The native grasslands of the Southern Riverina, New South Wales

Report to Australian Nature Conservation Agency

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National Herbarium of New South Wales
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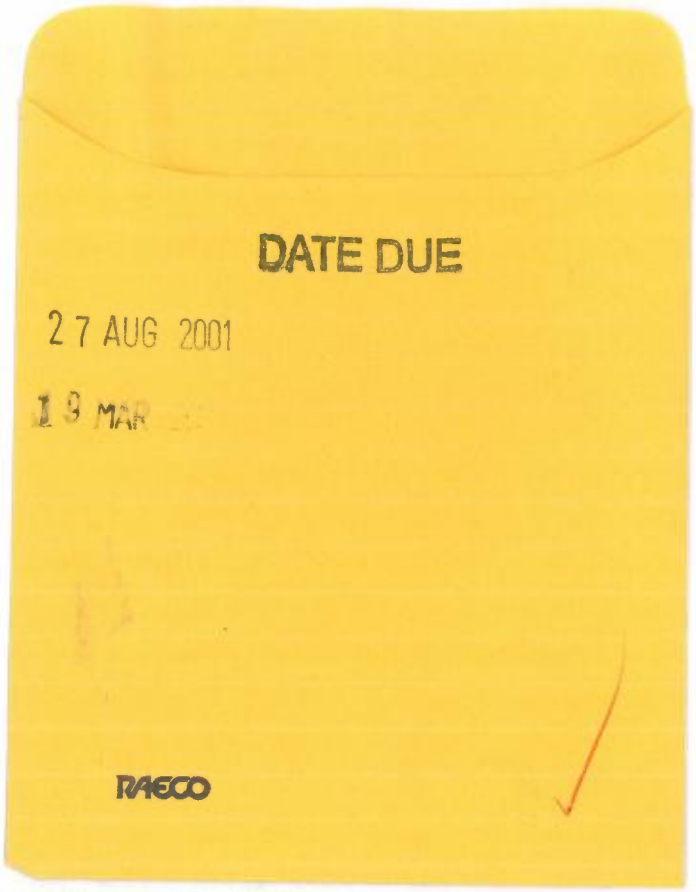

ERRATUM:

Page 31: "3-5 sheep/ha" should be "3-5 ha/sheep".

Benson, J.S., Ashby, E.M. and Porteners, M.F. (1996) *The native grasslands of the Southern Riverina, New South Wales.* National Herbarium of New South Wales, Royal Botanic Gardens, Sydney.

Cover photograph: Spring flowering in a lightly grazed grassland on Bundure Road, 30 km NE of Jerilderie. This is an example of Community 1a, the most widespred grassland type in the area, and is dominated by the grasses *Danthonia eriantha* and *Stipa nodosa* and the daisy *Chrysocephalum apiculatum*. *Swainsona murrayana* is visible in the foreground. The Plains-wanderer has also been recorded here. **Photo M. Porteners.**

		Date Borrowed	
Michael TODD	RIVERINA	27/7/01	✓
Lisa Holman	BRMD 6507	19/2/02	✓
Graham Turner	GIS thurst 5	5/7/00	✓

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Contents

Summary

Plant ecologists from the Royal Botanic Gardens, Sydney surveyed the derived native grasslands of the Riverine Plain in south-western NSW in the spring of 1995. A total of 224 species was found - 58 (25%) of these are exotic. The most common native grasses were wallaby grasses (*Danthonia* spp), cork screw grass (*Stipa* spp), Curly Windmill Grass (*Enteropogon ramosus*) and Windmill Grass (*Chloris truncata*). Numerous forbs in the daisy (Asteraceae) and pea (Fabaceae) families grew in the inter-tussock spaces. Four main types of native grassland were classified by analysing the data from 67, 20 x 10 m sample sites that were spread over the region. Some grassland types were widespread, while others were restricted to particular environmental niches such as low-lying swamps.

Six nationally rare or threatened plant species were recorded: *Brachycome muelleroides, Brachycome papillosa, Lepidium monoplocoides, Sclerolaena napiformis, Swainsona murrayana* and *Swainsona plagiotropis*. Many other species were recorded only once in the survey and are regionally rare. These included Kangaroo Grass (*Themeda australis*), some species of orchids, and the daisy *Leptorhynchos scaber*. This daisy was collected for the first time in NSW and is endangered in the state.

Areas that had not been ploughed, or continuously and heavily grazed, contained the best grassland remnants. These included public lands such as travelling stock routes and road reserves around Jerilderie, and some paddocks on private properties that had light grazing regimes. Some good stands of native grassland coincided with Plains-wanderer habitat, a threatened ground bird now restricted to the south-eastern inland plains of Australia. Future conservation planning should aim to protect the important sites already identified, and encourage further biological studies and mapping projects to gain a better understanding of conservation management of the grasslands.

The native grasslands of the Southern Riverina, New South Wales

Abstract

Benson, J.S., Ashby, E.M. and Porteners, M.F. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1996. The native grasslands of the Southern Riverina, New South Wales. A botanical survey of the derived, temperate, tussock grasslands of the 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 - with the view to finding more about its habitat requirements. All vascular plants were recorded (including cover estimates for each species) in 67, 10 m x 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 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.*

The lowland grasslands of south-eastern Australia are among the most threatened and poorly conserved ecosystems in the nation (McDougall and Kirkpatrick 1993). 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 native grasslands of the Victorian section of the Riverine Plain have been investigated for their ecological values by Foreman (1995). 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. A discussion on grassland management is also provided, taking into account the results of recent surveys of the endangered bird species *Pedionomus torquatus* (Plains-wanderer) (Schedule 1, Part 1, Threatened Species Conservation Bill), which is restricted to grassland habitat in south-eastern Australia, including the Riverine Plain (Maher 1996).

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. The Riverine Plain extends from Ivanhoe in NSW in the north to central-western Victoria in the south (Figure 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 on the Riverine Plain. These lighter soils are dominated by woodlands of *Eucalyptus* and *Callitris*. A large area of grassland was originally present south of Echuca on the Victorian section of the Riverine Plain, but only remnants remain (McDougall and Kirkpatrick 1993). 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 (Figure 2). This region of native grassland occurrence is covered by 11, 1:100 000 topographic maps (Figure 3). Some outlying grassland patches are present on low-lying plains, such as Bullenbong Plain east of Lockhart.

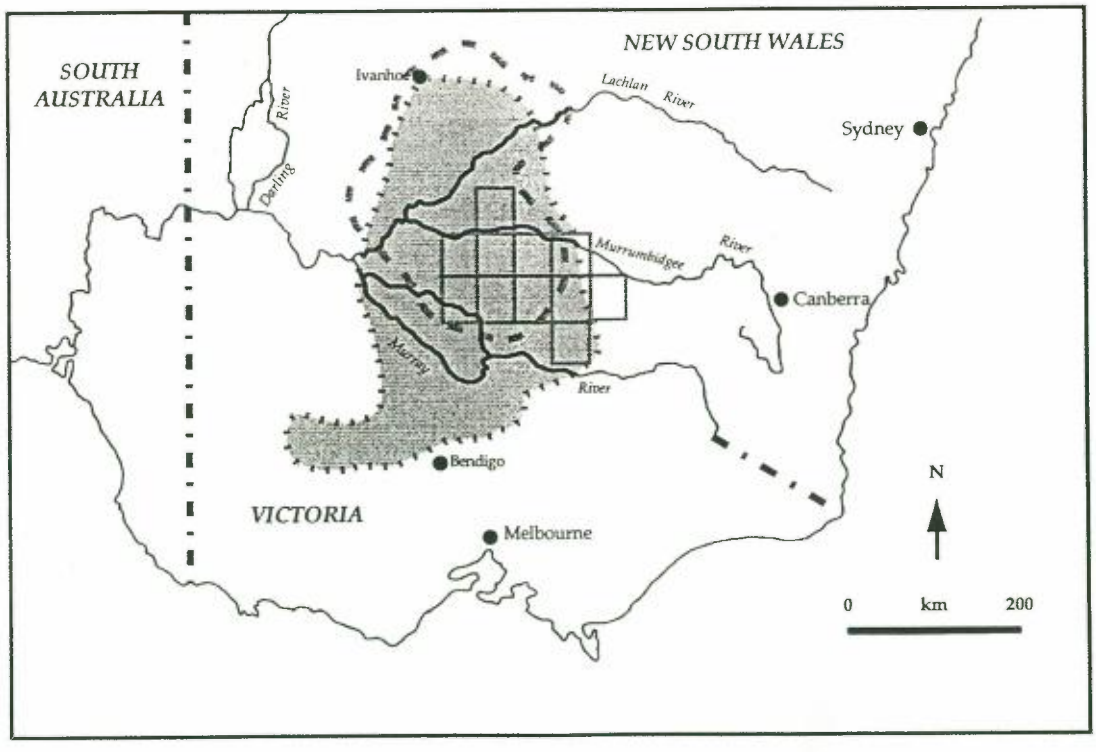

Figure 1. Location of the Riverine Plain as defined by Butler (1950) (shaded area), the Hay Plain as defined by Porteners (1993) (dashed line) and the 1:100 000 map sheets that cover the region where native grassland occurs (see also Figure 3).

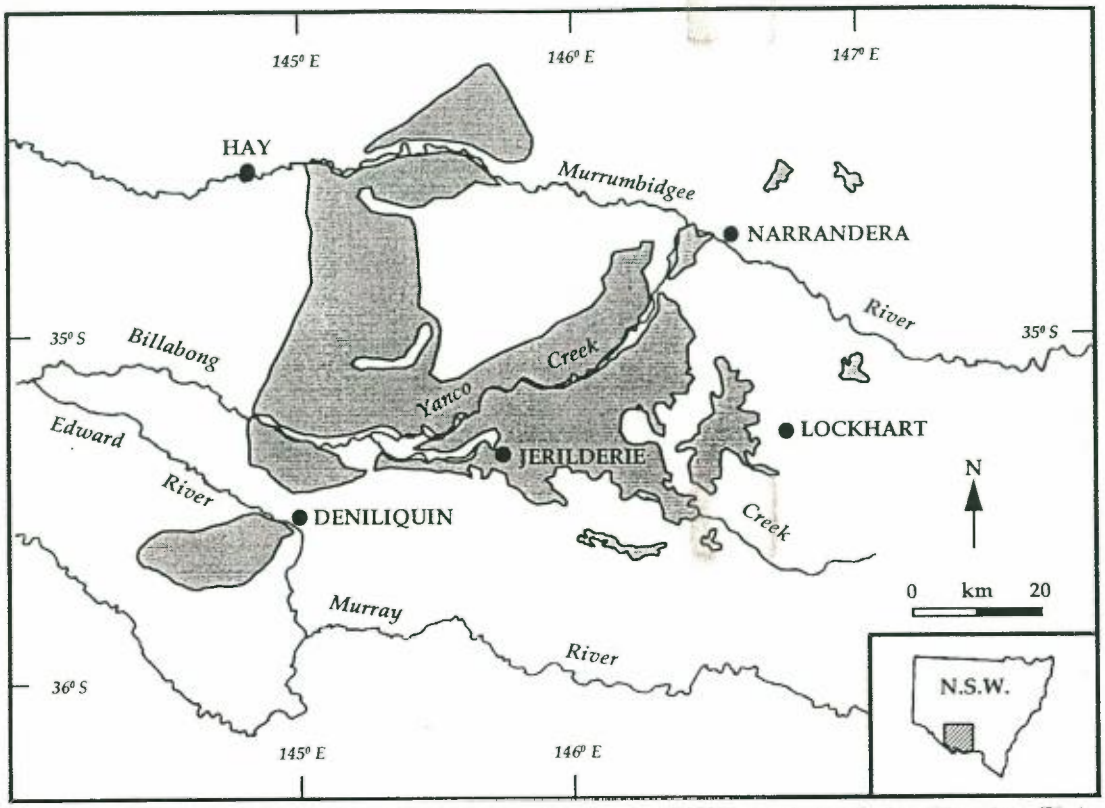

Figure 2. Extent of derived native grasslands on the NSW section of the Riverine Plain (derived from Beadle 1948 and Moore 1953a). Since the 1920s much of this native grassland has been altered by cultivation and pasture improvement. The area would have originally been vegetated with chenopod shrubland and Myall (*Acacia pendula*) open woodland, most of which was destroyed in the latter part of the 19th Century by a combination of drought and overgrazing by domestic stock and rabbits.

