The native grasslands of the Riverine Plain, New South Wales

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Benson, J.S., Ashby, E.M. and Porteners, M.F. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1997. The native grasslands of the Riverine Plain, New South Wales. Cunninghamia *5(1): 1–48.* A botanical survey of the derived, temperate, tussock grasslands of the Riverine Plain, bounded by the towns of Jerilderie, Deniliquin, Hay and Narrandera on the south western Plains of New South Wales, was conducted in spring 1995. Sample sites were selected to cover the different types and extent of grassland in the region. A number were placed at locations known to contain the Plains-wanderer (*Pedionomus torquatus*) – an endangered ground bird. All vascular plants were recorded (including cover estimates for each species) in 67, 10 m × 20 m quadrats. Grassland structure, physiographic attributes and an estimate of condition were also recorded for each quadrat. 224 species were recorded, of these 58 (25%) were exotic. Six plant communities were selected from an analysis of the floristic data using an agglomerative hierarchical cluster analysis. These communities are described in the text. Six nationally listed rare or threatened species were recorded, one of which (*Swainsona murrayana*) is common in the region and requires a review of its status. A number of plants were recorded only once. The collection of *Leptorhynchos scaber* was the first of this species in NSW and it should be considered endangered in NSW. Palatable species such as Kangaroo Grass (*Themeda australis*) and the Native Yam (*Microseris lanceolata*) have been severely depleted by grazing and are now rare in the region. A list of sites of botanical significance based on this and previous studies is provided, using the criteria of rare species presence, representativeness and condition. These sites occur in travelling stock routes, roadsides and privately-owned paddocks, all of which appear to have been less disturbed by grazing or ploughing. The main threats to the native grasslands are the extension of cultivation (including rice), rising soil salinity, pasture improvement, inappropriate grazing and small-scale urban development. A discussion is provided on the management of native grasslands in the region.

Introduction

The lowland grasslands of south-eastern Australia are among the most threatened and poorly conserved ecosystems in the nation (McDougall & Kirkpatrick 1994). A number of recent botanical studies have been undertaken in some of these grasslands (Stuwe 1986–Basalt Plains, Victoria; Benson 1994–Monaro, New South Wales; Sharp 1994–Australian Capital Territory; Kirkpatrick et al. 1988–Tasmania). In contrast to previous botanical research in native grasslands that concentrated on their pasture value (for example Robards et al. 1967), these studies have classified the native grasslands, documented important sites for protection and commented on grassland management for conserving native species.

The definition of a native grassland used in this survey was: *a grassland where >50% of the vegetative ground cover is composed of indigenous species of grasses and forbs (species*

native to the area before European settlement), >50% of the number of species are native, and where the minimum standing vegetation ground cover, alive or dead, exceeds 10% (Benson 1996). Areas where woody vegetation such as Myall, saltbush or cottonbush exceeded 10% cover were defined as shrublands.

In the Australian-wide classification of Moore (1970), the Riverine Plain grasslands were mapped as 'temperate shortgrass' dominated by *Danthonia-Stipa-Enneapogon*. Later, Moore (1993) reclassified them as 'saltbush-xerophytic mid-grass communities' (*Atriplex-Maireana-Chloris-Stipa*). This recognises that the Riverine Plain grasslands have been derived from a previous vegetation dominated by chenopod shrubs and *Acacia pendula* (Moore 1953a). Benson (1996) defines a derived or secondary native grassland as: *A 'native grassland' remaining after the removal or dieback of previous woody canopy vegetation (shrubs and trees), to a point where woody vegetation has less than 10% cover.*

Our survey of the native grasslands of the NSW section of Riverine Plain aimed to classify the different types of native grasslands present, discuss their floristic composition (including significant plant species) and document sites of botanical significance.

The study area

The study area is confined to that part of the Riverine Plain (Butler 1950) in New South Wales that contains native grasslands. It extends from Ivanhoe in NSW in the north to

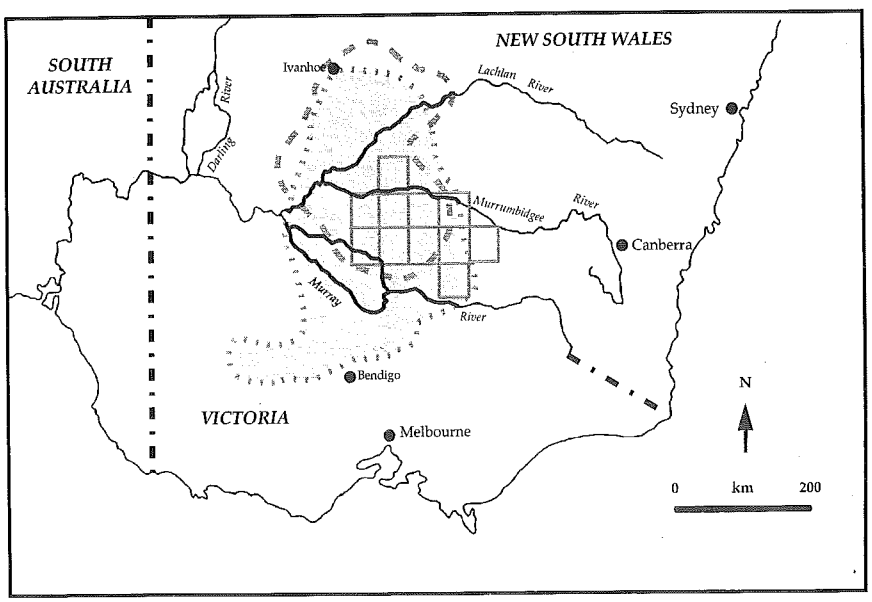

Fig. 1. Location of the Riverine Plain as defined by Butler (1950) (shaded area), the Hay Plain as defined by Porteners (1993) (dashed line) and the 1:100 000 map sheets that cover the region where native grassland occurs (see also Fig. 3).

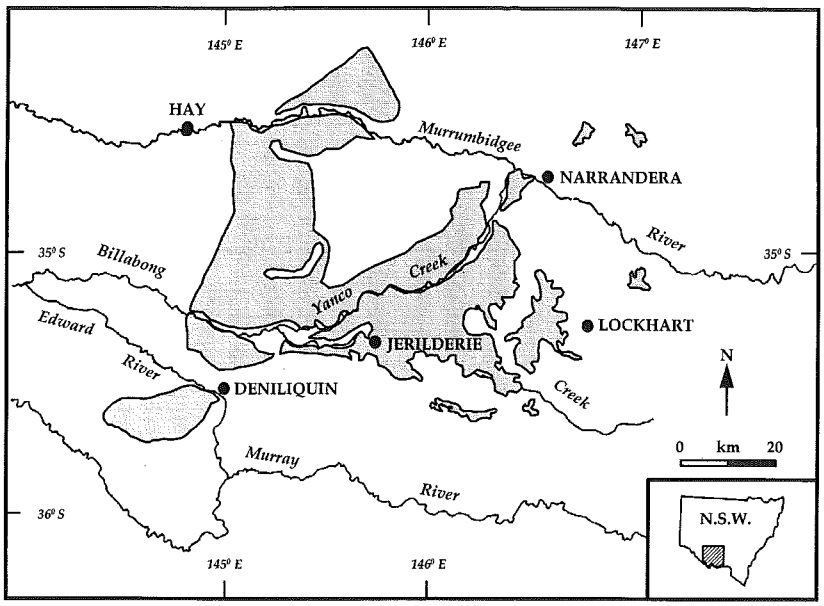

Fig. 2. Extent of derived native grasslands on the NSW section of the Riverine Plain (derived from Beadle 1948 and Moore 1953a). Since the 1920s much of this native grassland has been altered by cultivation and pasture improvement. The area would have originally been vegetated with chenopod shrubland and Myall (*Acacia pendula*) open woodland.

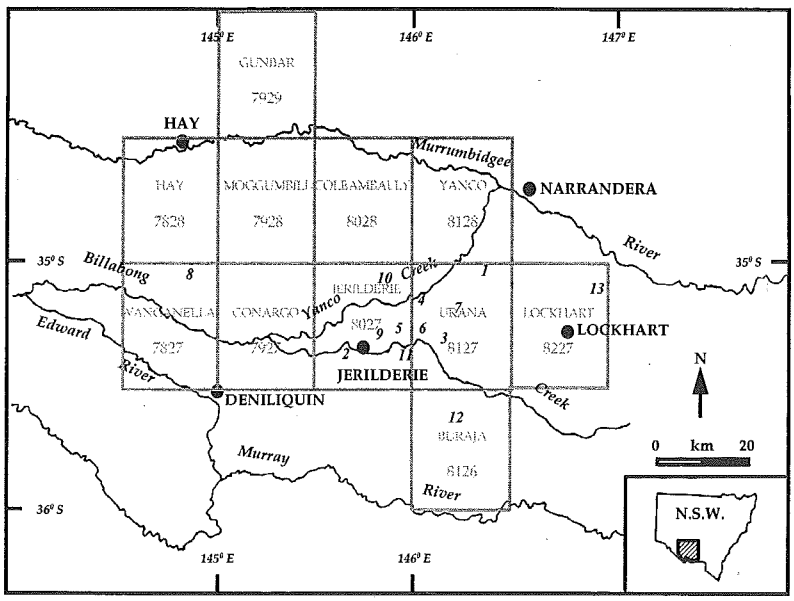

Fig. 3. The native grasslands extend over a region covered by eleven, 1:100 000 map sheets from Lockhart in the east to Hay in the north-west. Numbers 1– 13 indicate the approximate location of areas containing sites of botanical significance.

central-western Victoria in the south (Fig. 1). The Hay Plain, as defined in Porteners (1993), is principally a subset of the Riverine Plain and is mainly dominated by *Atriplex vesicaria* (Bladder Saltbush) and other species in the Chenopodiaceae. Grassland is absent from sandy-loam soils and these lighter soils are dominated by woodlands of *Eucalyptus*, *Casuarina* and *Callitris*. A large area of grassland was originally present south of Echuca on the Victorian section of the Riverine Plain, but only patches remain (McDougall & Kirkpatrick 1994). Native grasslands on the NSW section of the Riverine Plain are located between Urana in the south-east, Deniliquin in the south-west, Hay in the north-west and Narrandera in the north-east (Fig. 2). This region of native grassland occurrence is covered by eleven, 1:100 000 topographic maps (Fig. 3). Some outlying grassland patches are present on low-lying plains, such as Bullenbong Plain east of Lockhart.

Climate

The region experiences hot summers and cool winters with the summer maximum averaging over 30°C and winter minimum down to 5°C (Fig. 4). The average annual rainfall is about 400 mm in the region. It is wetter in the east with 500 mm at Narrandera, and drier in the west with 408 mm at Deniliquin and 367 mm at Hay. Rainfall peaks in May and September but falls throughout the year, with slightly more in winter and spring (Fig. 4). Summer rainfall comes mainly from storms and is less

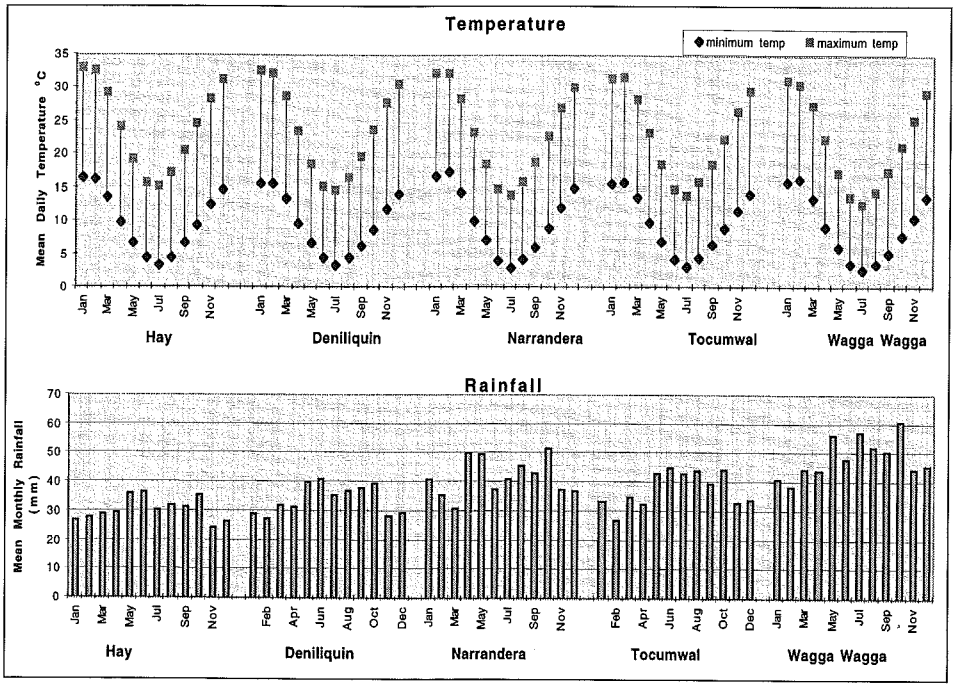

Fig. 4. Average monthly rainfall and temperatures recorded from towns in the study area (Bureau of Meteorology 1996). Rainfall increases from west to east across the Riverine Plain.

reliable than winter rainfall. The evaporation rate is much higher in summer than the cooler months. The main growing, flowering and fruiting period for grasses and forbs is spring, however, some native perennials benefit from summer rainfall.

