula* | | 25 | | 11 18 21 | |
| *J. semisolidus* | | | | 18 | |
| *J. subsecundus* | | | | | a |
| *J. usitatus* | | | | | a |
| **Juncaginaceae** | | | | | |
| *Triglochin calcitrapa* | | | | | ab |
| *T. hexagona* | | | | | a |
| *T. procera* | | | | | ade |
| *T. turrifera* | | | | | a |
| **Lemnaceae** | | | | | |
| *Spirodela pusilla* | | | | | a |
| **Lomandraceae** | | | | | |
| *Lomandra effusa* | | | 3b 3d | | |

| | | | | | |
|---|---|---|---|---|---|
| *L. filiformis* subsp. *coriacea* | | | | | a |
| *L. leucocephala* subsp. *robusta* | | | | | a |
| *L. multiflora* | | | | | a |
| **Najadaceae** | | | | | |
| *Najas marina* | | | | | a |
| *N. tenuifolia* | | | | | a |
| **Orchidaceae** | | | | | |
| *Caladenia carnea* | | | | | a |
| *C. dilatata* var. *dilatata* | | | | | a |
| *Diuris pedunculata* | | | | | a |
| *Microtis uniflora* | | | | | a |
| *Prasophyllum fuscum* | | | | | a |
| *P. patens* | | | | | a |
| *Pterostylis mutica* | | | | | a |
| **Phormiaceae** | | | | | |
| *Dianella longifolia* | | | | | abe |
| **Poaceae** | | | | | |
| *Agrostis avenacea* | 1 | 2 16 27 | | 8 11 19 21 | |
| **Aira cupaniana* | | 25 | | | |
| **Alopecurus geniculatus* | | 2 | | 18 | |
| *Amphibromus neesii* | | | | | ab |
| *A. nervosus* | | | | | ce |
| *A. whitei* | | | | | a |
| *Aristida calycina* var. *praealta* | | | | | a |
| *A. behriana* | | 27 | | 11 19 | |
| *A. jerichoensis* subsp. *subspinulifera* | | | | | a |
| *Astrebla lappacea* | | | | | a |
| *A. pectinata* | | | | | b |
| **Avena barbata* | | | | | e |
| **A. fatua* | | 2 16 25 27 28 | 3d | 8 8p 11 12 18 19 21 22 26 | |
| **A. sativa* | | | | 11 | |
| *Bothriochloa macra* | | | | | a |
| *Brachiaria milliiformis* | | | | | b |
| **Briza maxima* | | | | | a |
| **B. minor* | | 25 | | | |

| Botanical Name | Community | | | | | Other Records |
|---|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland | |
| **Poaceae (cont'd)** | | | | | | |
| *Bromus alopecuroides* | | | | | | a |
| *B. arenarius* | | | | 11 | 26 | |
| **B. catharticus* | | | | | | ace |
| [**B. unioloides*] | | | | | | |
| **B. diandrus* | | | | 11 21 22 | | |
| **B. hordeaceus* | | | | | | a |
| **B. madritensis* | | 2 4 16 25 27 | | 11 21 22 | 26 | |
| **B. molliformis* | | | | 11 | | |
| **B. rubens* | | | | 21 | | |
| **Cenchrus incertus* | | | | | | a |
| **C. longispinus* | | | | | | a |
| **Chloris gayana* | | | | | | a |
| *C. truncata* | | 2 27 | | 11 21 22 | 26 | |
| *C. ventricosa* | | | | | | a |
| *Cynodon dactylon* | | 28 | | | | |
| *Dactyloctenium radulans* | | | | | | ac |
| *Danthonia auriculata* | | | | | | ac |
| *D. caespitosa* | 1 | 2 4 16 24 25 27 28 | 3d | 8 8p 11 12 18 19 21 22 | 13 26 | |
| *D. duttoniana* | | | | | | ae |
| *D. eriantha* | | | | | 26 | |
| *D. linkii* var. *fulva* | | | | 21 | | |
| *D. setacea* | | 25 | | | | |
| *Deyeuxia quadriseta* | | | | | | ae |
| *Dichelachne micrantha* | | | | | | a |
| *Digitaria ammophila* | | | | | | ae |
| *D. brownii* | | | | | | a |
| **D. ciliaris* | | | | | | a |
| *D. coenicola* | | | | | | ab |
| *D. divaricatissima* | | | | | | ab |
| **D. sanguinalis* | | | | | | a |
| *Diplachne fusca* | | | | | | abc |
| *D. muelleri* | | | | | | b |
| *Echinochloa colona* | | | | | | ae |
| **E. crus-galli* | | | | 11 | | |
| **E. microstachya* | | | | | | a |