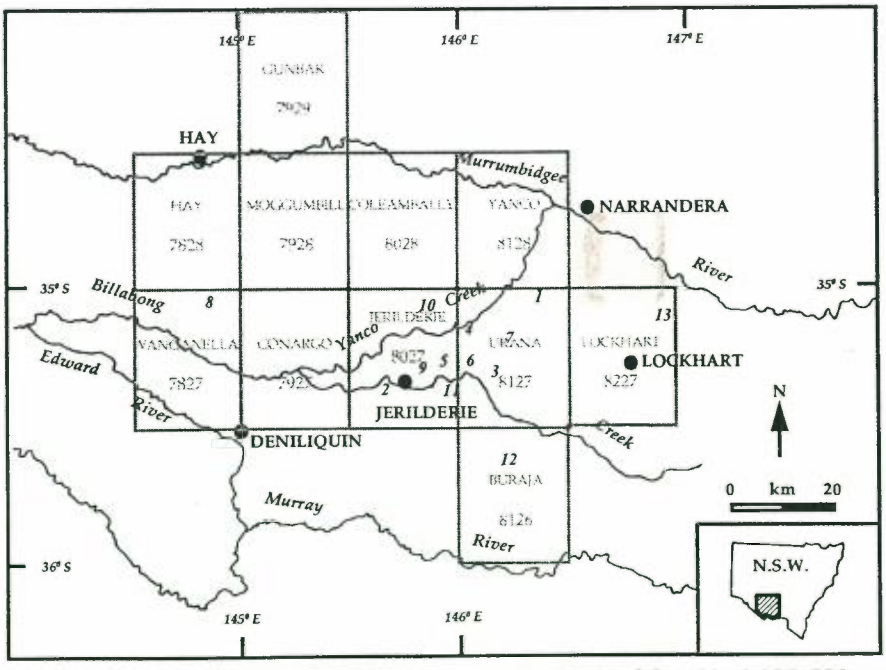

Figure 3. The native grasslands extend over a region covered by 11, 1:100 000 map sheets from Lockhart in the east to Hay in the north west. Numbers 1-13 indicate the approximate location of areas containing sites of botanical significance.

Climate

The region experiences hot summers and cool winters with the summer maximum averaging over 30° C and winter minimum down to 5° C (Figure 4). Rainfall peaks in May and September but falls throughout the year, with slightly more in winter and spring (Figure 4). Summer rainfall comes mainly from storms and is less 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.

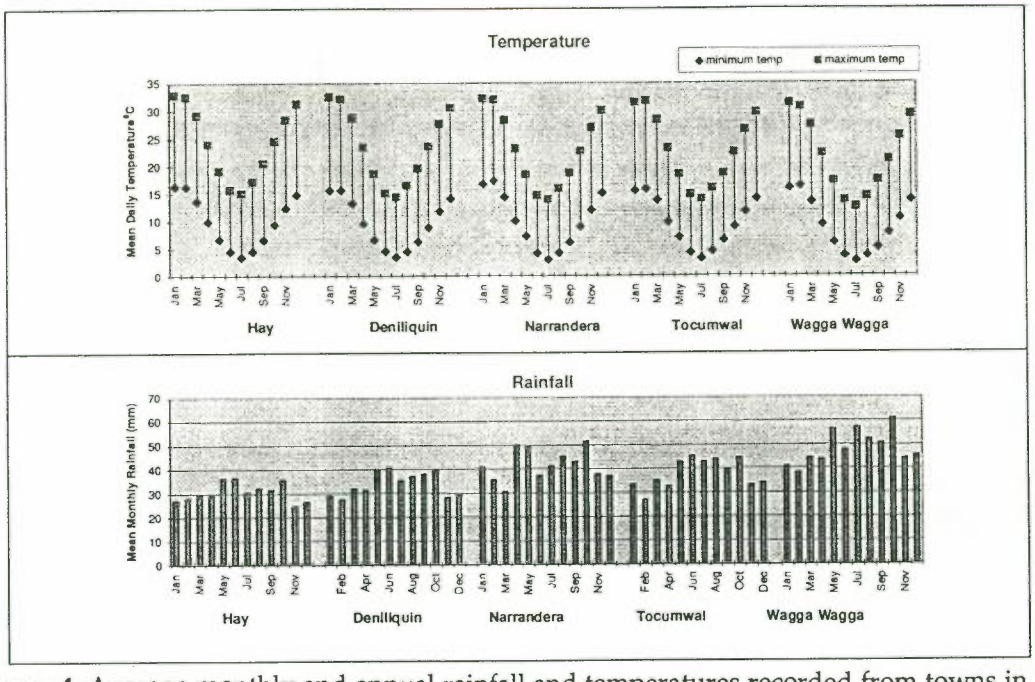

Figure 4. Average monthly and annual rainfall and temperatures recorded from towns in the study area (Bureau of Meteorology 1996). Rainfall increases from west to east across the Riverine Plain.

Geology and soils

The Riverine Plain is situated in the eastern part of the Murray Basin bounded by the western slopes of the Great Dividing Range in the east and semi-arid mallee-dominated dune systems on the plains 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 to a lesser degree (Butler *et al.* 1973). The plains have various surface modifications including scalds, channels, drains and depression (gilgai). Occasional aeolian features such as lunettes and source-bordering dunes of sandy soils 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.

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 tribes. Disease, combined with oppression by the settlers, led to the social disintegration and population decline in the tribes (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 1850's gold rushes. 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 1992-1995. 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. Saline water tables present a major threat to agriculture in the region, particularly in irrigated areas (Barson and Barrett-Lennard 1995).

In 1995 the NSW Government brought in a regulation, State Environmental Planning Policy No 46, to control clearing in NSW. This included the clearing of native grasslands. Following lobbying by landholders against this regulation, native grasslands were removed from SEPP 46 on 1 January 1996 (although the clearing of woody vegetation remained under the regulation). In its place, draft grassland management plans were compiled by catchment management committees. The Western Riverina Regional Grassland Management Plan sets guidelines for managing native grasslands on private property. It will be reviewed to conform with guidelines for such plans developed by the Department of Land and Water Conservation. The Plan will also be amended from time to time to take into account new 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. The *Danthonia* species were not in any danger of extinction.

Leigh and 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 and Mulham (1977) with a supplementary list by Mulham and 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. She delineated a White-top Grassland plant community as extending from north-east of Deniliquin northwards to near Gunbar.

Methods

Sampling the native grasslands

Sample sites were selected after field reconnaissance, through 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 was 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 x 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 and the different grassland communities observed during traverses of the region. Exotic grasslands (Benson 1996) were not sampled.

A total of 16 field days (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.

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, 1991, 1992, 1993).

Data analysis

All site data were entered in to the floristic ecological database (Advanced Revelation) used at the National Herbarium of NSW and the NSW National Parks and Wildlife Service.

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 to the definition of the group.

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). Table 1 shows the weediness of each grassland community.

Community	No. of Sample Sites	Total No. Species	No. Native Species	No. Exotic Species (%)
1a	24	130	91	39 (30%)
1b	17	104	74	30 (29%)
2	1	48	41	7 (15%)
3	7	100	71	29 (29%)
4	15	79	57	22 (28%)
5	3	50	37	13 (26%)

Table 1. Proportions of native and exotic species per grassland community

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 and Leigh 1995), on a state basis (NSW or Victoria) or within the region (Table 2). 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* (Figure 5) as rare in the region and nationally vulnerable being only recorded twice near "Coonong" and Jerilderie. *Swainsona murrayana* (Figure 6), 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.

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 and 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 and 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 and Luke (1994)
Swainsona swainsonioides		e	c?	v	Adjacent SWG 12
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

Table 2. 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 1995). 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.

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 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.).

It is recommended that the daisy, *Leptorhynchos scaber*, be listed 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* 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*.

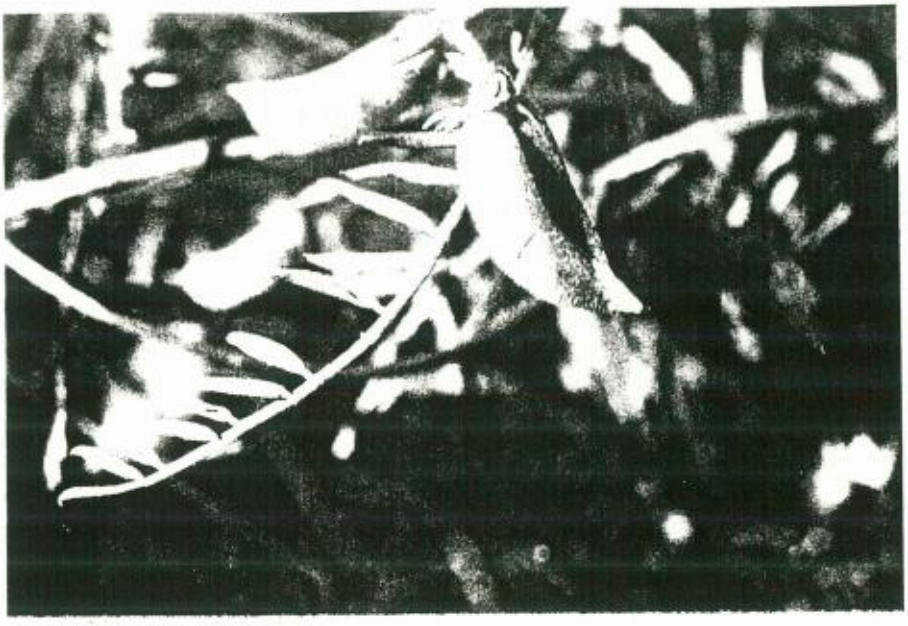

Figure 5. Seed pods of the nationally vulnerable *Swainsona plagiotropis*. Surveys since 1991 indicate that this species is mainly restricted to the Jerilderie district. A species recovery plan has been prepared for the species. Photo J. Benson.

Figure 6. *Swainsona murrayana* is listed as a vulnerable species nationally. This should be reviewed given its frequency and abundance recorded during our survey.
Photo M. Porteners.

Data analysis

The resulting dendrogram from the Kulczynski association and UPGMA clustering analysis (adjusted for misclassification) is shown in Figure 7. Six grassland communities were defined at a dissimilarity measure of 0.75 (Table 1). 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 UPGMA was run using cover data, the grassy woodland at site 3 clustered with site 1 at "Morundah" in Community 1a. They share a number of species including an abundance of *Lomandra effusa*. It is likely the "Morundah" site was originally a woodland dominated by *Callitris* and other woody species with is consistent with the vegetation in the nearby Buckingbong State Forest.

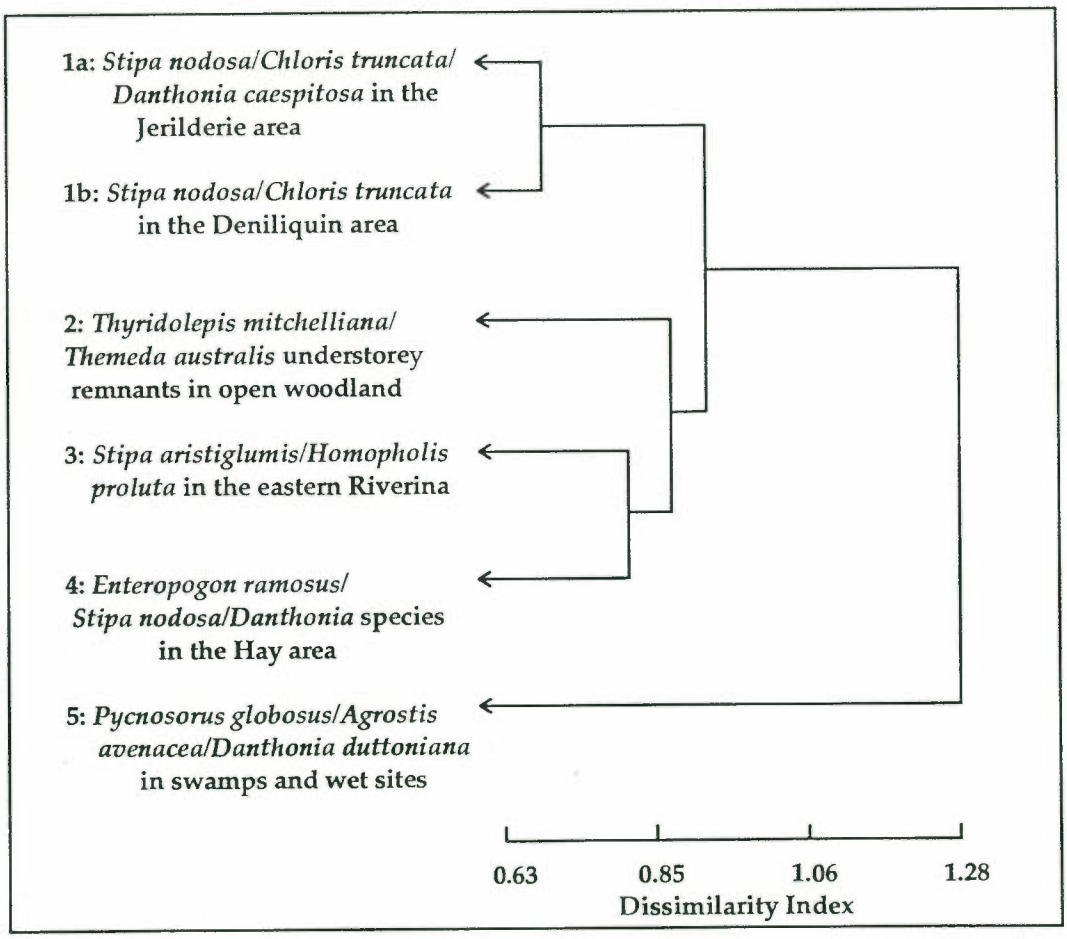

Figure 7. Dendrogram showing five plant communities produced from Kulczynski association and UPGMA clustering.