Geology and soils

The Riverine Plain, situated in the eastern part of the Murray Basin, is bounded by the western slopes of the Great Dividing Range in the east and semi-arid mallee-dominated dune systems to the west. It encompasses the fluvial plains of the Murray, Murrumbidgee, Goulburn and Lachlan Rivers (Butler et al. 1973) and is composed of alluvial deposits of Pleistocene and Recent origin largely derived from prior streams (Butler 1950).

Modern river systems such as Billabong and Yanco Creeks have deposited recent alluvia on the floodplains in the eastern part of the study area. There has been less recent deposition on the Hay Plain on the north-western section of the study area, where its present surface is a relict landform representing the final phase of prior stream deposition (Butler 1958).

Recent stream depositions have given the plains their form, with erosion influencing form to a lesser degree (Butler et al. 1973). The plains have various surface modifications including scalds, channels, drains and depressions (gilgai). Occasional aeolian features such as lunettes and source-bordering sand dunes overlay the alluvial plains.

Grasslands are mainly restricted to red-brown clays and grey-brown clays (Moore 1953a), and do not occur on porous sandy soils of prior stream channels or dunes bordering previous lakes. The red-brown clays occur on slightly elevated, well drained areas and are common in the east and south of the study area. North of Jerilderie, shallow red-brown earths overlay the heavier textured clays (Langford-Smith & Rutherford 1966). Scalding due to wind erosion is a common feature of this soil type. The grey-brown clays occur in depressions where water is retained for a longer period after rain (Butler et al. 1973). The Hay Plain in the north-western section of the study area contains grey cracking clays.

European land use history

Charles Sturt explored the lower Murray River region on two expeditions in 1829 and 1831 (Sturt 1833). In 1836 Thomas Mitchell explored the Lachlan-Murrumbidgee Rivers to the north-east of the study area. The first European settlers arrived in 1832 (Gammage 1986) and by 1840 pastoral runs covered the region. During the 1830s and 1840s there were many confrontations between the settlers and members of the Wiradyuri and Narrungderra Aboriginal people. Disease, combined with oppression by the settlers, quickly led to the social disintegration and population decline of the Aboriginal community (Gammage 1986).

Stock routes were established between townships. Cattle were grazed at first but sheep became more common during the 1860s (Gammage 1986). The region grew wealthy supplying food to the burgeoning population in south-eastern Australia attracted by the gold rushes of the 1850s. Overgrazing and drought affected the region in 1864 (Denny 1992). Dryland cropping commenced in the 1880s and at the same time rabbits invaded the region. Stock numbers peaked between 1887 and 1891, coinciding with further rabbit plagues and invasion by Paterson's Curse (*Echium plantagineum*) (Denny 1992). On visiting the Riverina in 1886, the Government veterinary surgeon, Mr Stanley, commented on the decline of the more valuable indigenous grasses due to 'excessive feeding off' (Mulham 1994). He also commented on the decline of saltbush and cotton bush on the plain

> *... within a generation the plains of lower Riverina were covered with salt and cotton bush and today either of these species of feed are looked upon almost as curiosities. Without doubt they have been fed out of the ground for many miles around Deniliquin, where they once grew in luxuriance ...*
>
> (quoted in Mulham 1994).

By 1920 irrigation had commenced on the Murrumbidgee River floodplain after the construction of the Burrinjuck Dam. In 1930 a drought coincided with the century's worst economic downturn and more rabbit plagues (Denny 1992). After World War II, irrigation increased and large tracts of floodplain country were intensively cropped. The region became Australia's largest irrigated area. Myxomatosis lowered the rabbit population from the 1950s, a time when wool prices and farm profits were high. Since then there have been two major droughts in 1965–67 and 1992–95. Between the 1970s and early 1980s large areas of Bladder Saltbush (*Atriplex vesicaria*) died back on the Hay Plain (Clift et al. 1987). Large wildfires swept the Hay area in 1990 and the Jerilderie area in 1991. Irrigation, particularly for rice farming, is increasing today even in places distant from the rivers. Rising saline water tables present a major threat to agriculture in the region, particularly in irrigated areas (Barson & Barrett-Lennard 1995).

In 1995 the NSW Government brought in a regulation, State Environmental Planning Policy No. 46, to control clearing in NSW. Initially, this included controls on clearing native grasslands, but following lobbying by landholders grassland management plans were compiled by catchment management committees to replace or complement the role of SEPP 46 in native grassland management. The Western Riverina Regional Grassland Management Plan covers our survey area and it sets guidelines for managing native grasslands on private property. This plan is to be regularly reviewed to take into account more information as it comes to hand.

Previous botanical studies

The first recorded comments on the vegetation were from Sturt (1833) where he noted Boree (*Acacia pendula*) and saltbushes near Narrandera, and the open nature of Hamilton Plain near Yanco Creek.

Various aspects of the vegetation of the Riverina, including grassland, have been studied since World War II. Beadle's (1948) map of the vegetation of western New South Wales includes a *Chloris–Danthonia* (Windmill Grass–Wallaby Grass) grassland association extending from the western side of Billabong Creek near Jerilderie to Hay. He mapped the vegetation as he saw it, not how it may have been prior to European settlement. Moore (1953a, 1953b) complemented Beadle's work by describing and mapping the major plant communities eastwards from Billabong Creek on the south western plain to Gundagai on the south western slopes. He suggested that the native grasslands were 'disclimax' communities derived through clearing and grazing of a pre-European woodland that was dominated by the small tree *Acacia pendula* (Myall) and the tall shrub *Atriplex nummularia* (Old Man Saltbush). Some areas would have been predominantly saltbush, others predominantly Myall. The now dominant grasses and forbs would have originally been less common occupying inter-shrub spaces. Moore (1953a) cites supporting evidence for this view from explorers' notes (Sturt 1833), descriptions of properties in early government gazettes, and the survival of *Atriplex nummularia* in lightly grazed horse paddocks on properties such as 'Coonong' and 'Coree'. Beadle (1948) suggested that the grasslands on the eastern edge of the Hay Plain would have once been dominated by *Atriplex vesicaria* (Bladder Saltbush).

Phenological studies by Williams (1961) indicated that most plants on the Riverine Plain flower exclusively in spring (including most exotics) and a group of perennial native species flower in both spring and autumn. He suggested that many of the native perennial species that respond to summer rainfall (with the exception of the opportunistic *Chloris truncata*) have disappeared, or have been reduced in abundance due to the impacts of grazing, and that grazing has favoured plant species that can complete their life-cycle during the wetter months of the year, i.e. between May and October (Williams 1961, 1971). In studying density changes of *Danthonia caespitosa* (and a range of other species) grazed by sheep, Williams (1968, 1969) concluded that a balance had been struck between the composition of the grassland and existing grazing pressure.

Leigh & Noble (1972) presented a coarse-scale vegetation map of the original vegetation of the Riverine Plain. This map does not show the grasslands present today, but instead shows the saltbush-Myall alliance that was proposed to have originally been present. A plant species list for the Riverine Plain was prepared by Leigh & Mulham (1977) with a supplementary list by Mulham & Jones (1981). These lists do not distinguish plant species that are restricted to native grasslands on the Plain, rather they include species recorded from all plant communities in the region.

Porteners (1993) mapped the vegetation of the Hay Plain, which includes the western section of the study area and delineated a White-top Grassland community extending from near Deniliquin to near Gunbar. Maher (1996) surveyed the distribution of the endangered ground bird the Plains Wanderer (*Pedionomus torquatus*) on the Riverine Plain. Based on a limited number of sample sites, McDougall & Kirkpatrick (1994) classified the native grasslands of the Riverine Plain, listed some significant botanical sites and rare species. The native grasslands of the Victorian section of the Riverine Plain have been investigated for their ecological values by Foreman (1995).

Methods

Sampling the native grasslands

Sample sites were selected after field reconnaissance, advice from local experts and landholders, and consultation with the literature on rare species of flora (such as *Swainsona plagiotropis*) and fauna (Plains-wanderer *Pedionomus torquatus*). 1:100 000 LANDSAT TM images helped to define where grassland occurred on the Riverine Plain but it was not possible to confidently delineate different floristic types from these images, for example species-rich native grasslands from species-poor exotic grasslands. Most of the primary and secondary roads were traversed in vehicles, as were many farm roads. This assisted with the selection of sample sites and establishing the distribution of grassland species and grassland communities. The vegetation was sampled at a total of 67 sites, each site being a 10 × 20 m quadrat. Detailed locations of these sites are given in Appendix 1. Twenty-one sites were located in areas identified as Plains-wanderer habitat (Maher 1996). Sampling attempted to cover the geographical distribution of grassland on the Riverine Plain. Exotic grasslands (Benson 1996) were not sampled.

A total of 57 person days were spent in sampling the vegetation. Eighteen sites were sampled in September 1995 and 49 in October 1995. Thus, to maximise species diversity, sampling was concentrated in the peak time for flowering and prior to drying off over summer. The drought in eastern Australia did not effect the Riverina as much as northern NSW and Queensland, nevertheless rainfall was less than the average in 1995 (Bureau of Meteorology pers. comm.).

All plant species were recorded in each quadrat and assigned a cover abundance rating based on a modified Braun-Blanquet 6-point scale (Poore 1955) (<1%, 1–5%, 6–25%, 26–50%, 51–75%, 76–100%). The structure of the vegetation was described by the number, height, cover and dominant species of each layer. The soil type was noted for each site, as was an estimate of the degree and type of disturbance.

Plant species nomenclature conforms with that currently recognised by the National Herbarium of NSW and follows Harden (1990–1993).

Data analysis

All site data were entered into the floristic ecological database Advanced Revelation used at the National Herbarium of NSW. Data were investigated using multivariate techniques available in PATN (Belbin 1993) and other unpublished software (Bedward pers. comm.). The presence/absence of native species were used for analysis as this data set provided maximum information with minimum noise. Analysis of cover data was also undertaken for comparison.

A hierarchical agglomerative classification was used to describe groupings of species and sites (Belbin 1991). The Kulczynski coefficient of dissimilarity was used for its superiority in ecological applications (Belbin 1993). This coefficient describes the dissimilarity between sites based on their shared species composition; it places less emphasis than other coefficients on the absence of species. This is particularly relevant

in a rural landscape where species may be absent due to grazing or other past disturbance, rather than due to an inherent likelihood of occurrence. A hierarchical classification of sites was then derived from a clustering strategy using flexible unweighted pair group arithmetic averaging (UPGMA).

To check for misclassified sites in the resultant groups, a checking routine of nearest neighbours (Bedward, unpublished software) was used. This examines the nearest neighbours of all sites (as measured in the association matrix) and assesses whether any given site is grouped with its nearest neighbours. A misclassified site is one in a group where none of that site's nearest neighbours are present, and where none of the other sites in the group has that site as a nearest neighbour.

Once the groupings were finalised, a measure of fidelity to those groupings was generated for each species within that group (Bedward, unpublished software) to elucidate the contribution each species made in defining it. This allowed indicator species to be identified for each plant community.

Results

Floristic composition

A total of 224 species (227 taxa) were recorded during the survey from the 67 grassland sites sampled and areas immediately adjacent. Of these, 58 species (25%) are exotic. The most common families represented were Asteraceae (51 species, 21% exotic), Poaceae (41 species, 38% exotic), Fabaceae–Faboideae (17 species, 65% exotic) and Chenopodiaceae (13 species, 8% exotic).

Rare, threatened or regionally significant plant species

A number of plant species are considered to be significant because they are rare or threatened nationally (Briggs & Leigh 1996), on a state basis (New South Wales or Victoria) or within the region (Table 1). This survey, together with NSW National Herbarium records, revealed that all but one of the six nationally listed species conform with their listing.

Sclerolaena napiformis is very rare having been recorded at only three places near Jerilderie. The survey also confirmed the status of *Swainsona plagiotropis* (Fig. 5) as rare in the region and nationally vulnerable as it was only recorded twice (near 'Coonong' and Jerilderie). Most recent records of this species are from close to the Jerilderie township (Appleby et al. 1991, Chappell & Luke 1994). *Swainsona murrayana*, however, was recorded in 19 sites and commonly observed in the region. While it is threatened in Victoria (Gullan et al. 1990), it is not threatened in NSW. This species should be down-listed from vulnerable to rare or taken off the national list.

Brachycome muelleroides was recorded only once in this survey in a community restricted to swampy places, thus confirming its threat status. *Brachycome papillosa* was not recorded in this survey but has been collected recently in the Jerilderie area and elsewhere in south-western NSW. *Lepidium monoplocoides* is an endangered species that

Table 1. Significant species in the study area showing their rare or threatened status.