| | | | | | |
|---|---|---|---|---|---|
| **E. oryzoides* | | | | | a |
| **Ehrharta calycina* | | | | | a |
| **E. longiflora* | | | | | ae |
| **Eleusine tristachya* | | | | | a |
| *Elymus scaber* [*Agropyron scabrum*] | | | | | abe |
| **Elytrigia repens* | | | | | e |
| *Enneapogon avenaceus* | | 2 27 | | | |
| *E. nigricans* | | 27 | | | |
| *E. polyphyllus* | | | | | a |
| *Enteropogon acicularis* | 1 | 2 16 25 27 28 | 8 18 21 | 26 | |
| *Eragrostis australasica* | 1 | 2 25 28 | 8 11 12 18 19 21 | 13 26 | |
| *E. brownii* | | | | | a |
| **E. cilianensis* | | 16 27 | | 26 | |
| **E. curvula* | | | | | a |
| *E. desertorum* | | | | | a |
| *E. dielsii* | | | 8p | | |
| *E. elongata* | | | | | ae |
| *E. eriopoda* | | | | | ab |
| *E. lacunaria* | | 2 16 | | | |
| *E. molybdea* | | | | | c |
| *E. parviflora* | | 25 | 8 | | |
| **E. minor* | | | | | a |
| *E. setifolia* | | | 21 | | |
| *Eriochloa australiensis* | | | | | ab |
| *E. crebra* | | | | | ac |
| *E. pseudoacrotricha* | | | | | abc |
| *Eulalia fulva* | | | | | a |
| *Glyceria australis* | | | | | a |
| **G. maxima* | | | | | a |
| **Holcus lanatus* | | | | | a |
| *Homopholis proluta* [*Panicum prolutum*] | | | 8p | | |
| **Hordeum glaucum* | | 25 | | | |
| **H. hystrix* | | 16 27 | 12 19 21 | | |
| **H. leporinum* | 1 | 2 4 16 17 24 25 28 | 8 8p 11 12 18 19 21 22 | 13 23 26 | d |
| **H. marinum* | | | | | ace |
| *Iseilema membranaceum* | | | | | a |
| *I. vaginiflorum* | | | | | b |
| **Lamarckia aurea* | | 25 | 8 11 | | |