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 and Kirkpatrick 1993). 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 3). 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 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, rye grass (*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.

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

Table 3. Grassland communities of the Riverine Plain (NSW).

Description of grassland communities

The five communities defined in the classification analysis are described below and summarised above in Table 3. 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 x 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** (Figure 8)

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).

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

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.*

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.

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 5).

Key sites for conservation: Site 1 in Boree paddock on the property "Morundah", owned by the Australian Navy. 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 and 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 (Figure 9)

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

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

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

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.*

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.

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 5).

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.

Figure 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.

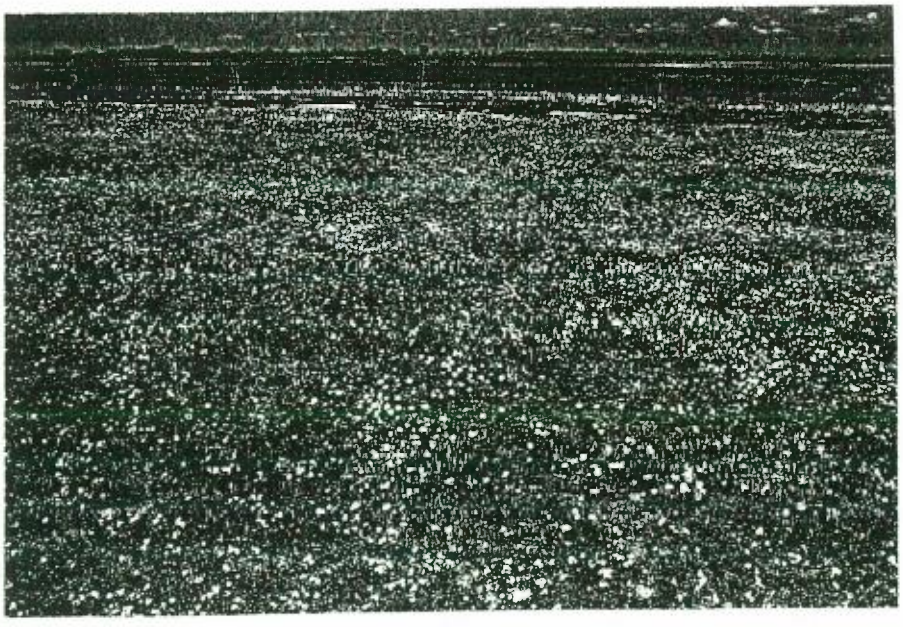

Figure 9. Community 1b at SWG 12, McLennons Bore Road north of Jerilderie dominated by *Rhodanthe corymbiflora*, *Stipa nodosa*, *Cotula bipinnata* and *Leucochrysum molle*. Photo M. Porteners.

Community 2. *Thyridolepis mitchelliana* - *Themeda australis* understorey remnants in open woodland (Figure 10)

Sample site: 3 (n=1)

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

Total no. native species: 41

Total no. exotic species: 7

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.*

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.

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 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** (Figure 11)

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

Structure: Open to dense, tall tussock grassland.

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

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.*

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.

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 5).

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 (Figure 12)

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.

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

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.*

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

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

Figure 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.

Figure 11. SWG6 in Community 3 is dominated by Plains Grass *Stipa aristiglumis* and the daisy *Calocephalus citreus*. This community mainly occurs in the eastern section of the region, often in low lying areas. Photo M. Porteners.

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

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 (Figure 13)

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

Structure: Mid-dense to dense, tussock grassland.

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

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.*

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

Distribution: Throughout the study area.

Condition: Two of the sites sampled are in excellent condition and are significant wet-grassland areas containing few weeds as well as rare and unusual species. 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*.

Figure 12. SWG37 in Community 4 on "Cooinbil", dominated by *Stipa nodosa*, *Danthonia eriantha*, *Enteropogon ramosus* and the introduced rye grass *Lolium rigidum*. This community is mainly confined to the western section of the study area. Photo M. Porteners.

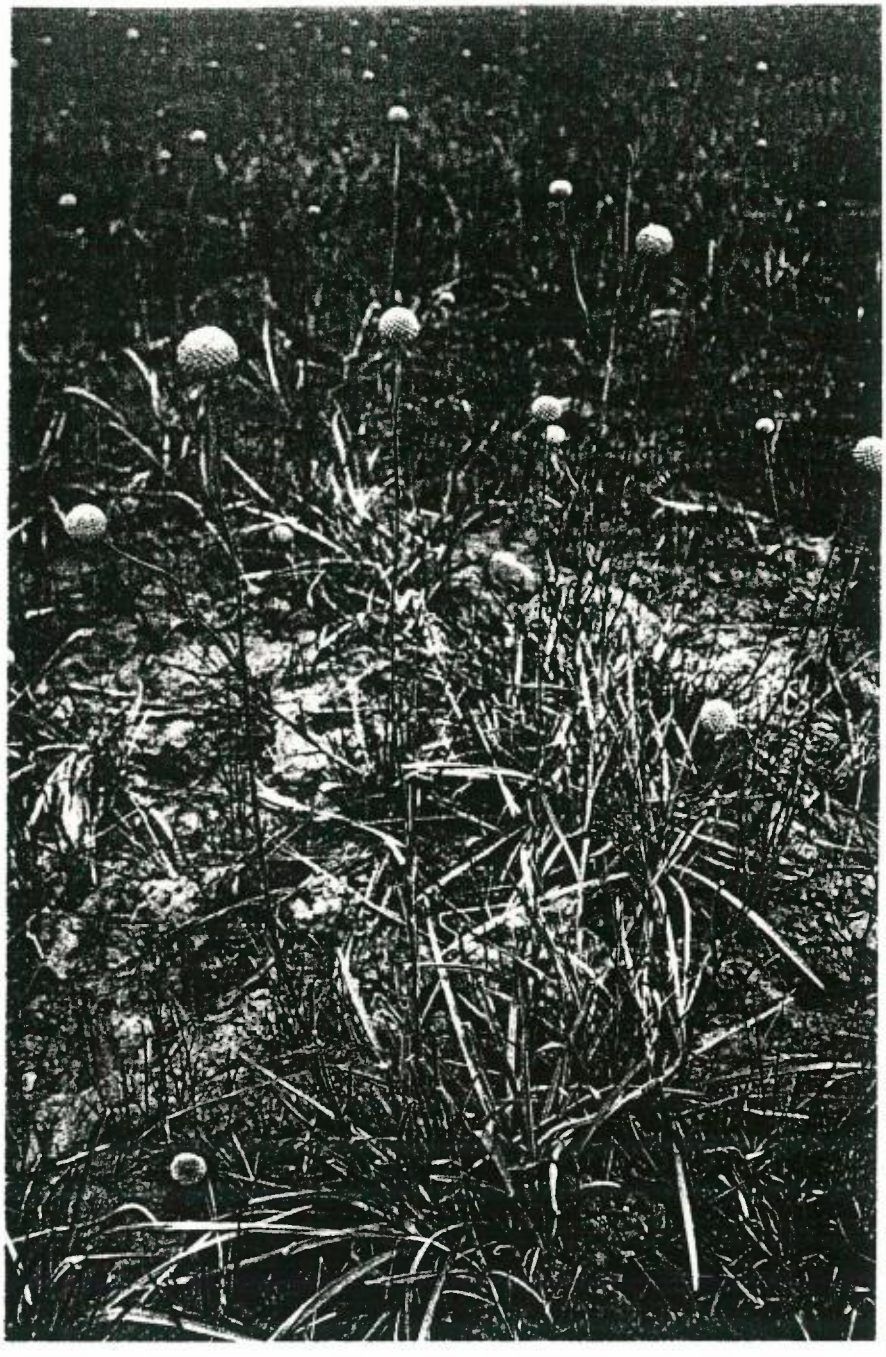

Figure 13. SWG 41 along the Narrandera-Urana Road in Community 5 dominated by *Pycnosorus globosus, Danthonia caespitosa, Agrostis avenacea* and *Juncus radula*. This community is confined to poorly drained, low lying areas. Photo J. Benson.

Grassland sites of botanical significance on the Riverine Plain

Seven criteria were used to determine the significance of the sample sites (see Table 4). 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. In addition to these sites we consider that all of the previous records 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 4 should, therefore, be considered only as a starting point in regional assessments of grassland sites of significance.

The most widespread Communities 1a (Figure 14) 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, as it contained 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 rye grass (*Lolium rigidum*) dominant in places.

Some properties are important for the protection of significant sites. They include parts of the properties "Coonong" (Figure 15) and "Cocketgedong", and a section of "Morundah" now owned by the Australian Navy (Figure 16), 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

Site	Comm.	Location (tenure)	Proposed Protection	Justification	Recommended Management
SWG 1	1a	"Morundah" (Navy)	NR	T1,T2,U,C,M,D,E	F,R
SWG 4	1a	TSR	CA	T1	LG,R
SWG 13	1a	?Airstrip	CA	T2,C,D,M	LG,R
SWG 14	1a	TSR	CA	T1,C,D	LG,R
SWG 21	1a	"Cocketgedong" (P)	CA	T2,C,D	LG,R
SWG 28	1a	"Coonong" (P)	CA	T2,U,D	LG
SWG 24 (adj.)	1b	TSR	CA	T1,E	LG,R
Council block west of Jerilderie	1b	Pn 3, Ph Jerilderie, Co Urana (Jerilderie Shire Council)	NR	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)	CA/NR	T1	LG,R
SWG 3	2	"Cocketgedong" (P)	NR	U,M,D,E	F,R
SWG 6	3	Bullenbong Plain (Road Reserve)	CA	U,E	LG,W
SWG 8	3	"Coonong" (P)	CA	T1,T2,U,D	LG,W,R
SWG 9	3	"Coonong" (P)	CA	T2,C,U,E	LG
SWG 67	3	Road Reserve	CA	U,E	W,LG
SWG 47	4	Warwillah Rd (P)	CA	C,E	LG,W
SWG 43	5	"Morundah" (Navy)	NR	T1,U,C,D,E	F,R
SWG 41	5	Road Reserve	CA	T1,U,C,D,E	F,R

Table 4. Grassland sites of botanical significance in the southern Riverina. **Proposed protection**: NR = nature reserve; CA = conservation agreement. **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. **Tenure**: P = private land, TSR = travelling stock reserve/route. **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.

Figure 14. SWG13 near an airstrip on Bundure Road, north of Jerilderie contains an extensive stand of Community 1a with relatively few exotic species. Photo M. Porteners.

Figure 15. SWG 9 on "Coonong" contains one of the few records of the grass *Eulalia aurea*. *Themeda australis* has also been recorded near this site indicating a history of lighter grazing in this paddock than surrounding areas. Photo M. Porteners.