National conservation status codes: **3** = species has distribution of over 100 km, **E** = endangered, **V** = vulnerable, **R** = rare, **C** = present in conservation reserve, **a** = considered to be adequately conserved, **i** = considered to be inadequately conserved (Briggs & Leigh 1996). Status in Victoria (Gullan et al. 1990), New South Wales (Schedules 1 & 2 NSW Threatened Species Conservation Act 1995 and authors' opinion) and the region (authors' opinion): **e** = endangered, **v** = vulnerable, **r** = rare, **c** = common.

Species	Conservation Status				Locations
	Nat'l	Vic	NSW	Reg'l	
Amaranthaceae					
Ptilotus polystachyus		e		v	SWG 3 and adjacent SWG 28
Asteraceae					
Brachycome muelleroides	3VCa	e	v	v	SWG 43
Brachycome papillosa	3V		v	v	Sites 3 & 4 of Chappell & Luke (1994) near Jerilderie
Leptorhynchos elongatus		r	c	r	SWG 17, 18, 49
Leptorhynchos scaber			e	e	Adjacent SWG 43
Microseris lanceolata				e	Adjacent SWG 27
Pogonolepis muelleriana				r	SWG 30
Vittadinia pterochaeta		e		r	SWG 11, 56
Brassicaceae					
Lepidium monoplocoides	3ECi	e	e	e	Adjacent SWG 43
Centrolepidaceae					
Centrolepis glabra				r	SWG 43
Chenopodiaceae					
Chenopodium desertorum subsp. *virosum*			c	r	SWG 7, 48, 54, 55, 60
Sclerolaena napiformis	3E	v	e	e	South Coree Road east of SWG 24 and sites 13 and 16 of Chappell & Luke (1994)
Cyperaceae					
Isolepis congrua		v	c?	r	SWG 67
Fabaceae–Faboideae					
Swainsona murrayana	3VCi	e	v	c	SWG 4, 6, 7, 8, 12, 13, 14, 20, 24, 27, 28, 29, 30, 32, 38, 41, 45, 46, 55 & adjacent SWG 1 & 19
Swainsona plagiotropis	3VCi	e	v	v	Sites 4, 8 & 22 of Chappell & Luke (1994)
Swainsona swainsonioides		e	c?	v	Adjacent SWG 12

Species	Conservation Status				Locations
	Nat'l	Vic	NSW	Reg'l	
Orchidaceae					
Diuris dendrobioides				r	Adjacent SWG 3
Diuris lanceolata				r	Adjacent SWG 3
Poaceae					
Eulalia aurea		c	c	v	SWG 9
Themeda australis		c	c	e	SWG 3 and near SWG 9
Astrebla lappacea		c	c	r	'South Burrabogie' 30 km SE of Hay

has been eliminated by grazing throughout its range. During the survey it was recorded only once. It has also been recently recorded in the Urana Nature Reserve (E. Whiting pers. comm.).

Leptorhynchos scaber (Asteraceae) warrants listing under the NSW Threatened Species Conservation Act (Schedule 1) as an endangered species. The collection from this survey is the first from NSW. It is also restricted in Victoria (P. Foreman pers. comm.) but is not on the national list because of its abundance in Western Australia. There is, however, the possibility that the Western Australian taxon may be different as it grows in a different habitat.

Some species are significant on a regional basis even though they may be common elsewhere. The grasses *Themeda australis* and *Eulalia aurea* (Fig. 6) were recorded once during the survey and are rare in the region having been grazed out over the last 150 years. Other palatable species, such as *Microseris lanceolata, Swainsona swainsonioides* and several species of orchids have also been depleted.

Several species listed by Gullan et al. (1990) as rare in Victoria are common in the study area. These include *Sporobolus caroli, Stipa setacea, Eleocharis pallens, Maireana aphylla, Maireana excavata, Leucochrysum molle, Leptorhynchos panaetioides* and *Brachycome chrysoglossa.*

Data analysis

The resulting dendrogram from the Kulczynski association and UPGMA clustering analysis (adjusted for misclassification) is shown in Fig. 7. Six grassland communities were defined at a dissimilarity measure of 0.75. Communities 1a and 1b are closely allied and share many species. Community 5 is most distinct. Community 2 (site 3) is also distinct as it contained many woodland species not recorded in other sites. When the analysis was run using cover data, the grassy woodland at site 3 clustered with site 1 at 'Morundah' in Community 1a. These sites share a number of species including an abundance of *Lomandra effusa.*

Fig 5. Seed pods of the nationally vulnerable *Swainsona plagiotropis*. Surveys since 1991 indicate that this species is mainly restricted to the Jerilderie district. A species recovery plan has been prepared for the species. Photo: J. Benson.

Fig. 6. *Eulalia aurea* and *Themeda australis* are now rare in the region, surviving in lightly grazed areas such as SWG 9 on 'Coonong'. Photo: M. Porteners.

Plant communities

A relatively large area of native grassland remains on the Riverine Plain, albeit as a derived native grassland, compared with other temperate grassland regions in south eastern Australia (McDougall & Kirkpatrick 1994). Based on the findings of Foreman (1995), it would appear the NSW section of the Riverine Plain contains larger areas of native grassland than that remaining on the Victorian section of the Riverine Plain.

Communities 1a and 1b are the most abundant native grassland communities in the study area and tend to be more species-rich than Communities 4 or 5 (Table 2). Community 1a is centred on Jerilderie and Urana, while the closely allied Community 1b mainly occurs in the vicinity of Deniliquin. Community 2 was sampled once only and occurs on sandy rises near Urana. Community 3 mainly occurs in the eastern section of the region. Community 4 occurs in the drier north-western section of the study area and Community 5 is scattered over the study area but restricted to more

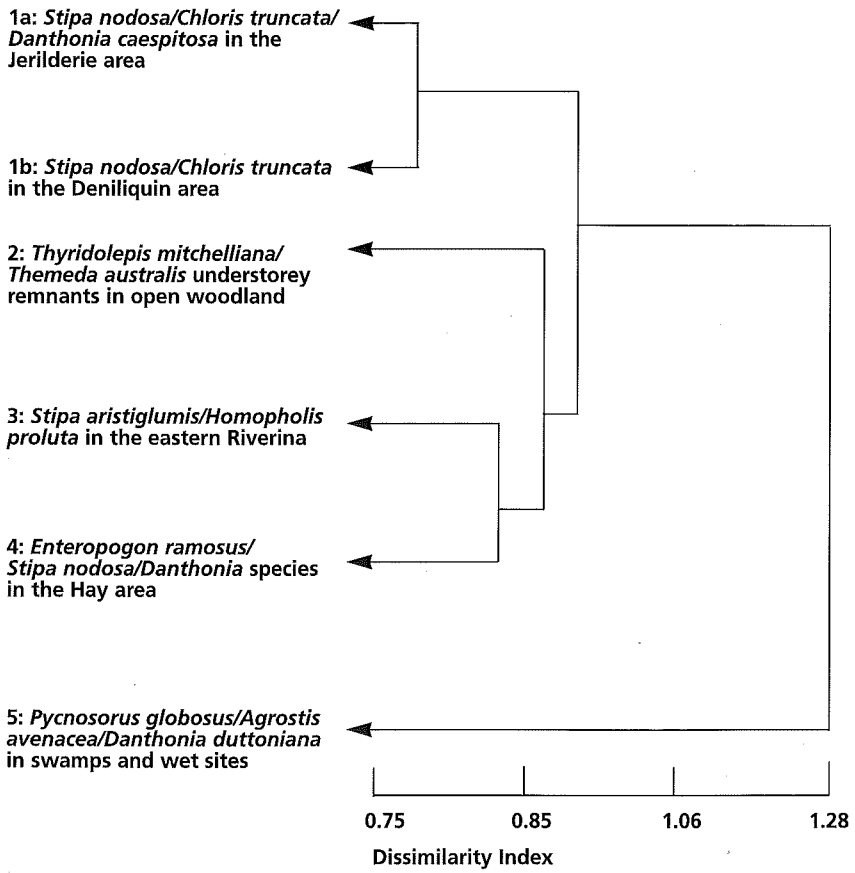

Fig. 7. Dendrogram showing five plant communities produced from Kulczynski association and UPGMA clustering.

Table 2. Grassland communities of the Riverine Plain (NSW).

Comm.	Main Grass Species	Distribution	No. Sites	Total No. Species	No. Native Species	No. Exotic Species(%)
1a	*Stipa nodosa* *Chloris truncata* *Danthonia caespitosa*	Jerilderie area	24	130	91	39 (30%)
1b	*Stipa nodosa* *Chloris truncata*	Deniliquin area	17	104	74	30 (29%)
2	*Thyridolepis mitchelliana* *Themeda australis* *Danthonia eriantha*	West of Lake Urana	1	48	41	7 (15%)
3	*Stipa aristiglumis* *Homopholis proluta*	Eastern Riverina	7	100	71	29 (29%)
4	*Enteropogon ramosus* *Stipa nodosa* *Danthonia* spp.	Hay area	15	79	57	22 (28%)
5	*Agrostis avenacea* *Danthonia duttoniana*	Scattered	3	50	37	13 (26%)

poorly drained sites. Some of the communities share a high proportion of species, others are more distinct, for example, Community 5 (see Appendix 2).

The numbers of exotic species vary within each community from site to site depending on past land use. At the time of sampling, Wimmera Ryegrass (*Lolium rigidum*) was the most common and widely distributed exotic grass. Cape Weed (*Arctotheca calendula*) was one of the most abundant exotic forbs in early spring, but had substantially died off by early summer. This highlights the importance of the timing of a survey as grassland floristic composition varies with the seasons and in response to different rainfall patterns.

Description of grassland communities

The five communities defined in the classification analysis are described below and summarised above in Table 2. The sites classified into each community are listed. Full location information of all sites is given in Appendix 1. The total and mean number of native and exotic species (+/- standard deviation) per 10 × 20 m plot is also shown.

Indicator species are those species that occurred in more than 40% of the sites in a community and were rarely or never found in another community (had a fidelity measure of more than 0.8 as calculated by fidelity analysis, Bedward unpublished software). **Dominant** grass species and other **common** species are those that occurred in more than 50% of the sites per community, and are listed in descending order of

frequency. The percent frequencies for each species within each community and overall are shown in Appendix 2.

Community 1a

***Stipa nodosa–Chloris truncata–Danthonia caespitosa* Jerilderie area** (Fig. 8) (similar to Community R1.2 in McDougall & Kirkpatrick 1994)

Landform, geology and soils: Level plains in the southern Riverine Plain, mainly on grey-brown cracking clay to red-brown, often scalded clay.

Distribution: Throughout the Jerilderie area, particularly south-west to north-east of Jerilderie.

Sample sites: 1, 2, 4, 7, 13, 14, 21, 25, 26, 27, 28, 29, 30, 31, 32, 38, 40, 42, 45, 56, 59, 60, 64, 66 (n=24)

Structure: Open to mid-dense, tussock grassland (with herbaceous ground layer).

Dominant native grass species: *Stipa nodosa, Chloris truncata, Danthonia caespitosa.*

Indicator species: *Brachycome chrysoglossa, Wahlenbergia gracilenta, Isoetopsis graminifolia.*

Other common native species: *Maireana pentagona, Triptilodiscus pygmaeus, Rhodanthe corymbiflora, Chrysocephalum apiculatum, Sida corrugata, Goodenia fascicularis, Daucus glochidiatus, Maireana excavata, Wurmbea dioica* subsp. *dioica, Hyalospermum glutinosum* subsp. *glutinosum, Ptilotus exaltatus* var. *exaltatus, Goodenia pusilliflora, Myriocephalus rhizocephalus, Calocephalus sonderi, Oxalis perennans, Crassula colorata, Asperula conferta.*

Common exotic species: *Hypochaeris glabra, Lolium rigidum, Arctotheca calendula, Medicago truncatula, Cotula bipinnata, Romulea rosea.*

Total no. native species: 91

Total no. exotic species: 39

Mean no. native species per site: 26 +/- 6

Mean no. exotic species per site: 9 +/- 3

Condition: Many of the sample sites had been moderately to heavily grazed and contain a high proportion of weeds. Several sites however, are in excellent condition, having a high native species diversity and density. Many areas once occupied by this community have been 'improved' and are dominated by exotic pasture species.

Threats and conservation status: This community is currently not represented in the conservation reserves, with large areas under freehold management. Several important sites are situated on travelling stock routes (TSRs). Increased grazing pressure, weed invasion and clearing for agriculture are the main threats. Sites 1, 13, 21, 26, 28, 29, 30, 42, 60 and 64 are known habitat for the Plains-wanderer (Maher 1996) (see Table 4).