| Botanical Name | Community | | | | Other Records | |
|---|---|---|---|---|---|---|
| | Forest | Woodland | Mallee | Shrubland | Grassland | |
| **Poaceae (cont'd)** | | | | | | |
| *Leptochloa digitata* | | | | 19 | | |
| **Lolium perenne* | 1 | 2 16 24 25 | | 11 18 19 21 22 | 26 | |
| **L. rigidum* | | | | | 26 | |
| **Lophochloa cristata* | | | | | | b |
| **L. pumila* | | | | | | b |
| **Oryzopsis miliacea* | | | | | | a |
| **Panicum capillare* var. *capillare* | | | | | | a |
| **P. capillare* var. *occidentale* | | | | | | a |
| *P. coloratum* | 1 | | | | | |
| *P. decompositum* | | | | 8 11 | | |
| *P. effusum* | | 27 | | | | |
| **P. gilvum* | | | | | | a |
| *P. queenslandicum* var. *queenslandicum* | | | | | | b |
| *P. laevinode* | | | | | | abc |
| **Parapholis incurva* | | | | | | abc |
| **P. strigosa* | | | | | | ab |
| *Paspalidium constrictum* | | 2 16 | | | | |
| *P. jubiflorum* | 1 | | | | | |
| *P. distans* | | | | | | d |
| **Paspalum dilatatum* | | | | | | ae |
| *P. distichum* | | | | | 23 | e |
| **Pennisetum villosum* | | | | | | a |
| **Pentaschistis airoides* | | | | | | a |
| *Perotis rara* | | | | | | b |
| **Phalaris aquatica* | | | | | | ab |
| **P. minor* | | | | 11 21 | | |
| **P. paradoxa* | 1 | 28 | | 11 12 18 19 21 | 13 | |
| *Phragmites australis* | 1 | | | | 23 | d |
| **Poa annua* | | | | | | a |
| **P. bulbosa* | | | | | | a |
| *P. fordeana* | 1 | 2 | | 11 | | |
| *P. labillardieri* | | | | | | ae |
| **P. pratensis* | | | | | | a |
| *P. sieberana* | | | | | | a |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Polypogon monspeliensis* | | | | | 23 | ade |
| *Pseudoraphis spinescens* | | | | | | ae |
| *Puccinellia stricta* | | | | | | ac |
| **Rostraria cristata* | | | | | | ab |
| **R. pumila* | | | | | | a |
| **Schismus barbatus* | | | | | | abcde |
| **Setaria geniculata* var. *pauciseta* | | | | | | a |
| **S. verticillata* | | | | | | a |
| *Sporobolus actinocladus* | | | | | | b |
| *S. caroli* | | 25 27 | | 11 | 26 | |
| *S. mitchellii* | | | | | | a |
| *Stipa aristiglumis* | | | | | | a |
| *S. bigeniculata* | | | | | | b |
| *S. blackii* | | | | | | a |
| *S. drummondii* | | 25 | | 11 | | |
| *S. elegantissima* | | | | 19 | | |
| *S. metatoris* | | | | | | e |
| *S. nitida* | | 4 16 25 | | 8 8p | | |
| *S. nodosa* | | 2 25 | | 11 | 26 | |
| *S. platychaeta* | | | | | | a |
| *S. scabra* subsp. *falcata* | | 16 | | 8 | | |
| *S. scabra* subsp. *scabra* | | 27 | | | | |
| *Stipa* sp. | 1 | 24 28 | | 12 21 | | |
| *Themeda australis* | | | | | | a |
| *Tragus australianus* | | | | | | abc |
| *Triodia scariosa* | | | 3b | | | |
| *Tripogon loliiformis* | | | | | | ab |
| *Triraphis mollis* | | | | | | ab |
| **Vulpia bromoides* | | 25 | | 11 | | |
| **V. myuros* | | 4 16 25 | | 11 21 | 26 | |
| **Pontederiaceae** | | | | | | |
| **Eichhornia crassipes* | | | | | | a |
| **Potamogetonaceae** | | | | | | |
| *Potamogeton crispus* | | | | | 23 | ad |
| *P. ochreatus* | | | | | | a |
| *P. pectinatus* | | | | | | a |
| *P. perfoliatus* | | | | | | a |
| *P. tricarinatus* | | | | | | ade |

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|---|---|---|---|---|---|---|
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| **Ruppiaceae** | | | | | | |
| *Ruppia maritima* | | | | | | a |
| *R. megacarpa* | | | | | | a |
| **Typhaceae** | | | | | | |
| *Typha domingensis* | | | | | 23 | ade |
| *T. orientalis* | 1 | 2 | | | 23 | ade |
| **Zanichelliaceae** | | | | | | |
| *Lepilaena australis* | | | | | | a |

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