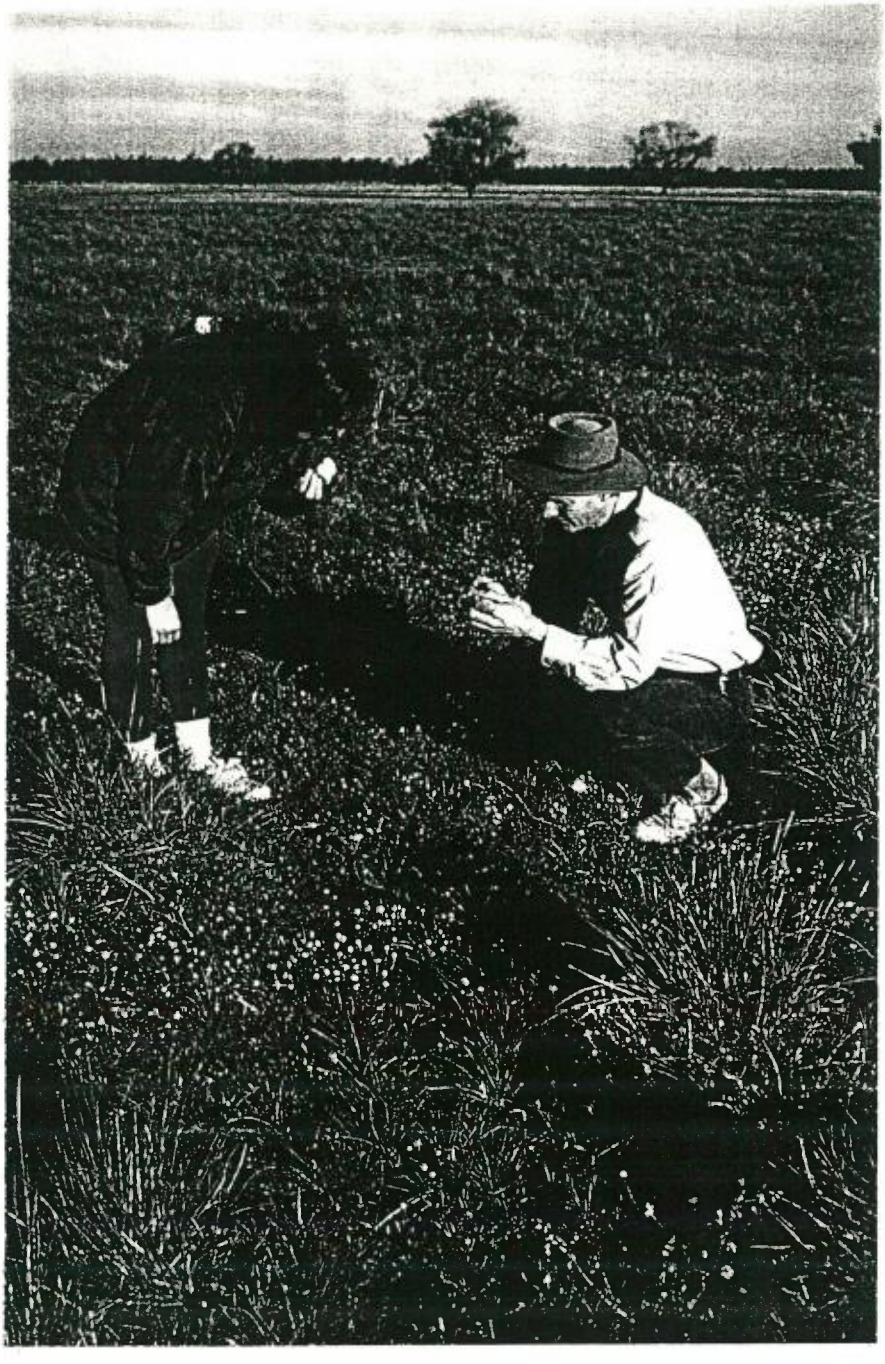

Figure 16. SWG 1 in Community 1a on "Morundah" with *Lomandra effusa* and *Leptorhynchos squamatus* subsp. A in the foreground with scattered *Acacia pendula* in the background. Photo M. Porteners.

A description of each location in order of conservation significance is given below. Detailed location maps of the sites are provided and their regional distribution is shown in Figure 3. Boundaries are only indicative. In some cases an area beyond the sample site is mapped out, based on ground traverses of the area. These may include sections of travelling stock routes or whole paddocks on private land. The *Swainsona plagiotropis* sites in the reports of Chappell and Luke (1994) and Appleby *et al.* (1991) in the Urana-Jerilderie region are also shown on the figures. These reports detail population size and ownership for each occurrence, although the site records in each report do not all coincide. This suggests that some *Swainsona plagiotropis* occurrences of 1991 were not apparent in 1994. The ephemeral nature of this species is illustrated by our 1995 survey results - we failed to locate it at a number of locations where it had been previously collected.

1. "Morundah" (Figures 16 &17)

Sample sites: SWG 1 SWG 43, and. SWG 41 on nearby road reserve
Plant communities: 1a and 5.
Location: Most of Boree Paddock on "Morundah".
Size: 500 ha.
Significant species: Only site recorded with three threatened species: *Lepidium monoplocoides* (3ECi), *Leptorhynchos scaber* (e NSW), *Brachycome muelleroides* (3VCa). Plains-wanderer also present.
Other significant features: Outstanding example of Communities 1a and 5. The dominance of *Lomandra effusa* places site 1 floristically distant from other sites in Community 1a. The area is well fenced and has been lightly grazed in the recent past (Diez and Foreman 1996).
Land tenure/ownership: Freehold/Commonwealth Defence Forces. Owned by the Australian Navy for a proposed communications tower.
Current management: Light grazing (3-5 sheep/ha), Navy to use the site for a communications tower.
Threats: Communications tower and associated disturbance e.g. roads, fire breaks, could disturb site.
Recommendations: Continue or reduce current stocking rates. Cultivation should not occur. The Navy tower should be moved to another paddock or to the western side of the Boree paddock. The Boree Paddock warrants nature reserve status or at least a conservation agreement with the Navy. The area offers an ideal opportunity for on-going monitoring and research of rare plants and the Plains-wanderer.

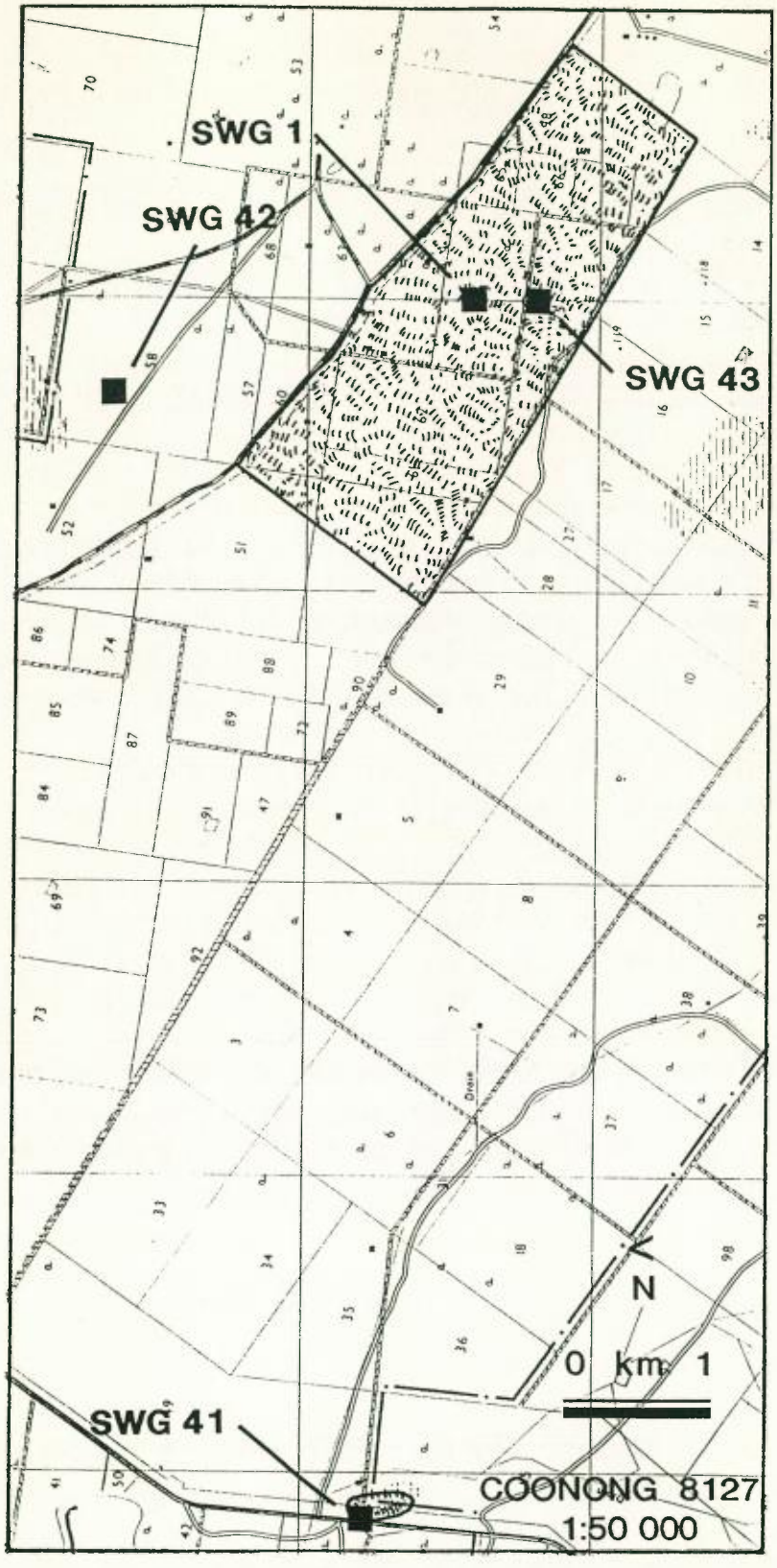

Figure 17. Significant site on "Morundah" owned by the Australian Navy for a communications tower.

2. Jerilderie and South Coree Road grasslands (Figure 18)

Sites: SWG 14 & 24, Chappell and Luke (1994) sites C1-C5, C7, C17-C21, Appleby *et al.* (1991) sites A1-A6 (which coincide with the some of Chappell and Luke's sites in this area).
Plant communities: 1a and 1b.
Location: Jerilderie township and immediate surrounds including the airstrip, Conargo Road and South Coree Road.
Size: SWG 7 TSR eastern edge of Jerilderie (including Chappell and Luke's site C5) = 40 ha; Chappell and Luke's combined sites C3 & C4 (Jerilderie airport = 80 ha); Chappell and Luke sites C1-2 (TSRs on Newell Highway = 50 ha); Chappell and Luke's site C17 on Jerilderie Shire Council block and C18 and C19 on lands adjoining this block = 100 ha; an extensive area of grassland was observed extending in a triangular shape along the road reserves, TSRs and private lands of South Coree Road, Hynes Lane and the southern side of the Jerilderie-Conargo Road = approximately 1125 ha. The approximate area of important grassland around Jerilderie is therefore about 1400 ha.
Significant species: The largest populations of *Swainsona plagiotropis* (3VCi) occur around the town of Jerilderie. One of the few know populations of *Sclerolaena napiformis* (3E) occurs on South Coree Road. *Brachycome papillosa* (3V) has been recorded at several sites near Jerilderie.
Other significant features: Species-rich native grasslands.
Land tenure/ownership: Travelling stock reserves, road reserves and private land.
Current management: Grazing and moving stock is the main use of the lands. These areas remain important for native grassland protection because they have not been cultivated, and/or continuously heavily grazed.
Threats: Changes in grazing regimes, cultivation of the private lands, expansion of Jerilderie township.
Recommendations: A nature reserve incorporating the Council Block west of the township and perhaps adjoining lands should be established. Conservation agreements should be entered into to protect the other sites including the road reserves and TSRs.

3. "Cocketgedong" Farm", west of Lake Urana (Figures 10 & 19)

Sample site: SWG3.
Plant community: 2
Location: Triangular paddock, 2 km north of Jerilderie-Urana Road on track into "Cocketgedong" Farm".
Size: 8 ha.
Significant species: The grasses *Thyridolepis mitchelliana* and *Themeda australis*, and the orchids *Diuris lanceolata* and *Diuris dendrobioides* are restricted or rare in the region.
Other significant features: Many species were only recorded at this species-rich site during the survey. It is in fact not a true grassland, rather more of a

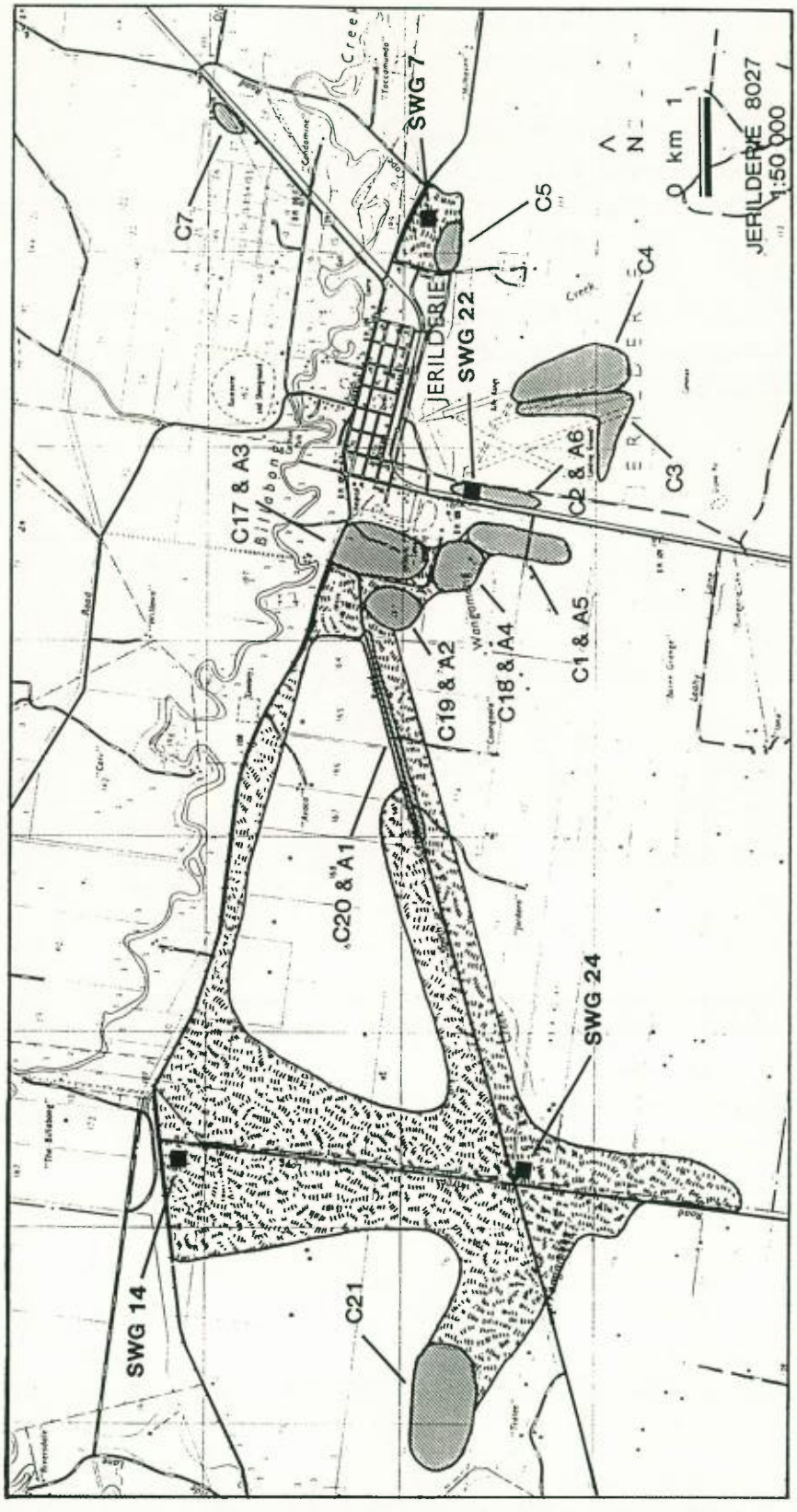

Figure 18. Jerilderie and South Coree Road grasslands. The Jerilderie Council-owned block on the western edge of the town is a proposed nature reserve.

shrubland dominated by *Allocasuarina verticillata* and *Callitris glaucophylla*. This small remnant ranks as one of the most important botanical sites on the Riverine Plain.