Key sites for conservation: Site 1 in Boree paddock on the property 'Morundah', owned by the Australian Navy (Fig. 14). This paddock contained an excellent stand of

this community, rich in native species including the endangered forbs *Lepidium monoplocoides* and *Leptorhynchos scaber*. This was the first substantiated NSW record of *Leptorhynchos scaber*. The area also contains important remnants of Community 5 (site 43). Other significant sites include 4, 13, 14, and 21 that are all species-rich and most contain rare or threatened species. Site 4 contains a population of the vulnerable species *Swainsona plagiotropis*. Other *Swainsona plagiotropis* populations have been recorded in this community in the past (Chappell & Luke 1994, Appleby et al. 1991). The vulnerable plant *Swainsona murrayana* was recorded at half of the sites sampled in this grassland community (1, 4, 7, 13, 14, 27, 28, 29, 30, 32, 38, 45) indicating it is not threatened nor rare on the NSW section of the Riverine Plain.

Community 1b

***Stipa nodosa–Chloris truncata* Deniliquin area** (Fig. 9)

Sample sites: 12, 15, 16, 19, 20, 22, 24, 36, 44, 46, 48, 50, 52, 53, 54, 55, 65 (n=17).

Landform, geology and soils: Floodplains and level plains in the southern Riverine Plain, mainly on grey cracking clay to red-brown loamy clay.

Distribution: Throughout the Deniliquin area, particularly north to north-east of Deniliquin with outliers around Jerilderie.

Structure: Open to mid-dense, tussock grassland (with herbaceous ground layer).

Dominant native grass species: *Stipa nodosa, Chloris truncata.*

Indicator species: *Leucochrysum molle.*

Other common native species: *Rhodanthe corymbiflora, Daucus glochidiatus, Maireana pentagona, Sida corrugata, Calotis scabiosifolia* var. *scabiosifolia, Chrysocephalum apiculatum, Leptorhynchos panaetioides, Goodenia fascicularis, Calocephalus sonderi, Maireana excavata, Goodenia pusilliflora, Chamaesyce drummondii.*

Common exotic species: *Lolium rigidum, Medicago truncatula, Arctotheca calendula, Cotula bipinnata, Hypochaeris glabra, Avena fatua, Romulea rosea, Echium plantagineum.*

Total no. native species: 74

Total no. exotic species: 30

Mean no. native species per site: 21 +/- 3

Mean no. exotic species per site: 8 +/- 2

Condition: Many sites have been moderately grazed and contain a high proportion of weeds. Most of the areas were of average to good condition with only one site judged as being in excellent condition. Many areas once occupied by this community have been 'improved' and are dominated by introduced pasture species.

Threats and conservation status: This community is currently not conserved with large areas under freehold management and on travelling stock routes (TSRs). Increased grazing pressure, weed invasion and clearing for agriculture are the main threats. Sites 15, 16, 52 and 53 are known habitat for the Plains-wanderer (Maher 1996) (see Table 4).

Key sites for conservation: Site 24 on South Coree Road near Jerilderie is in a TSR that contains one of only three known records in NSW of the vulnerable shrub *Sclerolaena napiformis*. The paddock immediately west of Jerilderie, sampled by Appleby et al. (1991) and J. Benson in October 1991, contains one of the largest populations of *Swainsona plagiotropis* and is a nature reserve proposal.

Community 2

***Thyridolepis mitchelliana–Themeda australis* understorey remnants in open woodland** (Fig. 10)

Landform, geology and soils: Elevated plains and low rises of red to red-brown clay to clay-loam soils, in a range of woodland communities.

Distribution: Very scattered and occasional occurrences throughout the south-eastern Riverina; most notable remnant in a small triangular paddock west of Lake Urana.

Sample site: 3 (n=1)

Structure: Mid-dense tussock grass understorey in open woodland.

Dominant native grass species: *Thyridolepis mitchelliana, Themeda australis, Danthonia eriantha, Stipa eremophila, Stipa setacea, Aristida jerichoensis* var. *jerichoensis, Monochather paradoxa.*

Indicator species (exclusive to this group): *Thyridolepis mitchelliana, Themeda australis, Stackhousia monogyna, Callitris glaucophylla, Allocasuarina verticillata, Stipa eremophila, Hakea tephrosperma, Drosera glanduligera, Eremophila longifolia, Levenhookia dubia, Pimelea micrantha, Minuria leptophylla, Thysanotus patersonii, Ptilotus polystachyus* var. *polystachyus, Cynoglossum suaveolens, Prasophyllum campestre, Aristida jerichoensis* var. *jerichoensis, Monochather paradoxa, Diuris lanceolata, Diuris dendrobioides, Dianella longifolia* var. *porracea.*

Other common native species: *Chrysocephalum apiculatum, Hyalosperma semisterile, Bulbine bulbosa, Lomandra effusa, Hyalospermum glutinosum* subsp. *glutinosum, Cheilanthes sieberi* subsp. *sieberi, Wahlenbergia stricta* subsp. *alterna, Actinobole uliginosum, Wahlenbergia luteola.*

Common exotic species: *Trifolium arvense, Aira elegantissima, Erodium crinitum, Hypochaeris glabra, Avena fatua, Arctotheca calendula, Romulea minutiflora, Parentucellia latifolia.*

Total no. native species: 41

Total no. exotic species: 7

Condition: The site sampled is in excellent condition and has been fenced off from grazing for some time. The understorey is dense and contains a high proportion of native species including *Stackhousia monogyna*, uncommon grasses and three orchid species. *Themeda australis* is now vulnerable in the Riverina Plain, being recorded only once during this survey.

Threats and conservation status: *Themeda australis* is now depleted on the Riverine Plain and remains poorly conserved, with remnants under freehold management. The

Fig. 8. A species-rich grassland in Community 1a dominated by *Danthonia linkii* var. *linkii, Stipa nodosa, Swainsona murrayana, Calotis scabiosifolia* var. *scabiosifolia* and *Brachycome chrysoglossa* on a travelling stock reserve adjacent to Hynes Lane, west of Jerilderie (site SWG 14). Photo: M. Porteners.

Fig. 9. Community 1b at SWG 12, McLennons Bore Road north of Jerilderie dominated by *Rhodanthe corymbiflora, Stipa nodosa, Cotula bipinnata* and *Leucochrysum molle.* Photo: M. Porteners.

nature of the remaining populations suggest *Themeda* was more abundant before grazing pressure increased, although this species may not have ever been as abundant in this region as in other grassland and grassy woodland areas in southern Victoria and eastern NSW.

Key sites for conservation: Site 3 is a small fenced-off corner of a paddock west of Lake Urana on 'Cocketgedong Farm'. Its ground cover is in excellent condition with a dense *Thyridolepis mitchelliana, Themeda australis* and *Danthonia eriantha* sward with very few weeds and many uncommon native herb species (such as orchids). This is a significant site of high species diversity and with a history of relatively low grazing intensity. It is a reference site warranting protection, as it has not been subject to stock grazing for decades (M. Driver pers. comm.).

Community 3

***Stipa aristiglumis–Homopholis proluta* eastern Riverina** (Fig. 11)

Landform, geology and soils: Level to depressed plains and floodplains, in the eastern Riverine Plain, on grey to dark brown, self-mulching clayey soils.

Distribution: Throughout the eastern portion of the study area, north-east to south-east of Jerilderie.

Sample sites: 5, 6, 8, 9, 39, 63, 67 (n=7)

Structure: Open to dense, tall tussock grassland.

Dominant native grass species: *Stipa aristiglumis, Homopholis proluta.*

Indicator species: *Calotis anthemoides, Rumex dumosus, Arthropodium minus, Stipa aristiglumis, Asperula conferta, Leptorhynchos squamatus* subsp. A.

Other common native species: *Wurmbea dioica* subsp. *dioica, Crassula decumbens* var. *decumbens, Maireana pentagona, Goodenia fascicularis, Rhodanthe corymbiflora, Oxalis perennans, Enteropogon ramosus.*

Common exotic species: *Arctotheca calendula, Hypochaeris glabra, Lolium rigidum, Trifolium arvense, Romulea rosea, Echium plantagineum, Medicago truncatula.*

Total no. native species: 71

Total no. exotic species: 29

Mean no. native species per site: 21 +/- 7

Mean no. exotic species per site: 10 +/- 3

Condition: Most sites contain a high proportion of weeds because they are water and nutrient sinks, and have been moderately to heavily grazed. Some sites are in good condition with a high density of native grasses.

Threats and conservation status: This community is currently not conserved and most sites are under freehold management with weed invasion and increased grazing pressure the main threats. Sites 8, 9 and 63 are habitat for the threatened Plains-wanderer (Maher 1996) (see Table 4).

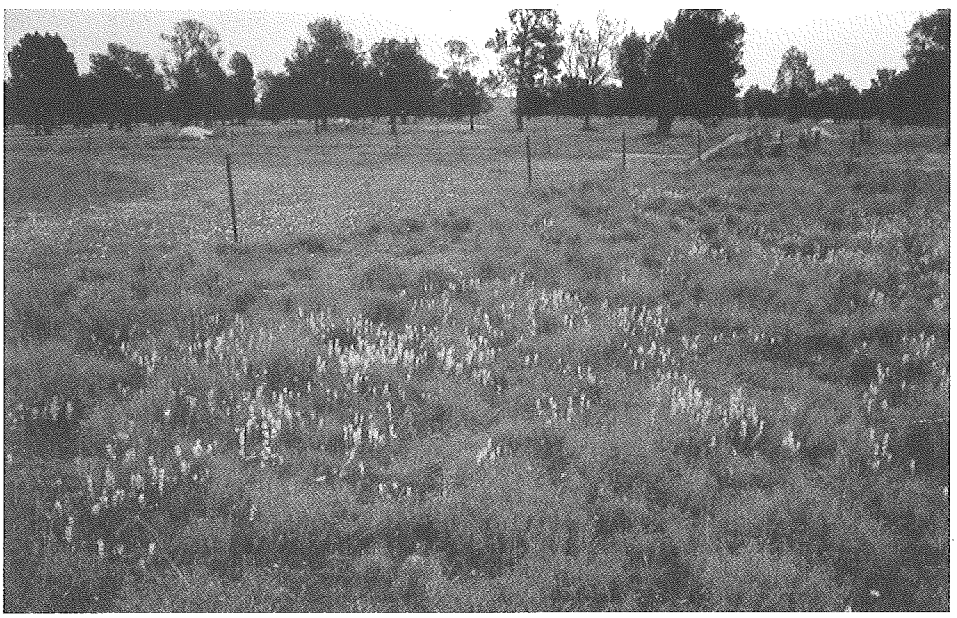

Fig. 10. *Thyridolepis mitchelliana* and *Stackhousia monogyna* dominant at SWG 3 in Community 2, near the 'Cocketgedong Farm', west of Lake Urana. This site has been fenced off for decades and contains a number of significant plant species including Kangaroo Grass, *Themeda australis*, which is now rare in the region. Photo: M. Porteners.

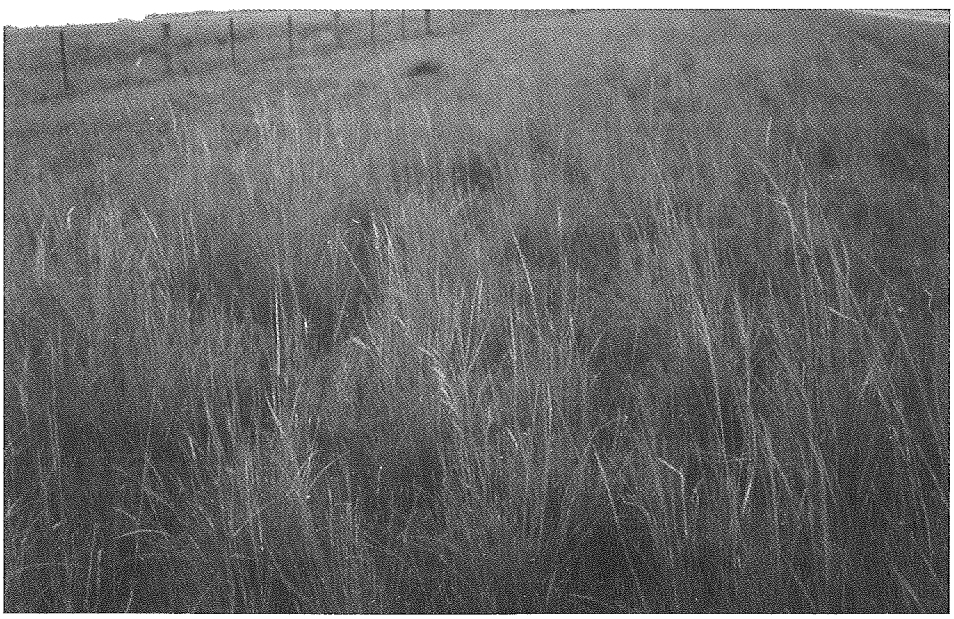

Fig. 11. SWG 39 in Community 3 is dominated by Plains Grass *Stipa aristiglumis*. This community mainly occurs in the eastern section of the region mostly on grey clays in low lying areas. Photo: J. Benson.

Key sites for conservation: Sites 6, 8, 9 and 67. Site 8 contains a population of the vulnerable pea *Swainsona plagiotropis* some distance from most of the other populations of this species.

Community 4

***Enteropogon ramosus–Stipa nodosa–Danthonia* species in the Hay area** (Fig. 12)

Landform, geology and soils: Level plains, in the western to south-western Riverine Plain, on grey cracking clay to red-brown clay.

Distribution: Throughout the western portion of the study area, near Hay and north-east of Deniliquin.

Sample sites: 10, 11, 17, 18, 33, 34, 35, 37, 47, 49, 51, 57, 58, 61, 62 (n=15)

Structure: Mid-dense to dense, tussock grassland.

Dominant native grass species: *Enteropogon ramosus, Stipa nodosa* (one or more species of *Danthonia* were always present at the site).

Indicator species: No indicator species.

Other common native species: *Rhodanthe corymbiflora, Crassula colorata* var. *acuminata, Sida corrugata, Atriplex leptocarpa.*

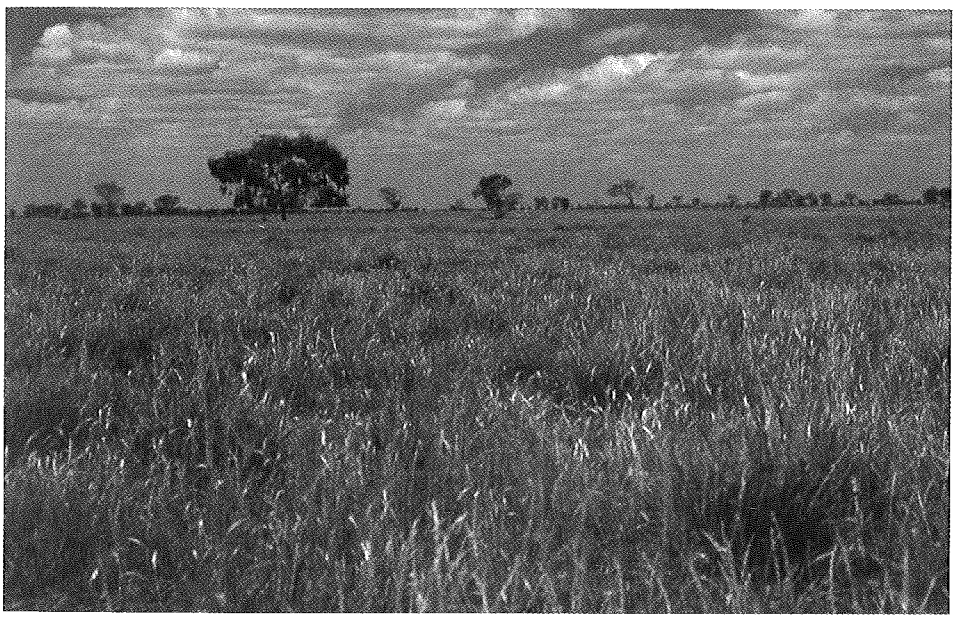

Fig. 12. SWG 37 in Community 4 on 'Cooinbil', dominated by *Stipa nodosa, Danthonia eriantha, Enteropogon ramosus* and the introduced Wimmera Ryegrass *Lolium rigidum*. This community is mainly confined to the western section of the study area. Photo: M. Porteners.

Common exotic species: *Lolium rigidum, Avena fatua, Medicago truncatula, Arctotheca calendula, Echium plantagineum, Cotula bipinnata, Erodium cicutarium.*

Total no. native species: 57

Total no. exotic species: 22

Mean no. native species per site: 15 +/- 4

Mean no. exotic species per site: 8 +/- 2

Condition: Most sites are of average to poor condition, contain a high proportion of weeds (mostly naturalised pasture grasses), and have been moderately grazed.

Threats and conservation status: This community is currently not conserved and most sites are under freehold management with weed invasion and increased grazing pressure the main threats. Site 49 is known habitat for the Plains-wanderer (Maher 1996) (see Table 5).

Key sites for conservation: Most sites sampled in this community are species poor and contain a high proportion of exotic species. Few sites can be singled out for special conservation action. Site 47 on Warwillah Road was noted as being in excellent condition and contains substantial clumps of *Danthonia linkii* var. *fulva.*

Community 5

***Pycnosorus globosus–Agrostis avenacea–Danthonia duttoniana* in swamps and wet sites** (Fig. 13) (similar to to Community R1.3 in McDougall & Kirkpatrick 1994)

Landform, geology and soils: Depressions, swamps and low-lying plains, on grey cracking clay.

Distribution: Throughout the study area.

Sample sites: 23, 41, 43 (n=3)

Structure: Mid-dense to dense, tussock grassland.

Dominant native grass species: *Agrostis avenacea, Danthonia duttoniana, Eragrostis australasica, Homopholis proluta.*

Indicator species: *Marsilea drummondii, Myriophyllum crispatum, Eragrostis australasica, Eleocharis pallens, Agrostis avenacea, Danthonia duttoniana, Pycnosorus globosus, Swainsona procumbens, Juncus radula, Ranunculus pentandrus* var. *platycarpus.*

Other Common native species: *Myriocephalus rhizocephalus, Teucrium racemosum, Crassula decumbens* var. *decumbens.*

Common exotic species: *Alopecurus geniculatus, Arctotheca calendula, Cotula bipinnata, Lolium rigidum, Juncus articulatus.*

Total no. native species: 37

Total no. exotic species: 13

Mean no. native species per site: 19 +/- 5

Mean no. exotic species per site: 6 +/- 5

Condition: Two of the sites sampled are in excellent condition and are significant wet-grassland areas containing rare and unusual species and few weeds. The other site had been burnt and grazed. Many floodplains and depressions across the Riverine Plain once containing this community have been cleared for irrigation and cropping.

Threats and conservation status: Clearing, overgrazing and pugging by stock appear to be the main threats to this community which is currently not conserved with most sites under freehold management.

Key sites for conservation: Site 43 on 'Morundah' is a significant wetland-grassland community containing the vulnerable species *Brachycome muelleroides*. Other uncommon or unusual plants recorded in this community include *Myosurus minimus* var. *australis*, *Utricularia dichotoma*, *Centrolepis glabra*, *Isolepis hookeriana*, *Isolepis victoriensis* and *Triglochin procerum*.

Fig 13. SWG 41 along the Narrandera-Urana Road in Community 5 dominated by *Pycnosorus globosus*, *Danthonia caespitosa*, *Agrostis avenacea* and *Juncus radula*. This community is confined to poorly drained, low lying areas. Photo: J. Benson.

Grassland sites of botanical significance on the Riverine Plain

Seven criteria were used to determine the significance of the sample sites (see Table 3) including presence of significant species, diversity, condition and management options. Of the 67 plots surveyed, 15 were designated as containing features warranting listing as sites of botanical significance. The presence of significant plant species was most heavily weighted in defining these. In addition to these sites, we consider that all of the previous recorded locations of *Swainsona plagiotropis* should also rank as sites of significance.

Sampling covered only a small proportion of the landscape and did not cover every farm or every paddock (although most of the roads were traversed and previous information on the grasslands was used to refine the sampling). It is likely that other important sites exist. The significant sites listed in Table 3 should, therefore, be considered only as a starting point in regional assessments of grassland sites of significance.

The most widespread Communities 1a and 1b, centred on Jerilderie, Urana and Deniliquin, account for the majority of the sites listed. These communities are species rich and contain most of the ROTAP and other significant plant species recorded during the survey or by previous studies. Site 3 in Community 2 is floristically distinct, containing many species that were not recorded elsewhere. This is because it has been fenced off from stock for several decades and it is situated on a sandy rise unlike other sites. Community 4 was found to contain fewer significant species and a lower species richness than Communities 1a and 1b. It also had a relatively high number and cover of exotic species, with Wild Oats (*Avena fatua*) and Wimmera Ryegrass (*Lolium rigidum*) dominant in places.

Some properties are important for the protection of significant sites. They include parts of the properties 'Coonong' and 'Cocketgedong', and a section of 'Morundah' now owned by the Australian Navy (Figure 14), which appear not to have been over-grazed or over-improved in the past. Similarly, 'Invermay' near Urana and 'Boonoke' near Conargo have been lightly grazed. 'Invermay' contained unusually tall and dense Plains Grass (*Stipa aristiglumis*). 'Boonoke' had extensive stands of Community 1b and regular records of Plains-wanderers. However, these areas are not nominated as special as no significant plant species were found.

Relationship of native grassland with Plains-wanderer sites

The Plains-wanderer is the monotypic representative of the Pedionomidae and is endemic to Australia. It is a cryptic, ground-dwelling bird that, despite its common name, is sedentary if the habitat remains suitable (Marchant & Higgins 1993). The biology, conservation and management of the endangered Plains-wanderer have recently been addressed by Baker-Gabb (1987, 1988, 1990), Baker-Gabb et al. (1990), Harrington et al. (1988) and Maher (1996).

Table 3. Grassland sites of botanical significance in the southern Riverina.

Tenure: **P** = private land, **TSR** = travelling stock reserve/route. Justification: **T1** = contains rare or threatened plant species; **T2** = contains rare or threatened animal species; **U** = contains uncommon or regionally rare taxa; **C** = is in relatively good/excellent condition (low ratio of weeds: natives, lack of major disturbance); **M** = is well fenced or easy to manage in other ways; **D** = contains a high diversity of native plant species; **E** = outstanding example of a plant community. Recommended Management: **LG** = light intermittent grazing based on past land use; **F** = fencing of site as protection from grazing; **W** = weed control of major concern; **R** = monitoring/research of populations of rare species. Note: *Swainsona murrayana* was not considered a T1 species because it was found to be common in the region. Only a proportion of the Plains–wanderer sites delineated by Maher (1996) are listed, being those recorded in good condition or containing significant plant species.

Site	Comm.	Location (tenure)	Justification	Recommended Management
SWG 1	1a	'Morundah' (Navy)	T1,T2,U,C,M,D,E	F,R
SWG 4	1a	Urana–Jerilderie Rd (TSR)	T1	LG,R
SWG 13	1a	Bundure Rd (Airstrip)	T2,C,D,M	LG,R
SWG 14	1a	Hynes Lane (TSR)	T1,C,D	LG,R
SWG 21	1a	'Cocketgedong' (P)	T2,C,D	LG,R
SWG 28	1a	'Coonong' (P)	T2,U,D	LG
SWG 24 (adj.)	1b	Hynes Lane (TSR)	T1,E	LG,R
Council block west of Jerilderie	1b	Pn 3, Ph Jerilderie Co Urana (Jerilderie Shire Council)	T1, U,C,M,D,E	LG,R
All *Swainsona plagiotropis* sites	Probably 1a and 1b	Jerilderie area (see Chappell & Luke '94 and Appleby et al. '91)	T1	LG,R
SWG 3	2	'Cocketgedong' (P)	U,M,D,E	F,R
SWG 6	3	Bullenbong Plain (Road Reserve)	U,E	LG,W
SWG 8	3	'Coonong' (P)	T1,T2,U,D	LG,W,R
SWG 9	3	'Coonong' (P)	T2,C,U,E	LG
SWG 67	3	Bullenbong Plain (Road Reserve)	U,E	W,LG
SWG 47	4	Warwillah Rd (P)	C,E	LG,W
SWG 43	5	'Morundah' (Navy)	T1,U,C,D,E	F,R
SWG 41	5	Narrandera–Urana Rd (Road Reserve)	T1,U,C,D,E	F,R

Historically, the Plains-wanderer was formerly widespread and common across the Darling Downs, the slopes and tablelands of NSW (including around Sydney), South Gippsland and west across Victoria to the Adelaide Plains (Marchant & Higgins 1993).

Its distribution has contracted markedly and its abundance declined as agriculture has intensified (Baker–Gabb et al. 1990). In NSW, it is now found regularly only in the Riverina, and Willandra National Park (north-east of Hillston) is the only reserve known to contain the species (Baker–Gabb 1990).

Baker-Gabb (1990) defined suitable habitat for Plains-wanderers as sparse native grassland on soils that do not support dense pasture growth under any seasonal conditions. Specifically, he characterised the grassland as having:

- about 50% bare ground, with no more than 10% leaf litter;
- two layers of vegetation with most (94%) in the lower layer;
- the lower layer less than 5 cm in height;
- the upper layer rarely exceeding 5 cm in height with tussocks spaced between 10–20 cm.

It is assumed that this structure allows for easy foraging and offers adequate concealment from predators.