Land tenure/ownership: Private land owned by "Cocketgedong", V. Stonnill.

Current management: Fenced off from grazing for several decades.

Threats: Many herbaceous species that are rare in the region would be lost if grazing were introduced to the site, either deliberately or accidentally through damage to the fences.

Recommendations: The fence must be maintained to keep stock out if the site. The area could be added to the nearby Urana Nature Reserve, even though it is 2 km from it.

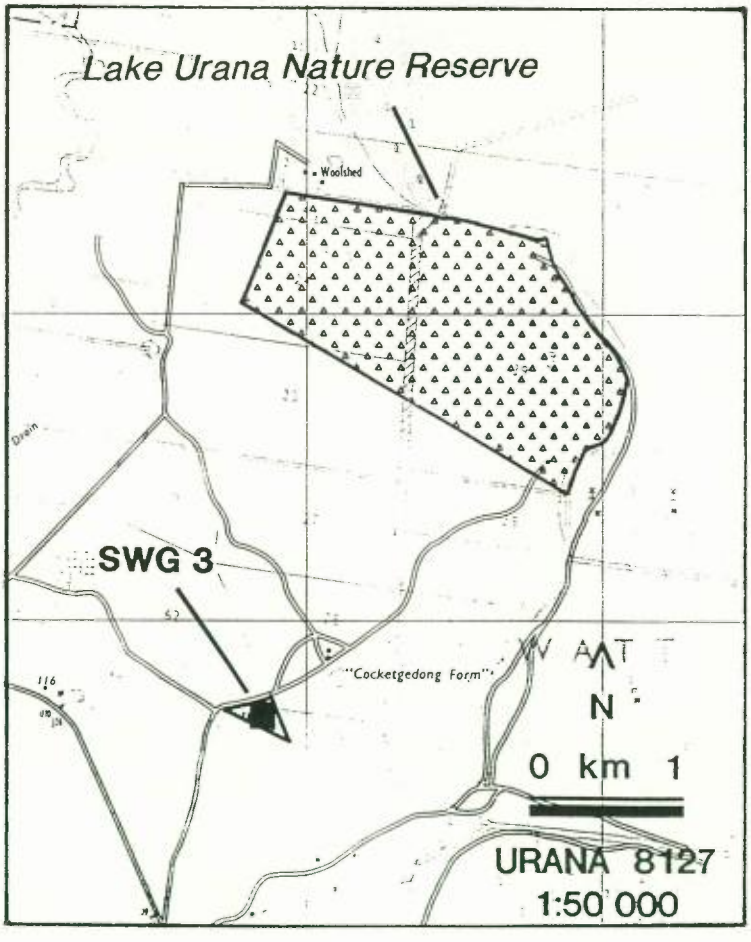

Figure 19. "Cocketgedong Farm", west of Lake Urana. A small fenced off paddock contains an unusual assemblage of plant species.

4. Bundure Siding, "Coonong" (Figures 15 & 20)

Sample sites: SWG 9 & SWG 28.
Plant communities: 1a and 3.
Location: Area between the unused Tocumwal-Narrandera railway line and the access road to "Coonong" near Bundure siding on "Coonong".
Size: 1350 ha.
Significant species: Only record of the grass *Eulalia aurea* during the survey. *Themeda australis* is also in the area (P. Maher pers. comm.) which is the only record of this grass in a true grassland environment on the Riverine Plain. The Plains-wanderer has also been recorded in this grassland.
Other significant features: A large area of native grassland which appears not to have been over-grazed.
Land tenure/ownership: Private land, part of "Coonong".
Current management: Sheep grazing.
Threats: Changes in grazing practices, cultivation.
Recommendations: Continue the current grazing management or reduce grazing pressure to allow *Themeda* and *Eulalia* to expand. Cultivation should not occur. A conservation agreement should be negotiated to meet these objectives.

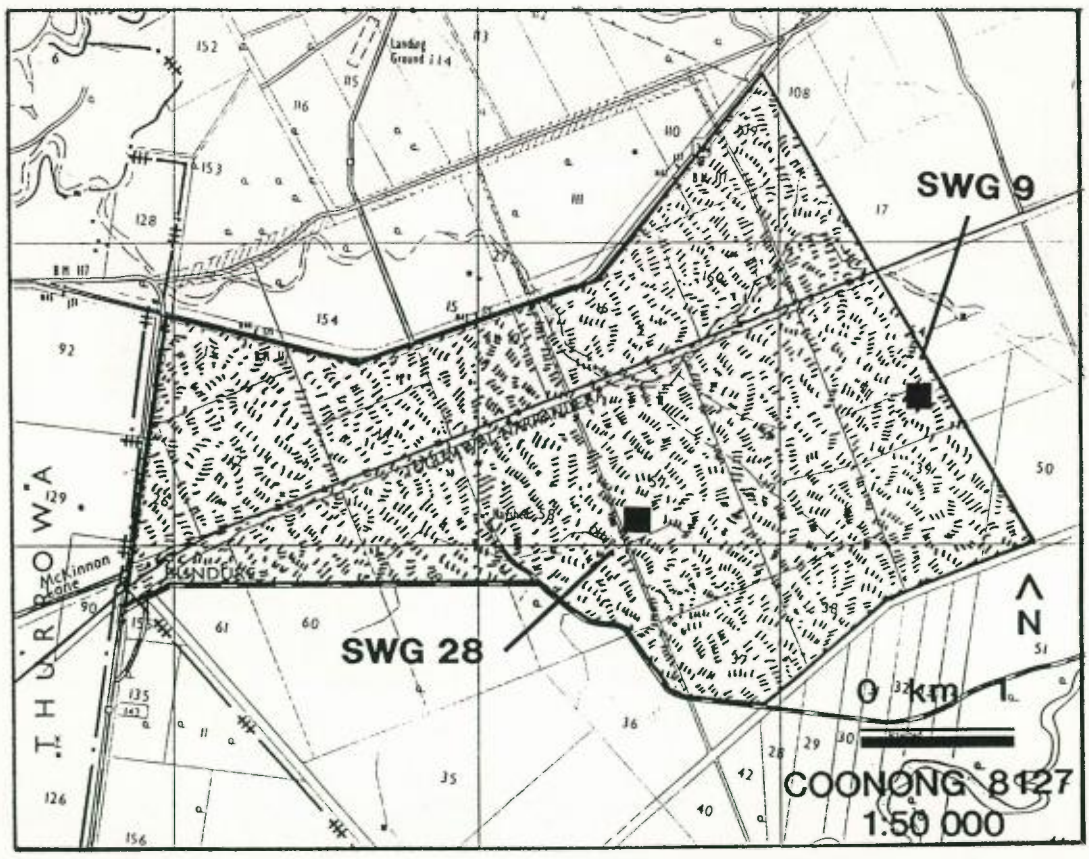

Figure 20. Bundure Siding, "Coonong" which contains large areas of Communities 1a and 3.

5. "North Yathong" (Figure 21)

Sample sites: SWG 2, 27 and 38; Chappell and Luke (1994) C 8-C 13; Appleby *et al.* (1991) A 8-A 11.
Plant community: 1a.
Location: Urana-Jerilderie road reserve, Elliot Lane road reserve and some patches on private land, 24 km west of Urana near "North Yathong".
Size: NA.
Significant species: A number of populations of *Swainsona plagiotropis* (3VCi) and one population of *Sclerolaena napiformis* are present in the area. The Plains-wanderer has been recorded on "North Yathong".
Other significant features: Extensive grasslands occur in the area with road reserves providing protection from overgrazing of grasslands. The native yam, *Microseris lanceolata*, once common on the plains was located only once during the survey at SWG27.
Land tenure/ownership: Road reserves and private land.
Current management: Travelling stock on road reserves; stock grazing on private land; some cultivation.
Threats: Increased grazing pressure or cultivation.
Recommendations: Conservation agreements for key sites.

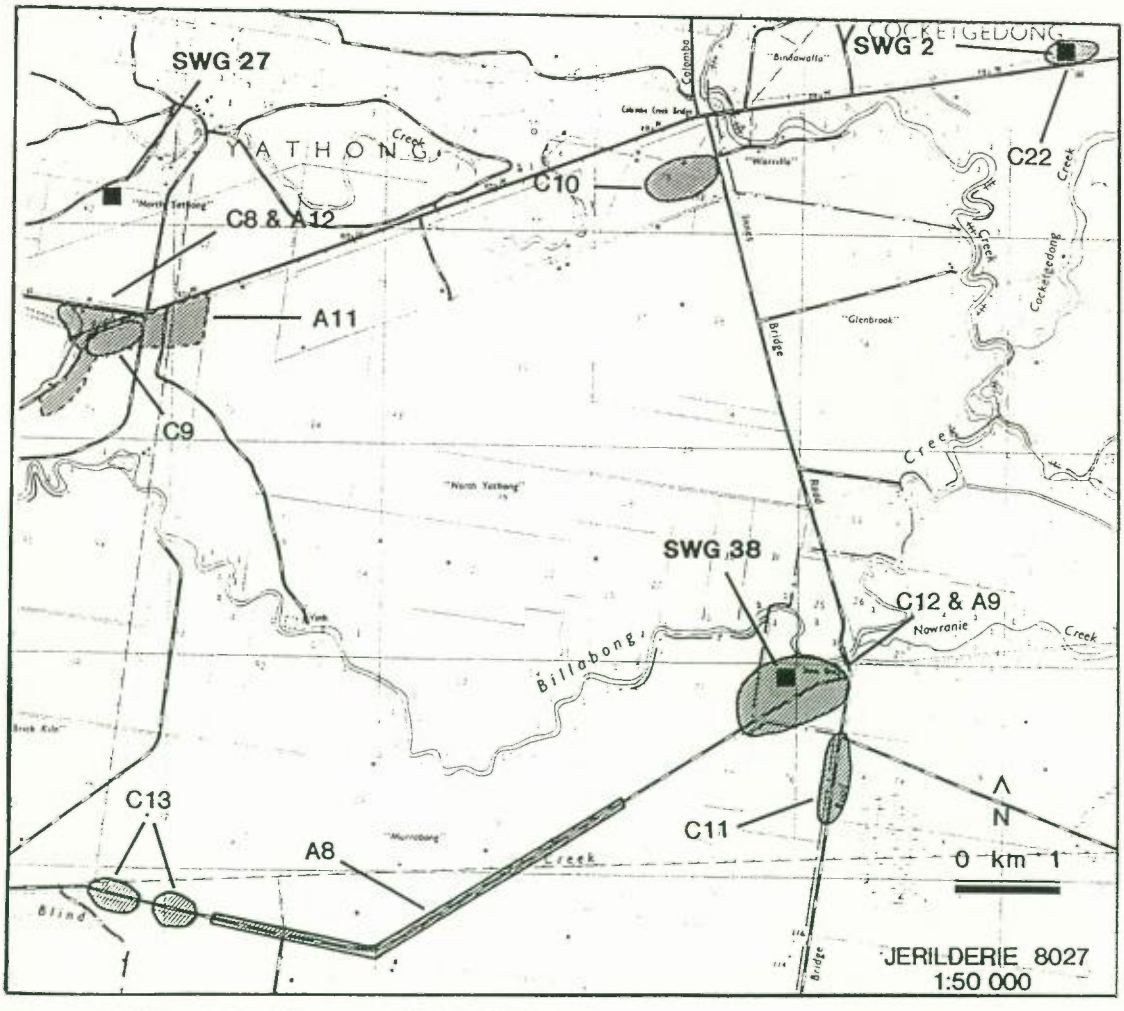

Figure 21. Sites of significance at "North Yathong".