Twenty one of the 67 sample sites coincided with areas identified by Maher (1996) as Plains-wanderer habitat. Table 4 lists these sites, the type of Plains-wanderer habitat as

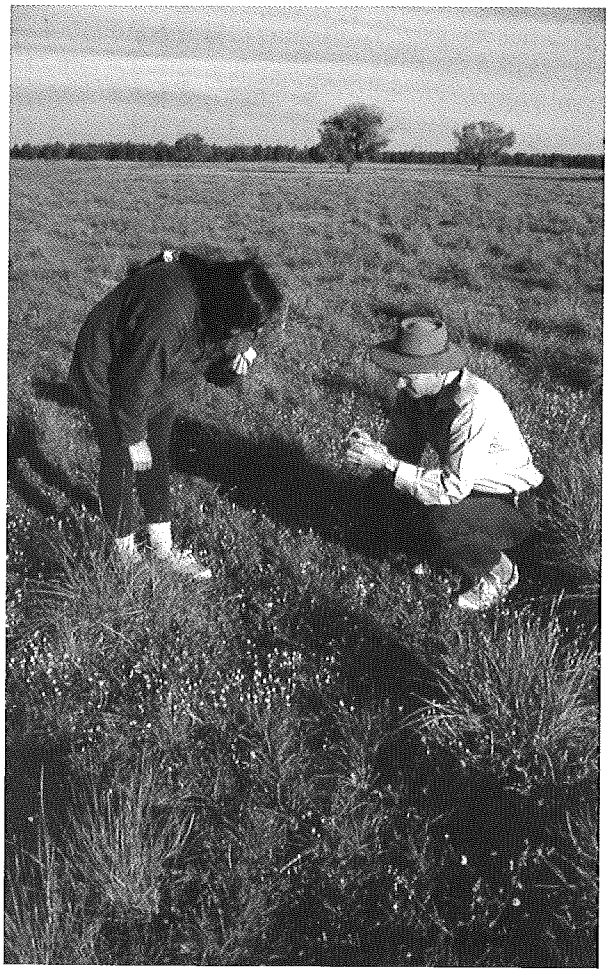

Fig 14. SWG 1 in Community 1a on 'Morundah' with *Lomandra effusa* and *Leptorhynchos squamatus* subsp. A in the foreground with scattered *Acacia pendula* in the background. Photo: M. Porteners.

Table 4. Structure and vegetation community of Plains-wanderer sites.

Site	Plains-wanderer habitat type (from Maher 1996)	Layer	Structure October 1995 Hgt (m)	% Cover	Comm
SWG 1	suitable Mar/Apr 1995	tussock	0.3	25	1a
		herb/grass	0.1	60	
SWG 8	suitable Mar/Apr 1995	tussock	0.3	35	3
		herb/grass	0.1	60	
SWG 9	suitable Mar/Apr 1995	tussock	0.5	40	3
		herb/grass	0.1	40	
SWG 10	marginal Mar 1995	tussock	0.4	35	4
		herb/grass	0.1	60	
SWG 13	suitable Mar 1995	herb/grass	0.2	90	1a
SWG 15	P-w recorded 1982–1995	herb/grass	0.2	70	1b
SWG 16	suitable Dec 1993	herb/grass	0.3	70	1b
SWG 21	suitable Oct 1995, o/grazed Mar/Apr 1995	herb/grass	0.2	60	1a
SWG 25	suitable Mar 1995	tussock	0.3	50	1a
		herb/grass	0.2	25	
		herb/grass	0.1	10	
SWG 26	suitable Mar 1995	tussock	0.3	40	1a
		herb/grass	0.25	30	
		herb/grass	0.1	15	
SWG 28	suitable Mar/Apr 1995	tussock	0.5	10	1a
		herb/grass	0.1	60	
SWG 29	suitable Mar/Apr 1995	shrub	0.3	15	1a
		herb/grass	0.1	50	
SWG 30	suitable Mar/Apr 1995	herb/grass	0.2	70	1a
SWG 42	suitable Mar/Apr 1995	tussock	0.5	30	1a
		herb/grass	0.1	40	
SWG 49	P-w recorded 1982–1995	tussock	0.4	40	4
		herb/grass	0.1	40	
SWG 52	P-w recorded 1982–1995	tussock	0.3	50	1b
		herb/grass	0.1	20	
SWG 53	P-w recorded 1982–1995	tussock	0.3	50	1b
		herb/grass	0.1	30	
SWG 59	marginal Apr 1995	tussock	0.3	60	1a
		herb/grass	0.1	30	
SWG 60	marginal Dec 1993	tussock	0.3	35	1a
		herb/grass	0.1	20	
SWG 63	o/grazed Mar/Apr 1995	tussock	0.3	50	3
		herb/grass	0.1	30	
SWG 64	suitable Mar/Apr 1995	tussock	0.3	30	1a
		herb/grass	0.1	20	

defined by Maher (1996), and their structure and vegetation community as defined in this study.

Discussion

The analysis of the site data suggests there are four main types of native grassland in the region: Communities 1a and 1b combined cover most of the southern and eastern areas; Community 3 occupies lower lying sites in eastern areas with higher nutrient soils; Community 4 is restricted to the western part of the region on grey cracking soils; and Community 5 occurs in poorly drained sites or 'swamps'. Community 2 should be considered as a regrowth woodland with a native grassland ground cover. It is possible that other sites (such as site 1 at 'Morundah') contained woodland patches as remnant *Callitris* trees are present nearby.

The main environmental determinants of species and grassland community distribution are soil type, rainfall and hydrology. All grasslands occur on clay soils but these differ in the texture and nutrients across the landscape depending on their depositional origin, distance from river channels and erosional status. Scalding was commonly observed in Communities 1a and 1b.

Compared to other temperate grassland regions of Australia (McDougall & Kirkpatrick 1994), the derived native grasslands of the Riverine Plain are extensive. Significant plant species and species-rich grasslands survive in restricted patches that are less disturbed—the best native grassland sites were found in areas that had not been ploughed. Additionally, the occurrence of rare species such as *Swainsona plagiotropis*, *Sclerolaena napiformis* and *Brachycome papillosa* mainly on travelling stock routes and road reserves suggests that these areas have not been continuously heavily grazed or cultivated. Continuous grazing adversely effects some flora. Moore (1953a) recorded the Native Yam, *Microseris lanceolata*, in 24% of his sites, but it was recorded only once during our survey. Upright forbs such as this are more susceptible to stock grazing compared to flat-rosette species (McIntyre et al. 1993). *Microseris lanceolata* would appear now to be threatened in the region.

The survey also revealed that some species previously regarded as rare are not so. *Swainsona murrayana* is listed nationally as a threatened species, yet it occurred in one third of the sites sampled. It is not a rare species in the region but may be rare in other parts of its range. Similarly, the yellow daisy *Brachycome chrysoglossa* was located in half of the Community 1a sites and so is relatively common, but it is considered to be vulnerable in Victoria. Alternatively, the single recording of the first confirmed specimen in NSW of *Leptorhynchos scaber*, along with the nationally endangered *Lepidium monoplocoides* on the 'Morundah' site confirms their threatened ranking in the region.

For some species rarity cannot be adequately assessed from one survey as they are ephemeral or respond differently to rainfall patterns or disturbances such as fire. 1991 was a bumper year for *Swainsona plagiotropis* relative to recent years. This may have

been a response to the high rainfall of 1991 as well as to the fire that swept through Jerilderie at that time.

Seasonal or annual changes in the vegetation

The relative abundance of species and the structure of a patch of grasslands differs from year to year depending on the timing and level of rainfall, temperatures and degree of grazing by stock. This is illustrated by Figs 15 and 16 showing the Council-owned paddock on the western fringe of Jerilderie in October 1995 and October 1991. In October 1995 the site was dominated by Cape Weed (*Arctotheca calendula*), without a tall cover of grassland. The paddock had been heavily stocked and may also have been recovering from drought. The same site in October 1991, before the onset of the drought and during a spring of high rainfall, contained tall *Danthonia* grasses and little Cape Weed. On both occasions, however, inspection revealed that the species composition was similar, including the presence of the vulnerable *Swainsona plagiotropis*. What had changed was the degree of dominance of certain species and the growth stage (structure) of the grassland. This example highlights the danger of judging the condition of a grassland on one visit only.

In their report on the locations of *Swainsona plagiotropis* Chappell & Luke (1994) noted the species from 22 locations, many of which adjoin each other. We sampled three of these locations at SWG 7, 22, and 38 but failed to record this species. This illustrates the ephemeral nature of some species in the region and reveals that longer term monitoring is required to establish an understanding of the flora.

Plains-wanderer habitat

The fact that Plains-wanderers have always been found in the Riverina raises a question about habitat requirements and the pre-European vegetation structure. Baker-Gabb's evidence (1990) shows that the birds have very specific and narrow habitat requirements and, in particular, are intolerant of upper canopy and dense grassland. However, Moore (1953a and 1953b) and others indicate that prior to European settlement, the Riverina was principally a shrubland community of *Acacia pendula* and *Atriplex* species. For these facts to remain consistent, the original shrubland vegetation must have been patchy, with the birds occupying the open areas of sparse grassland in between. The sparse grassland was probably restricted to soils that were scalded by wind erosion—much as it is today.

Although 70% of the Plains-wanderer sites measured in this survey were in Community 1, this would be expected as that community is the dominant one in the area: 61% of all vegetation sample sites were in Community 1. Also, 63% of vegetation sites of Community 1 had no related Plains-wanderer records. Consequently, the vegetation community type or floristic composition are not necessarily good predictors of Plains-wanderer habitat. If grassland structure is the key determinant of Plains-wanderer habitat, it changes rapidly over time and single measurments will not reveal the suitability of a site for the bird.

Fig. 15. Paddock on the western side of Jerilderie owned by Jerilderie Shire Council photographed in October 1995. Cape Weed *(Arctotheca calendula)* was abundant and the native grasses were very short. Photo: M. Porteners.

Fig 16. The same Council-owned paddock shown in Figure 15 but in October 1991. Cape Weed is not abundant and tall native grasses dominate the grassland. Photo: J. Benson

Threats to and management of native grasslands

The greatest threat to the native grasslands on the Riverine Plain is further extension of cultivation for either pasture improvement or crops. With the expansion of markets in Asia for Australian rice, there is a demand for increased production of this crop. Rice farming is intensive agriculture requiring major earthworks to build paddy fields (Fig. 17), applications of fertiliser and pesticides, and the use of large quantities of water. It is extending beyond the floodplains of the major rivers to areas relying on bore water for irrigation. It is possible that its expansion could conflict with grassland conservation. Site inspection to ascertain the importance of an area should be mandatory before any rice paddies are constructed in native grasslands in the region.

Ploughing of paddocks for any reason (including the sowing of exotic pastures) may threaten important sites for native grassland protection. Most properties have some areas of improved pasture. A balance needs to be struck between the maintenance of native grasslands and exotic grasslands. Ploughing provides an environment suitable for the invasion of exotic weeds. Even in the 'best' native grasslands, exotic species made up a significant proportion of the flora.

There is increased salinisation in the Riverina due to a rising saline water table caused by increased irrigation and the clearing of deep-rooted perennial vegetation (Macumber 1990). This problem, and its economic impacts on the Murray-Darling Basin as a whole, is discussed by Crabb (1988). Its impact on the various ecosystems on the Riverine Plain is likely to increase in the future. This may be a major long term threat to all vegetation including native grasslands. Since many of the native grasses

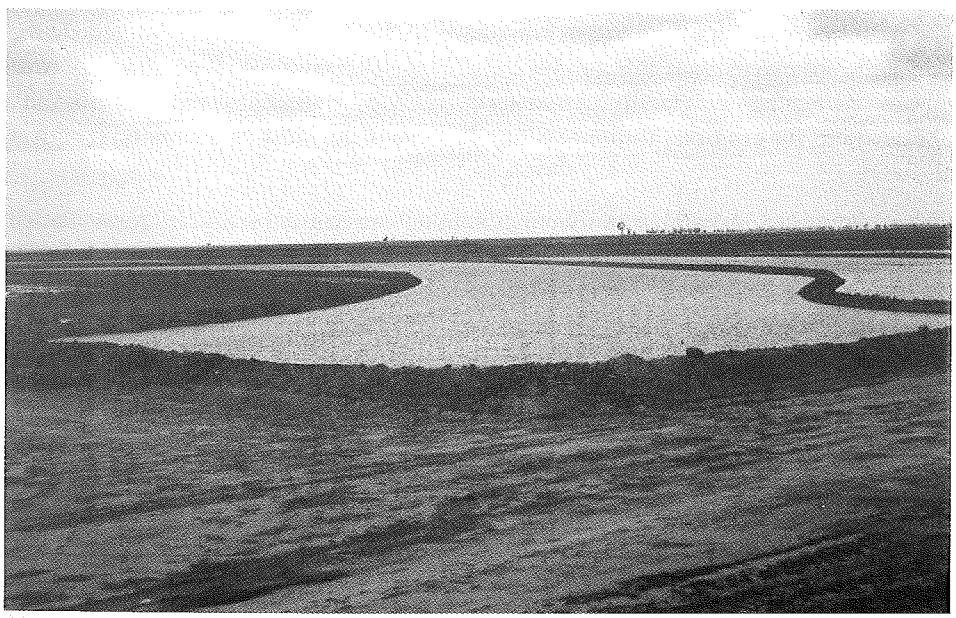

Fig. 17. One of the major threats to native grasslands on the Riverine plain is the construction of additional rice paddy fields where the grassland is completely destroyed. Photo: John Benson

are biannual or short-lived perennial (Leigh & Mulham 1966) and deep-rooted, their maintenance may help minimise future salinisation.