6. "Cocketgedong" and environs (Figure 22)

Sample sites: SWG 4, 19 & 32; Chappell and Luke (1994) C 14 and 22; A. Slee collection 1988.
Plant community: 1a.
Location: Road reserve along both sides of Urana-Jerilderie Road near "Cocketgedong". Also Cocketgedong TSR and sites to the south of the homestead.
Size: 10 km of road reserve, 30 ha Cocketgedong TSR, two other sites each about 20 ha.
Significant species: Several populations of *Swainsona plagiotropis* have been recorded along the Urana-Jerilderie Road. Chappell and Luke's site C 14 (Cocketgedong TSR) contained a population of about 23 000 *Swainsona plagiotropis* in September 1993. *Scerolaena napiformis* was recorded by Chappell and Luke at C 16 in 1993.
Other significant features: Contains species-rich examples of Community 1a on the road reserves.
Land tenure/ownership: Urana road reserve, Jerilderie Shire; Cocketgedong TSR Rural Lands Protection Board, Urana; Chappell and Luke's site C16 owned by V. Stonnill of "Cocketgedong".
Current management: The road reserve is managed for travelling stock, private lands for grazing.
Threats: Overgrazing and weed invasion.
Recommendations: This section of the Urana-Jerilderie road reserve should be managed under a conservation agreement ensuring the road reserve is managed for light grazing. Stock should not be moved during wet periods nor be camped on the reserve. The *Swainsona plagiotropis* occurrences on private land should be managed as they have been in the recent past - for grazing. Cultivation should not be permitted at locations where significant species occur.

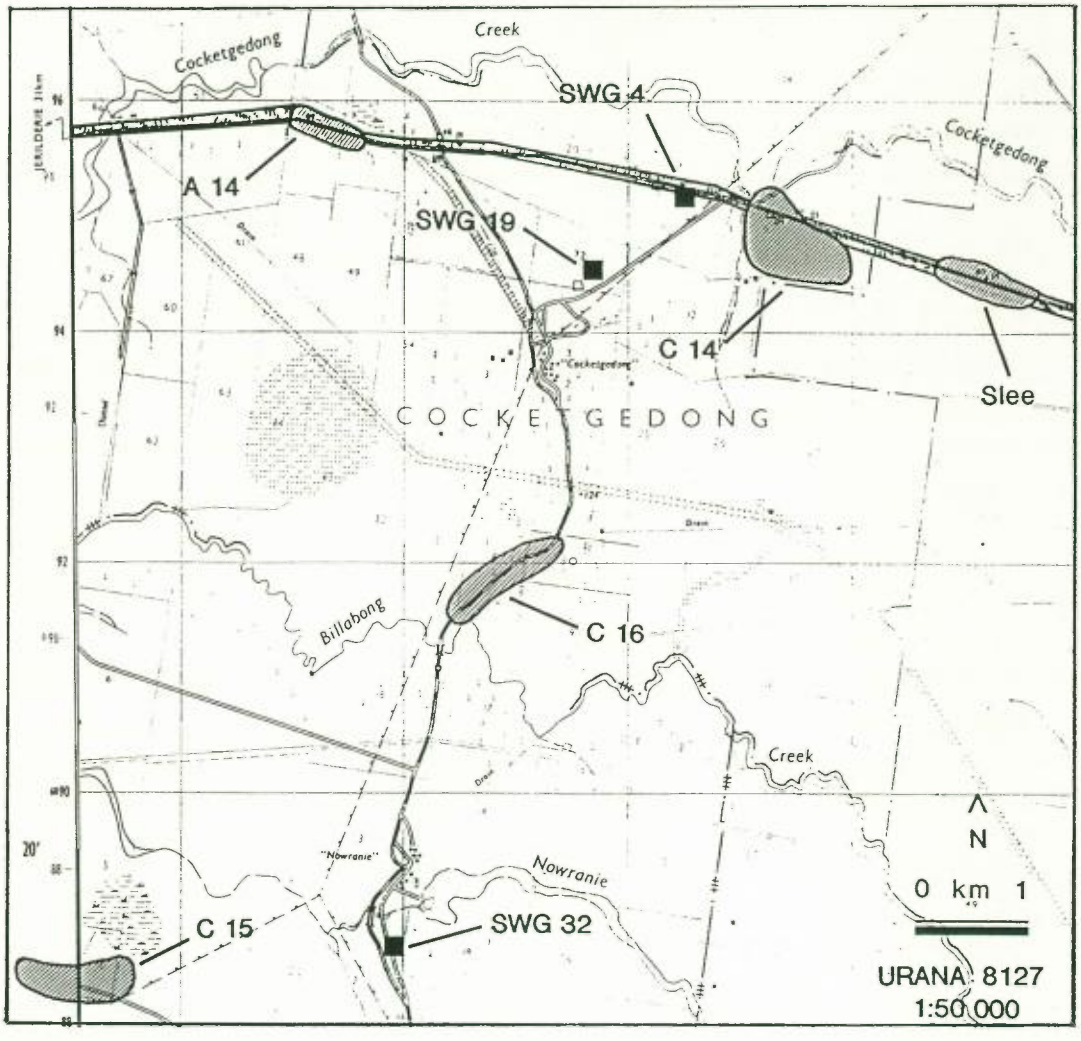

Figure 22. Sites of significance in the "Cocketgedong" area.

7. Coonong Road (Figure 23)

Sample site: SWG 8 (sites SWG 29 and 30 also in the area).
Plant communities: 1a and 3.
Location: Several paddocks on either side of Coonong Road between Colombo Creek and the Urana-Narrandera Road, 5 km north-east of the property "Coonong".
Size: 1000 ha.
Significant species: Outlying occurrence of *Swainsona plagiotropis*. Only record in the survey of *Pogonolepis muelleriana* (Asteraceae). The Plains-wanderer has been regularly recorded in and around "Coonong".
Other significant features: Large area of species-rich native grassland in good condition.
Land tenure/ownership: Private - "Coonong".
Current management: Stock grazing.
Threats: No immediate threat.
Recommendations: Conservation agreement to maintain grazing regime and no cultivation of area.

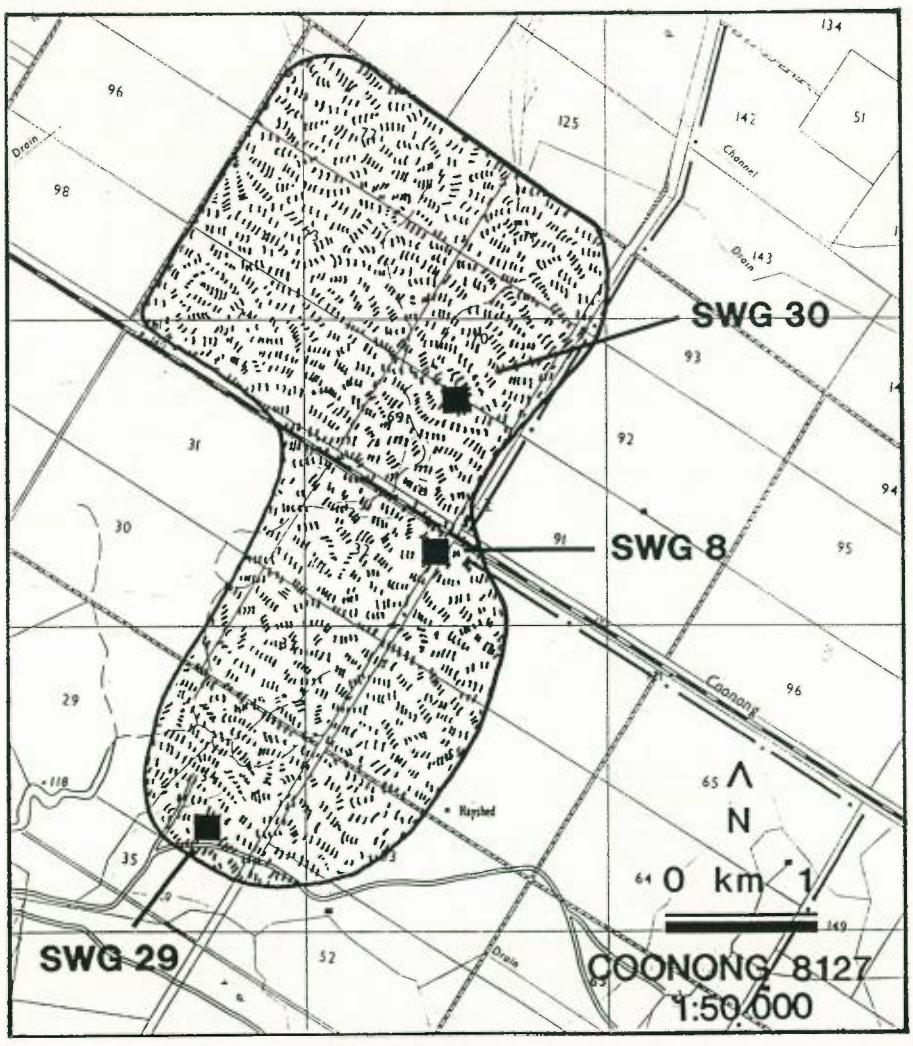

Figure 23. Important grassland along Coonong Road.

8. Warwillah Road (Figure 24)

Sample site: SWG 47.
Plant community: 4.
Location: Land adjoining Warwillah Road, off the Cobb Highway, 60 km north of Conargo.
Size: 750 ha.
Significant species: None.
Other significant features: One of the only areas sampled in Community 4 that was assessed as being in good condition.
Land tenure/ownership: Mostly private land on the property "Warwillah" with the road reserve also containing grassland.
Current management: Stock grazing.
Threats: Pasture improvement.
Recommendations: Area should continue to be managed for grazing but not allowed to be ploughed or cultivated.

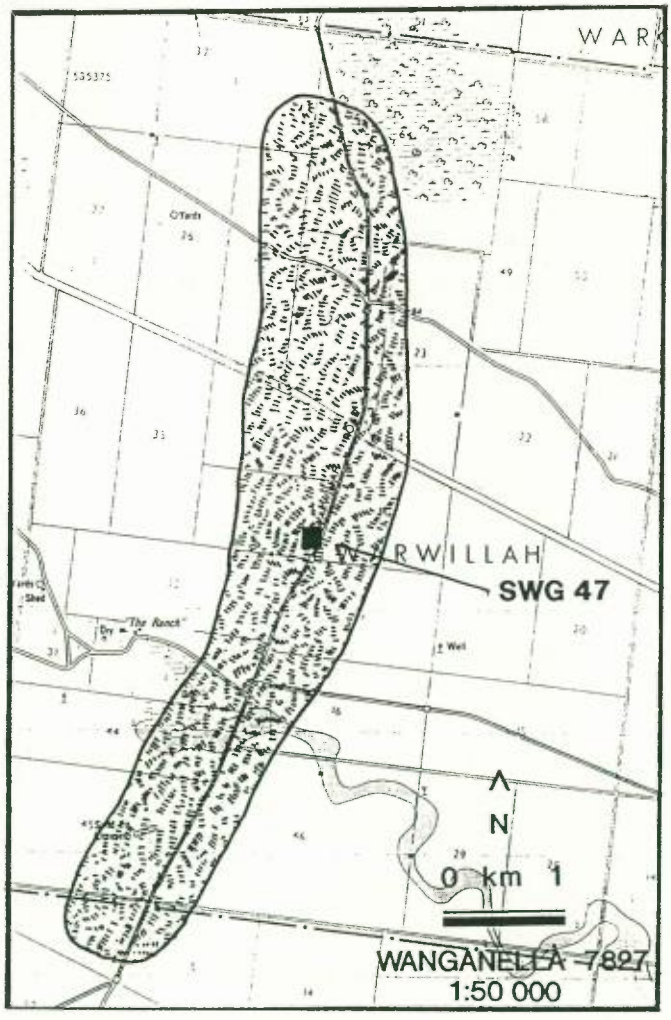

Figure 24. Community 4 grassland along Warwillah Road.

9. Old Urana Road and Billabong Creek (Figure 25)

Sample sites: Chappell and Luke (1994) C6; Appleby *et al.* (1991) A7 and A10.
Plant community: NA.
Location: A7 occupies the northern side of Billabong Creek near "Cannarney", 4 km east of Jerilderie. C6 and A10 are at the same locations on the Old Urana Road 7 km north-east of Jerilderie.
Size: A7 = 100 ha; C6(A10) = 150 ha.
Significant species: *Swainsona plagiotropis*.
Other significant features: Relatively large patches of native grassland.
Land tenure/ownership: Old Urana Road TSR and private -"Cannarney"
Current management: Grazing stock on the private land; moving stock on the TSR.
Threats: Changed grazing regimes.
Recommendations: Conservation agreements with landholders.