Over-grazing remains a threat to native grasslands. Continuous and often heavy grazing by stock over the last 150 years has markedly reduced the cover of chenopod shrubs, palatable native perennial grasses and native annual forbs in favour of exotic annual species (Cheal 1993). Some plant species have only survived in areas that have been lightly or not continuously grazed. Stock grazing should be excluded from areas where it has been absent in the past (Lunt 1991). Such areas are rare on the Riverine Plain but may include fenced-off roadsides or paddocks such as site SWG 3. Certain regimes of grazing may benefit some native grasslands and retain a diverse range of native species. Inter-tussock forbs, in particular, may be out-competed by vigorous grass growth (Tremont 1994) if biomass is not reduced. This can be achieved through either light grazing or infrequent burning. Large properties such as 'Coonong', 'Boonoke' and 'Cocketgedong' are generally not over-stocking their native grasslands. Diez & Foreman (1996) recommend that past grazing regimes should continue, or be lowered in intensity, at sites which contain valuable native grassland. They also suggest that stock should be removed, or their numbers lowered, in important sites between August and November, when most native species of grass and forbs flower and set seed. Heavy grazing in the flowering and fruiting season may influence the soil seed bank and hence future abundance of some native species. Examples where this could apply are where the threatened plants *Swainsona plagiotropis* and *Brachycome papillosa* survive on travelling stock reserves and adjoining paddocks around Jerilderie. These areas have been grazed, but in a way that has not eliminated these species—probably intermittently. Important sites should not be grazed during wet periods where pugging by stock can severely disturb the soil.

The rabbit population in the native grasslands of the Riverine Plain is limited by the prevalence of clayey soils that inhibit burrowing. This contrasts with the impact of rabbits on vegetation on loamy and sandy ridges such as on 'Zara' and 'Oolanbeyan', or elsewhere, for example, Yathong Nature Reserve to the north of the region (Leigh et al. 1989).

Fire is known to be important in maintaining species diversity in some native grassland types such as those dominated by *Themeda australis* (Stuwe & Parsons 1977). On the Riverine Plain fire is infrequent compared to eastern regions and its impacts are largely unstudied. Nevertheless, some plant species may benefit from burning due to its impact on biomass and its role in stimulating some seeds to germinate. The intensity and frequency of fire cannot be recommended without research and it is likely to be different for particular communities or species.

The indiscriminate use of herbicides kills native grasses and forbs, although selective use can be important for controlling exotic weeds. Application of fertilisers mainly favours exotic annual species over most of the native grassland species (Lunt 1991). Another occasional threat to native grasslands is the inappropriate planting of trees in landscapes where they did not originally grow. This is often done by well-meaning community groups or local government. On the Riverine Plain it would be quite appropriate to grow Myall (*Acacia pendula*) on the cracking clays where it was once

common, but not appropriate to plant other tree species that never occurred in this habitat.

Several sites on the edge of Jerilderie are threatened by expansion of the town. Planning for the town's growth should take into account the presence of these sites. The significant grassland owned by the Australian Navy at 'Morundah' (SWG 1) could be adversely affected by the postion of a communications tower and associated frequent burning, mowing and road construction. Impacts would be minimised if the tower was placed distant from the paddock containing the significant grassland.

Conservation of native grasslands

Sites of botanical significance are summarised in Table 3 and detailed descriptions of these sites are given in Benson et al. (1996). Most of the native grassland in the region is being managed for extensive grazing. In some cases this can be compatible with native grassland conservation. Conflict arises where native grasslands are ploughed, over-fertilised or over-grazed.

The Western Riverina Grassland Management Plan should be reviewed regularly to take new information into account. This Plan should stipulate clearly how native grassland will be protected and managed in the region. Given that the majority of the region is used for grazing domestic stock, minimal stocking rates should be encouraged (Diez & Foreman 1996).

Many of the more important sites containing threatened plant species are on public lands—road reserves and travelling stock reserves. There is an opportunity for the managers of such sites to enter into conservation agreements under the NSW National Parks and Wildlife Act to formalise sympathetic management of their native grasslands. Several areas warrant nature reserve status so that these ecosystems are sampled in the State's reserve system. These TSRs and/or nature reserves would be suitable places for long term research on species and native grassland management.

Future research

This survey provided a basis of understanding the different types of native grasslands and their species composition on the Riverine Plain. It may be beneficial for managing the different native grasslands communities if they could be mapped. Some could be more easily mapped than others. Community 4 is restricted to the western section of the study area; Community 3 is restricted to the centre and eastern parts; Community 5 is restricted to swamps. The greatest difficulty in a native grassland mapping exercise would be to distinguish between Communities 1a, 1b, 3 and exotic pastures, as these are widespread and overlap in their distribution. Mapping the native grassland communities would best be achieved through intensive field work, working from property to property at a reasonably fine scale of resolution. It would be beneficial for such a project to be conducted in spring after good rainfall, as this may lead to the discovery of additional species and sites of botanical significance, thereby assisting the development of plans for grassland conservation. In contrast, summer fieldwork can target native perennial grasses with less abundance of annual species.

Long term monitoring of species changes in relation to climatic and disturbance factors at some key sites such as 'Morundah', the Council-owned paddock at Jerilderie, the travelling stock reserves and on 'Coonong' would assist in managing these sites. Demographic studies of threatened species, such as that outlined in Foreman (1994) for *Swainsona plagiotropis* would underpin the management of key species.

Our results reveal that further work on linking botanical data to Plains-wanderer habitat is required, particularly in relation to the structure of the grassland and grazing management. The absence of Plains-wanderers at one point of time does not necessarily mean they will not be present in the future because the structure of grasslands changes, with the seasons, grazing intensity and other disturbances. Also, since little is known of the reptiles, mammals and invertebrates that live in the native grasslands of the region, surveys of these would help refine conservation priorities.

A native grassland conservation program will only succeed with the involvement of the local community. This has already commenced as a consequence of the compilation of the Western Riverina Grassland Management Plan by the Murrumbidgee Catchment Management Committee, but more needs to be done. A primary objective should be the development of a detailed regional native grassland management plan linked to property management plans, both of which should be based on sound biological survey, research results and community knowledge.

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Appendix 1: Detailed locations of 67 sampling sites in the study area, showing AMG grid references and 1:100 000 map sheets. The map sheets are Buraja 8126 (Bur), Coleambally 8028 (Col), Conargo 7927 (Con), Gunbar 7929 (Gun), Hay 7828 (Hay), Jerilderie 8027 (Jer), Lockhart 8227 (Loc), Moggumbill 7928 (Mog), Urana 8127 (Ura), Wanganella 7827 (Wan), and Yanco 8128 (Yan). Sites in known Plains-wanderer habitat (Maher 1996) are marked with an asterisk.

Site	East	North	Map	Location Description
*SWG 1	446100	6122900	Ura	'Morundah'
SWG 2	408300	6095800	Jer	Urana Rd, 3.6 km E Colombo Ck Bridge
SWG 3	421800	6093300	Ura	1km W Lake Urana, Pn 29, Ph 'Cocketgedong'
SWG 4	414500	6095100	Ura	9.4 km E Colombo Ck Bridge, W Urana
SWG 5	451600	6091100	Ura	'Invermay'
SWG 6	429800	6056200	Bur	7 km W Daysdale
SWG 7	386300	6085600	Jer	1 km E Jerilderie, on Oaklands Rd
*SWG 8	429000	6106300	Ura	5 km NW along Coonong Siding from Morundah Rd
*SWG 9	415000	6108900	Ura	'Coonong'
*SWG 10	364000	6111300	Jer	Moonbria Lane, 6.5 km W Wilson Rd, opposite 'Eastpark
SWG 11	369500	6122600	Jer	Mabins Well Rd, 0.7 km from Mabins Corner Tank
SWG 12	369500	6122600	Jer	McLennons Bore Rd, 7.1 km from Jerrys Lane
*SWG 13	402400	6114200	Jer	Airstrip on Bundure Rd
SWG 14	376700	6088200	Jer	Hynes Lane, 9 km W Jerilderie
*SWG 15	340600	6104500	Con	Black Sandhill Paddock on 'Boonoke', 2.3 km NW ruins
*SWG 16	357600	6155500	Mog	1.2 km E along 'Cooinbil' access road
SWG 17	360400	6206300	Gun	Carrathool Rd, 23.5 km S Tabbita Lane
SWG 18	343500	6193200	Gun	'Uardry' outstation road, 8.0 km N Carrathool-Hay Rd
SWG 19	413700	6094500	Ura	1 km NE 'Cocketgedong' between homestead and Urana Rd
SWG 20	419000	6093800	Ura	Urana-Jerilderie Rd, 4 km W Lake Urana
*SWG 21	410500	6099600	Ura	'Cocketgedong', 2 km S Colombo Ck
SWG 22	383300	6085300	Jer	Near Jerilderie airstrip, E Newell Hwy
SWG 23	380200	6077900	Jer	Newell Highway, 8 km SW Jerilderie
SWG 24	376700	6084900	Jer	Intersection Hynes Lane and South Coree Rd
*SWG 25	387400	6091300	Jer	1 km SE 'Willawa' woolshed
*SWG 26	385900	6091800	Jer	2 km S 'Willawa' woolshed
SWG 27	399300	6094200	Jer	1 km W 'North Yathong'
*SWG 28	413100	6108200	Ura	'Coonong'
*SWG 29	427200	6104700	Ura	'Coonong', 2 km SW Coonong Rd
*SWG 30	429100	6107400	Ura	'Coonong', Pn 70
SWG 31	444300	6089500	Ura	Between Urangeline Ck and Lockhart-Urana Rd

SWG 32	411900	6088400	Ura	On S side Nowranie Ck, near Nowranie
SWG 33	369800	6104500	Jer	'Wononga', Pn 106 on Crockett's Lane
SWG 34	370000	6110000	Jer	Moonbria Rd, 800 m from Wilson Rd
SWG 35	379500	6114600	Jer	Jerry's Lane, 9.8 km from Coleambally Rd
SWG 36	367000	6149900	Col	2 km SE 'Cooinbil' homestead
SWG 37	371900	6145300	Col	0.5 km NW 'Cooinbil' woolshed on homestead road
SWG 38	305900	6089900	Jer	0.5 km W Innes Bridge on Elliott Lane
SWG 39	421400	6111300	Ura	Coonong Siding Road, 5 km SE from Newell Highway
SWG 40	433500	6107200	Ura	Narrandera-Urana Rd, 3.6 km N Coonong Siding Road
SWG 41	437800	6123600	Ura	7 km N along Narrandera-Urana Rd
*SWG 42	445200	6125300	Ura	'Morundah', Pn 58
SWG 43	446000	6122500	Ura	Swamp on 'Morundah'
SWG 44	344800	6088600	Con	Conargo-Jerilderie Rd, 10 km E Conargo
SWG 45	355900	6085400	Con	Intersection Coree Rd and Conargo-Jerilderie Rd
SWG 46	353900	6088400	Con	'Heartwood', Pn 37, 1 km NW homestead
SWG 47	307400	6120500	Wan	Warwillah Rd
SWG 48	307100	6080800	Wan	Near Boree Ck escape channel, 2 km N 'Pretty Pine'
*SWG 49	329300	6104600	Con	Willurah Rd on 'Boonoke', 8 km N Conargo
SWG 50	327900	6115600	Con	Willurah Rd, 5.7 km N Delta Ck
SWG 51	330000	6138500	Mog	1 km W Conargo-Burrabogie Rd, 2 km N Coleambally Ck
*SWG 52	343300	6109500	Con	'Boonoke', 5.5 km S Edgar State Forest
*SWG 53	337400	6105300	Con	'Boonoke', Pn 63, Charlies Paddock
SWG 54	313500	6070800	Wan	Cobb Highway, 4.6 km NW Deniliquin
SWG 55	296300	6083600	Wan	Moulamein Rd, 13 km NW 'Pretty Pine'
SWG 56	288900	6112100	Wan	14 km W along Wanganella-Moulamein Rd on'Windrington'
SWG 57	301300	6170300	Hay	Jerilderie Rd, 0.6 km W Cobb Highway, 9 km S Hay
SWG 58	314400	6163300	Hay	Intersection Glencoe Rd and Jerilderie Rd
*SWG 59	359400	6109800	Con	Moonbria Rd, 3 km S 'Moonbria' homestead
*SWG 60	355500	6142400	Mog	Carrathool Rd, at Four Corners Tank
SWG 61	358100	6167500	Mog	Gum Ck on Gum Ck Rd
SWG 62	333100	6168000	Mog	Burrabogie Lane, 12 km S Sturt Highway
*SWG 63	412300	6117500	Ura	1 km N Yellow Clay Ck
*SWG 64	419100	6123800	Ura	1 km W Muddy Ck
SWG 65	418900	6139700	Yan	Yamba Rd, 0.5 km N Morundah Rd
SWG 66	456500	6112700	Loc	John's Rd, 2 km west of Oaklands-The Rock railway
SWG 67	499800	6112800	Loc	Bullenbong Plain, eastern edge

Appendix 2. Plant species list, their percent occurrence in sites per community and overall. Species recorded from outside the sample plots are indicated by X; species recorded by Chappell and Luke (1994) are marked 'A'. Nationally rare or threatened species are marked 'ROTAP'; rare or threatened taxa in Victoria 'Vic'; extension of known range within NSW 'Ext'; new record for NSW 'New'. Introduced species are marked with an asterisk.

	% Occurrence in Community (number of sites)						
Botanical Name	**1a (24)**	**1b (17)**	**2 (1)**	**3 (7)**	**4 (15)**	**5 (3)**	**Overall (67)**
Amaranthaceae							
Alternanthera denticulata	21	6		14		67	12
Ptilotus exaltatus var. *exaltatus*	67	24	100	43			36
Ptilotus polystachyus var. *polystachyus* Vic	X		100				1
Ptilotus spathulatus	13	6		14			7
Amaryllidaceae							
Calostemma purpureum	8		X		7	33	6
Anthericaceae							
Arthropodium minus	13			43			9
Dichopogon fimbriatus	8	12	100	29			10
Thysanotus patersonii			100				1
Apiaceae							
Daucus glochidiatus form G	79	88	100		27		58
Eryngium plantagineum	4	X		29			4
Eryngium rostratum	17	6		14			9
Asphodeliaceae							
Bulbine bulbosa	42	6	100	43			22
Bulbine semibarbata		12			33	33	12
Asteraceae							
Actinobole uliginosum	4		100				3
**Arctotheca calendula*	75	71	100	86	73	67	75
Brachycome basaltica var. *gracilis*	X						
Brachycome chrysoglossa Vic,New	46						16
Brachycome lineariloba	4	6					3
Brachycome muelleroides ROTAP, Vic						33	1
Brachycome papillosa ROTAP, A							
Brachycome species B					7		1
Calocephalus citreus	13	6		29			9
Calocephalus sonderi	58	59		14	33		45

Calotis anthemoides	4			43			6
Calotis cuneata var. *cuneata*	4						1
Calotis hispidula	17		100		7		9
Calotis scabiosifolia var. *scabiosifolia*	46	82		43	33	33	51
**Carthamus lanatus*	8						3
Chrysocephalum apiculatum	92	76	100	43			58
**Cirsium vulgare*	13	6		14	13		10
**Cotula bipinnata*	63	71		29	53	67	58
Eclipta platyglossa				14		33	3
Euchiton sphaericus	4	6			7		4
**Hedypnois rhagadioloides* subsp. *cretica*	33	41		29	20		30
Hyalosperma glutinosum subsp. *glutinosum*	71	12	100	43	27		40
Hyalosperma semisterile		6	100				3
**Hypochaeris glabra*	96	59	100	100	27		52
Isoetopsis graminifolia	63	35					31
Leptorhynchos elongatus[Vic]					20		4
Leptorhynchos panaetioides[Vic]	21	71		29	40		37
Leptorhynchos scaber[New]						X	
Leptorhynchos squamatus subsp. A	39	6		43			19
Leucochrysum molle[Vic]	13	47					16
Microseris lanceolata	X						
Minuria leptophylla			100				1
Myriocephalus rhizocephalus	63	6		43		67	31
Myriocephalus stuartii				14			1
**Onopordum acaulon*	4						1
Podolepis jaceoides[A]							
Podolepis muelleri					7		1
**Podospermum resedifolium*	4	6		14			4
Pogonolepis muelleriana	4						1
Pycnosorus globosus	8	12		14	7	100	13
Rhodanthe corymbiflora	92	100		57	100	33	88
Rhodanthe pygmaeum	33	18	100		13		21
Senecio runcinifolius		6					1
**Sonchus asper* subsp. *glaucescens*	13	6		14	20		12
**Sonchus oleraceus*	13	12					7
Stuartina muelleri	4		X				1

**Taraxacum officinale*						33	1
Triptilodiscus pygmaeus	96	24	100	14			43
Vittadinia cervicularis var. *subcervicularis*	4			X			1
Vittadinia cuneata var. *cuneata*	4	6			20		7
Vittadinia cuneata var. *hirsuta*	17	18	100				12
Vittadinia gracilis	X				7		1
Vittadinia pterochaeta[Vic]	4				7		3
Boraginaceae							
Cynoglossum suaveolens			100				1
**Echium plantagineum*	25	47		57	67		42
Brassicaceae							
Lepidium monoplocoides[ROTAP,Vic,Ext]						X	
**Rapistrum rugosum*	4	6					3
**Sisymbrium orientale*		6					1
Campanulaceae							
Wahlenbergia gracilenta	4	12		14			3
Wahlenbergia gracilis	46	6					19
Wahlenbergia luteola	4		100				3
Wahlenbergia stricta subsp. *alterna*	4	X	100				4
Caryophyllaceae							
**Spergularia rubra*	21				27		18
Casuarinaceae							
Allocasuarina verticillata			100				1
Centrolepidaceae							
Centrolepis glabra						33	1
Chenopodiaceae							
Atriplex leptocarpa	8	35		29	67		30
Chenopodium desertorum subsp. *virosum*	8	18					7
Enchylaena tomentosa		6			7		3
Maireana aphylla[Vic]	25	35		29	47		31
Maireana decalvans[A]							
Maireana excavata[Vic]	79	53			47		52
Maireana pentagona	96	94		57	47		75
Rhagodia spinescens		6	X				1
**Salsola kali*	13	35		14	13		18
Sclerolaena diacantha	4						1

Sclerolaena muricata var. *semiglabra*	8	X			20		7
Sclerolaena muricata var. *villosa*	4	12		14	27		12
Sclerolaena napiformis[ROTAP,Vic]		X					
Sclerolaena stelligera	X	12		14	27		10
Colchicaceae							
Wurmbea dioica subsp. *dioica*	79	41	100	71	7	33	51
Convolvulaceae							
Convolvulus erubescens	33	X	100	14	7		16
Dichondra species A				14			1
Crassulaceae							
Crassula colorata var. *acuminata*	54	29		29	73		46
Crassula decumbens var. *decumbens*	46	6		71	13	67	31
Cupressaceae							
Callitris glaucophylla[Vic]			100				1
Cyperaceae							
Eleocharis pallens[Vic]	X			14		67	4
Isolepis congrua[Vic]	X			14			1
Isolepis hookeriana						33	1
Isolepis victoriensis						33	1
Droseraceae							
Drosera glanduligera			100				1
Euphorbiaceae							
Chamaesyce drummondii	33	47			33		31
Fabaceae–Faboideae							
**Medicago polymorpha*	17	18		14	47		22
**Medicago praecox*		6					1
**Medicago truncatula*	67	88		57	87	33	73
Swainsona behriana[Ext]	33	18	100	X			18
Swainsona murrayana[ROTAP,Vic]	46	29		29		33	28
Swainsona plagiotropis[ROTAP,Vic]	4			14			3
Swainsona procumbens	21	12		29		100	18
Swainsona sericea[A]							
Swainsona swainsonioides[Vic]		X			X		
**Trifolium angustifolium*	4	6					3
**Trifolium arvense*	38	24	100	86	13		33
**Trifolium campestre*				14			1

**Trifolium glomeratum*	25			43			13
**Trifolium hirtum*	4						1
**Trifolium repens*				29		33	4
**Trifolium subterraneum*	4			14			3
**Trifolium tomentosum*	4	6		29	7		7
Fabaceae - Mimosoideae							
Acacia homalophylla[A]							
Acacia pendula[Vic]	X	6			X	X	1
Gentianaceae							
**Cicendia quadrangularis*	X						
Geraniaceae							
**Erodium cicutarium*	21	12			53		22
Erodium crinitum	17	29	100	29	40		27
**Erodium malacoides*	X						
Goodeniaceae							
Goodenia fascicularis	79	65		57	33		58
Goodenia pinnatifida	13	6	100		7		9
Goodenia pusilliflora	67	53	100	29	33		49
Haloragaceae							
Myriophyllum crispatum						67	3
Hypoxidaceae							
Hypoxis glabella var. *glabella*	21	18		28	7		16
Iridaceae							
**Gynandriris setifolia*	21	18					12
**Romulea minutiflora*	29	12	100		13		18
**Romulea rosea*	50	53		71	13		42
Juncaceae							
Juncus aridicola				14		33	3
**Juncus articulatus*						67	3
**Juncus bufonius*	4			14			3
Juncus radula	17			29		67	12
Juncaginaceae							
Triglochin procerum						33	1
Lamiaceae							
**Marrubium vulgare*		6					1
Teucrium racemosum	17	41		14	13	67	24

Lentibulariaceae							
Utricularia dichotoma						33	1
Linaceae							
Linum marginale	17			14	7		9
Lobeliaceae							
Pratia concolor				14			1
Lomandraceae							
Lomandra effusa	4		100				3
Lythraceae							
**Lythrum hyssopifolia*	4					33	3
Malvaceae							
Sida corrugata	88	88		29	73	33	75
Sida trichopoda		6					1
Marsileaceae							
Marsilea drummondii						100	4
Myoporaceae							
Eremophila longifolia			100				1
Nitrariaceae							
Nitraria billardierei	X	X					
Ophioglossaceae							
Ophioglossum lusitanicum subsp. *coriaceum*[A]							
Orchidaceae							
Diuris dendrobioides s. lat.[Ext]			X				
Diuris lanceolata[Ext]			X				
Prasophyllum campestre			100				1
Oxalidaceae							
Oxalis perennans	58	35	100	57	47		48
Phormiaceae							
Dianella longifolia var. *porracea*			X				
Plantaginaceae							
**Plantago coronopus* subsp. *commutata*	13						4
Plantago cunninghamii	13	12		14	7		10
Plantago drummondii	4	29			7		10
Plantago gaudichaudii	4						1
Plantago hispida	4			14			3
Plantago turrifera	13	12			7		9

Poaceae

Agrostis avenacea var. *avenacea*	8	12			7	100	12
**Aira elegantissima*	17		100				7
**Alopecurus geniculatus*	13	6		29		67	12
Amphibromus macrorhinus	X			14			1
Aristida jerichoensis var. *jerichoensis*			100				1
**Avena fatua*	42	59	100	43	87		55
**Briza minor*	17			43		33	12
**Bromus diandrus*	X						
**Bromus molliformis*	13				7		6
Chloris truncata	92	71		43	20	33	61
Chloris ventricosa[A]							
Danthonia caespitosa	50	29		14		33	33
Danthonia duttoniana		18			7	67	9
Danthonia eriantha	33	6	100	14	27		22
Danthonia laevis				14			1
Danthonia linkii var. *fulva*	4	12		14	33		13
Danthonia linkii var. *linkii*	4	18		29	7		10
Danthonia setacea	4	18		14	7		9
Enteropogon ramosus	25	41		57	73		42
Eragrostis australasica					X	67	3
**Eragrostis cilianensis*					X		
Eulalia aurea				14			1
**Holcus lanatus*		6		14			3
Homopholis proluta	25	24		86	40	67	36
**Hordeum leporinum*	17	12		14	40	33	21
**Lolium rigidum*	88	100		86	93	67	90
Monachather paradoxa			X				
**Pentaschistis airoides*	4					33	3
**Phalaris aquatica*				14	27		7
**Rostraria cristata*	17	6					7
Sporobolus caroli[Vic]	8	29			7		12
Stipa aristiglumis	4	6		71		33	12
Stipa bigeniculata	13	X		14			6
Stipa eremophila			100				1
Stipa nodosa	92	88		14	73		73

Stipa setacea[Vic]			X	14			1
Themeda australis			100				1
Thyridolepis mitchelliana			100				1
**Vulpia bromoides*				14	7		3
**Vulpia muralis*	17	6		14	7		10
**Vulpia myuros*	4	12			20		9
Polygonaceae							
Rumex dumosus		6		43			6
Rumex tenax				14		33	3
Portulacaceae							
Calandrinia eremaea	4						1
Primulaceae							
**Anagallis arvensis*				14			1
Proteaceae							
Hakea tephrosperma[Vic]			100				1
Ranunculaceae							
Myosurus minimus var. *australis*		X				33	1
Ranunculus pachycarpus	4						1
Ranunculus pentandrus var. *platycarpus*		6		43	7	67	10
Ranunculus pumilio var. *politus*				14			1
Ranunculus sessiliflorus var. *pilulifer*	4						1
Rosaceae							
Aphanes australiana	X			14			1
Rubiaceae							
Asperula conferta	50	29		86	7		36
Scrophulariaceae							
**Parentucellia latifolia*	29		100	43			16
**Veronica peregrina*						33	1
Sinopteridaceae							
Cheilanthes sieberi subsp. *sieberi*	4		100				3
Solanaceae							
Solanum esuriale	17	18			7		12
Stackhousiaceae							
Stackhousia monogyna			100				1

Stylidiaceae				
Levenhookia dubia	100			1
Stylidium despectum			33	1
Thymelaeaceae				
Pimelea micrantha	100			1
Zygophyllaceae				
Zygophyllum glaucum		7		1