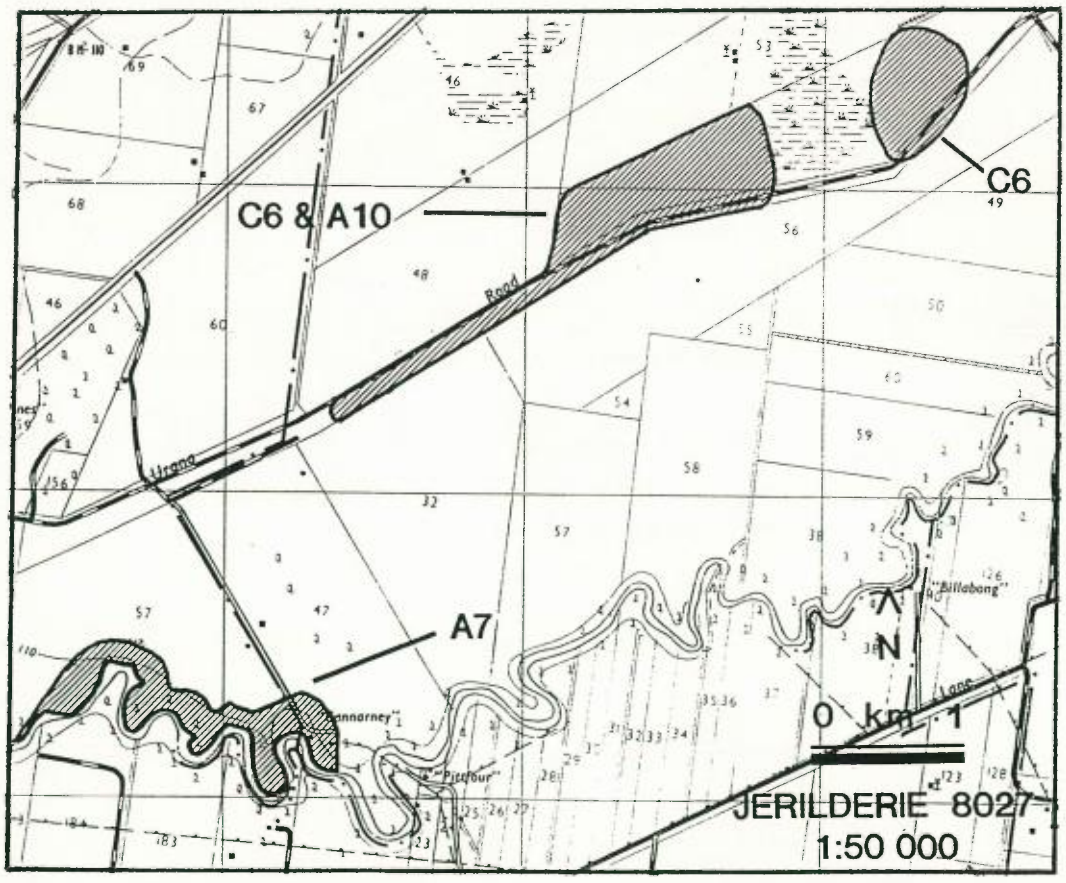

Figure 25. *Swainsona plagiotropis* sites along Old Urana Road and Billabong Creek.

10. Airstrip, Bundure Road - Thurrowa Road (Figures 14 & 26)

Sample site: SWG 13.
Plant community: 1a.
Location: Portions 27 and 28, Parish Bundure, County Urana including surrounds of an airstrip at the junction of Bundure and Thurrowa Roads, 38 km north of Jerilderie.
Size: 125 ha.
Significant species: Plains-wanderer.
Other significant features: Paddock of native grassland in good condition, apparently not over-grazed.
Land tenure/ownership: Unknown; used as an airstrip.
Current management: Grazing and airstrip.
Threats: Pasture improvement may be a threat as nearby paddocks have been improved.
Recommendations: Conservation agreement with the owner to maintain present use of the land.

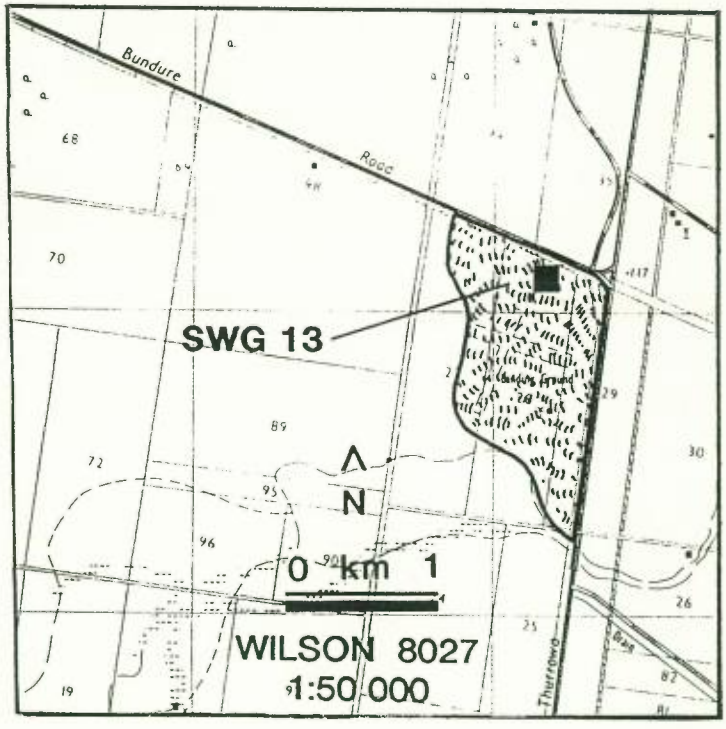

Figure 26. Community 1a grassland around the airstrip on Thurrowa Road.

11. Colombo Creek (Figure 27)

Sample site: SWG 21.
Plant community: 1a.
Location: 1 km north-west of the "Cocketgedong" access road, 3 km south of Colombo Creek, 30 km north-east of Jerilderie.
Size: 125 ha.
Significant species: Plains-wanderer has also been recorded at this site.

Other significant features: A large area of species-rich native grassland in good condition.
Land tenure/ownership: Private - "Cocketgedong".
Current management: Stock grazing.
Threats: Pasture improvement.
Recommendations: Conservation agreement to maintain present management.

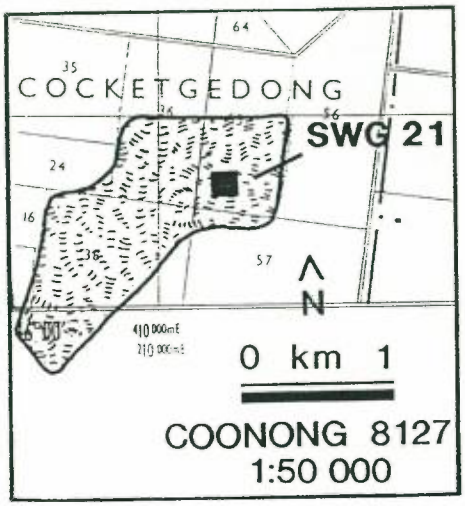

Figure 27. Community 1a grassland on "Cocketgedong" near Colombo Creek.

12. Oaklands (Figure 28)

Sample site: SWG6.
Plant community: 3.
Location: Small outlying grassland remnant 8 km west of Daysdale, 10 km south of Oaklands, 32 km south of Urana.
Size: 50 ha.
Significant species: Only collection of *Myriocephalus stuartii* (Asteraceae) in the survey.
Other significant features: Outlying remnant in good condition
Land tenure/ownership: Road reserve.
Current management: Road reserve is lightly grazed and surrounded by cultivated fields.
Threats: Weed invasion, dumping of road soil.
Recommendations: The site should be brought to the attention of the Corowa Shire.

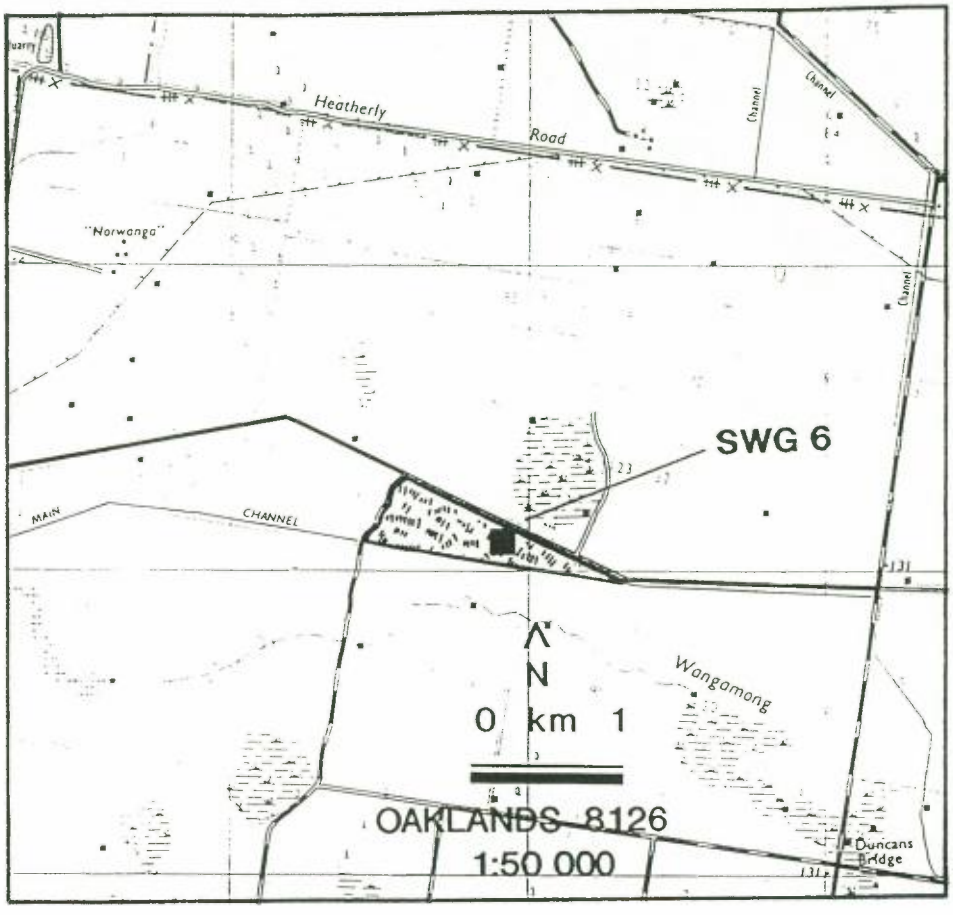

Figure 28. Community 3 near Oaklands, a small remnant south-east of the major grassland areas.

13. Bullenbong Plain (Figure 29)

Sample site: SWG67.
Plant community: 3.
Location: Lockhart-Wagga Wagga road reserve at Bullenbong Plain, 30 km east of Lockhart.
Size: Small, 5 ha of road side.
Significant species: Only collection of *Dichondra* sp. A during the survey and one of two collections of *Eclipta platyglossa*.
Other significant features: Outlying eastern grassland remnant.
Land tenure/ownership: City of Wagga Wagga - road reserve. Private land on adjoining plain.
Current management: Road reserve.
Threats: Weed invasion, road-widening.
Recommendations: Alert Wagga Wagga City. Further surveys of Bullenbong Plain required.

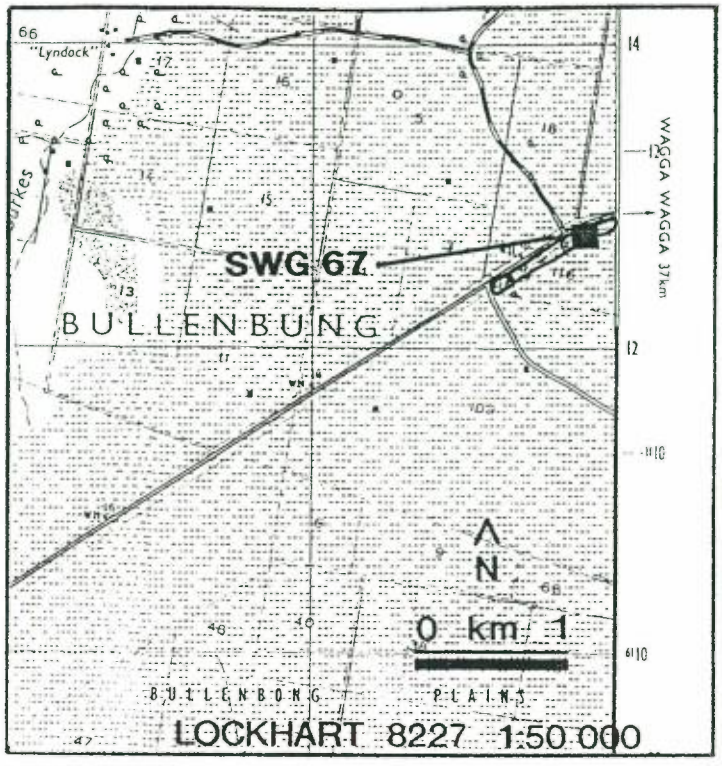

Figure 29. Community 3 grassland at Bullenbong Plain north-east of Lockhart.

Relationship of native grassland with Plains-wanderer sites

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). 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 and Higgins 1993).

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 and 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 them (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 5 lists these sites, the type of Plains-wanderer habitat as defined by Maher (1996), and their structure and vegetation community as defined in this study. Based on the structural criteria of Baker-Gabb *et al.* (1990), 17 of the 67 sample sites qualified as Plains-wanderer habitat. However, these two subsets of the data only overlapped for 3 sites - SWG 29, 42 and 49. Maher (1996) classified these sites as:

- suitable habitat in March/April 1995, with concurrent sightings (SWG 29);
- suitable habitat in March/April 1995 (SWG 42);
- Plains-wanderer recorded 1982-1995 (SWG 49).

There are no definitions in Maher (1996) regarding habitat type, nor is there adequate description of the habitat assessment procedure. It is difficult, therefore, to explain the seemingly anomalous structure measured in Spring 1995.

One hundred and twenty seven plant species (130 taxa) from 35 families were recorded from these 21 sites (Appendix 3). Baker-Gabb (1990) reported 20 "common plant species" recorded in 186 quadrats from Riverina grasslands occupied by Plains-wanderers (Appendix 3). These 20 species represented 9 families that are widespread in grassland communities - the majority were grasses, chenopods and daisies. The discrepancy between the floristics reported for our 21 sites and Baker-Gabb's 186 sites may be due to a combination of differing methodology, expertise and timing. However, their relative contribution cannot be assessed as Baker-Gabb (1990) does not report on methodology.

Site	Plains-wanderer habitat type (from Maher 1996)	Structure October 1995			Comm.
		Layer	Hgt (m)	% Cover	
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	

Table 5. Structure and vegetation community of Plains-wanderer sites.

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". The grassy woodland of Community 2 is restricted to deeper, sandy soils in the eastern part. It appears that he main environmental determinants of species and grassland community distribution are soil type, rainfall and hydrology. All grasslands occur on clay soils but these soils 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, 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 reserve and road reserves, suggests that these areas have not been continuously heavily grazed or cultivated. Continuous grazing continues to threaten 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" confirms their threatened ranking in the region.

However, rarity cannot be adequately assessed from one survey as many of the species on the Riverine Plain 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 Figures 30 and 31 showing the Council-owned paddock adjoining 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 and 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 past 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 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.

The structural and floristic vegetation data from our survey shed little light on the habitat of the Plains-wanderer, probably because the floristic and structural measurements were not made at the same time as the observation of the birds. Vegetation structure changes over time, and so it is not altogether surprising that sites where Plains-wanderers had been sighted 18 months previously did not display the "ideal" number of layers or density.

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

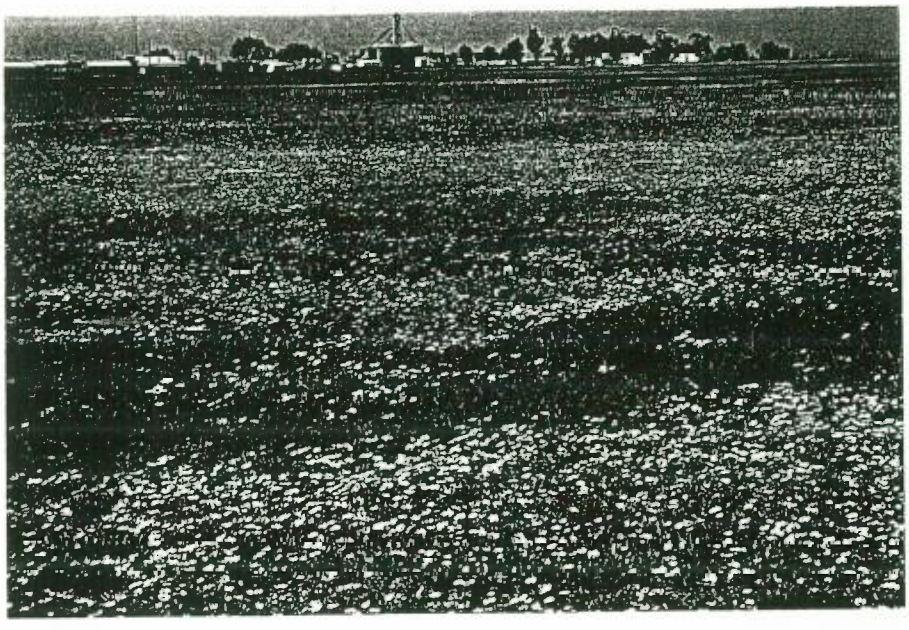

Figure 30. Paddock on the western side of Jerilderie owned by Jerilderie Shire Council photographed in October 1995. Cape weed (*Arctotheca calendula*) was abundant and the native grasses were very short. Photo M. Porteners.

Figure 31. The same Council-owned paddock shown in Figure 30 in October 1991. Cape weed is not abundant and tall native grasses dominate the grassland. Photo J. Benson.

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 a good predictors of Plains-wanderer habitat.

Using Baker-Gabb's structural criteria, 17 sites were identified as potential Plains-wanderer habitat. However, only 3 of these corresponded with areas identified by Maher (1996) as Plains-wanderer habitat. Also, of the 21 Plains-wanderer sites measured, only 3 displayed the structural characteristics defined by Baker-Gabb *et al.* (1990). This difference probably reflects a difference in methodology as well as the temporal complication. Therefore, a structural classification based on this survey does not produce reliable predictors of Plains-wanderer habitat.

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 their is a demand for increased production of this crop. Rice farming is intensive agriculture requiring major earthworks to build paddy fields (Figure 32), 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 more "natural" native grasslands, exotic species made up a significant proportion of the flora.

There is increased salinization 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 are biannual or short-lived perennial (Leigh and 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 SWG3. Certain regimes of grazing may benefit some native grasslands that have adjusted to them 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 a limited degree of grazing or burning. Large properties such as "Coonong", "Boonoke" and "Cocketgedong" are generally not over-stocking their native grasslands. Diez and Foreman (1996) recommend that appropriate grazing regimes should continue where they have been in the past or be lowered in intensity. 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 soils in the region and 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 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 kill 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 occurrence of these sites. The placement of a communications tower by the Australian Navy in the important "Morundah" site could effect the grassland through disturbances associated with burning, mowing and road construction. It would be best if the tower could be placed in the paddock to the north of its present proposed location.

Figure 32. 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 J. Benson.

Conservation of native grasslands

Recommendations for sites of botanical significance are summarised in Table 4. Most of the native grassland in the region is being managed for extensive grazing. In some cases this be compatible with native grassland conservation. Conflict arises where native grasslands are ploughed, over-fertilised or over-grazed. The Draft Western Riverina Grassland Management Plan recognises the importance of native grasslands for production and also states that sites of scientific importance should be protected. This Plan should be amended to stipulate more clearly how native grassland will be managed and protected in the region. It could also be amended to incorporate the results of this botanical survey, the Plains-wanderer survey (Maher 1996) and the management guidelines of Diez and Foreman (1996). Given that the majority of the region is used for grazing domestic stock, minimal stocking rate grazing should be encouraged. For this to succeed, Pickard (1994) argues that

grazing enterprises in inland NSW must be economically viable; only then will they be able to afford to spend funds on nature conservation.

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. Both the TSRs and 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. We have not mapped out the distribution of the described native grassland communities because it is difficult to discriminate between a native grassland and an exotic pasture from aerial photos or LANDSAT images. It is possible, however, to map out where grassland (in the general sense) occurs from LANDSAT images (trials for the Urana and Jerilderie 1:100 000 map sheets were done, not included here). Some grassland communities are restricted to parts of the region and so could more easily be 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 some 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 sites of botanical significance, thereby assisting the development of plans for grassland conservation.

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 change 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.

It is more likely that a native grassland conservation program would achieve its objectives with the involvement of the local community. This has already commenced as a consequence of SEPP 46, 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 and research results. An educational booklet on outlining the values of the native grasslands of the Riverine Plain would assist to publicise the benefits of conserving indigenous species.

Expenditure of grant funds

A total of $50 300 was provided in a grant to assist with this survey by the Australian Nature Conservation Agency. Most of these funds were spent on the salary of a botanist who assisted with the field survey and species identification. Other funds were spent on purchasing maps, LANDSAT images, film, field equipment and travelling allowance for the participants of the survey.

Salary of temporary botanist (including on-costs)..... **$41,318**

Travel allowance for field work spring 1995..... **$6,554**

Maps, LANDSAT 1:100 000 images, field equipment **$2 428**

Total **$50 300**

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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	1 km 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 road 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 SF
*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"

Site	East	North	Map	Location Description
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.

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
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

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
**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*							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

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
Caryophyllaceae							
**Spergularia rubra*	21				27		18
Casuarinaceae							
Allocasuarina verticillata			100				1
Centrolepidacea							
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

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
Euphorbiaceae	33	47			33		31
Chamaesyce drummondii							
Fabaceae - Faboideae	17	18		14	47		22
**Medicago polymorpha*		6					1
**Medicago praecox*	67	88		57	87	33	73
**Medicago truncatula*	33	18	100	X			18
Swainsona behriana[Ext]	46	29		29		33	28
Swainsona murrayana[ROTAP,Vic]	4			14			3
Swainsona plagiotropis[ROTAP,Vic]	21	12		29		100	18
Swainsona procumbens							
Swainsona sericea[A]		X			X		
Swainsona swainsonioides[Vic]	4	6					3
**Trifolium angustifolium*	38	24	100	86	13		33
**Trifolium arvense*				14			1
**Trifolium campestre*	25			43			13
**Trifolium glomeratum*	4						1
**Trifolium hirtum*				29		33	4
**Trifolium repens*	4			14			3
**Trifolium subterraneum*	4	6		29	7		7
**Trifolium tomentosum*							
Fabaceae - Mimosoideae							
Acacia homalophylla[A]	X	6			X	X	1
Acacia pendula[Vic]							
Gentianaceae	X						
**Cicendia quadrangularis*							
Geraniaceae	21	12			53		22
**Erodium cicutarium*	17	29	100	29	40		27
Erodium crinitum	X						
**Erodium malacoides*							
Goodeniaceae	79	65		57	33		58
Goodenia fascicularis	13	6	100		7		9
Goodenia pinnatifida	67	53	100	29	33		49
Goodenia pusilliflora							
Haloragaceae						67	3
Myriophyllum crispatum							
Hypoxidaceae	21	18		28	7		16
Hypoxis glabella var. *glabella*							
Iridaceae	21	18					12
**Gynandriris setifolia*	29	12	100		13		18
**Romulea minutiflora*	50	53		71	13		42
**Romulea rosea*							

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
Juncaceae				14		33	3
Juncus aridicola						67	3
**Juncus articulatus*	4			14			3
**Juncus bufonius*	17			29		67	12
Juncus radula							
Juncaginaceae						33	1
Triglochin procerum							
Lamiaceae		6					1
**Marrubium vulgare*	17	41		14	13	67	24
Teucrium racemosum							
Lentibulariacea						33	1
Utricularia dichotoma							
Linaceae	17			14	7		9
Linum marginale							
Lobeliaceae				14			1
Pratia concolor							
Lomandraceae	4		100				3
Lomandra effusa							
Lythraceae	4					33	3
**Lythrum hyssopifolia*							
Malvaceae							
**Malva parviflora*	88	88		29	73	33	75
Sida corrugata		6					1
Sida trichopoda							
Marsileaceae						100	4
Marsilea drummondii							
Myoporaceae			100				1
Eremophila longifolia							
Nitrariaceae	X	X					
Nitraria billardierei							
Ophioglossaceae							
Ophioglossum lusitanicum subsp. *coriaceum*[A]							
Orchidaceae			X				
Diuris dendrobioides s. lat.[Ext]			X				
Diuris lanceolata[Ext]			100				1
Prasophyllum campestre							

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
Oxalidaceae	58	35	100	57	47		48
Oxalis perennans							
Phormiaceae			X				
Dianella longifolia var. *porracea*							
Plantaginaceae	13						4
**Plantago coronopus* subsp. *commutata*	13	12		14	7		10
Plantago cunninghamii	4	29			7		10
Plantago drummondii	4						1
Plantago gaudichaudii	4			14			3
Plantago hispida	13	12			7		9
Plantago turrifera							
Poaceae	8	12			7	100	12
Agrostis avenacea var. *avenacea*	17		100				7
**Aira elegantissima*	13	6		29		67	12
**Alopecurus geniculatus*	X			14			1
Amphibromus macrorhinus			100				1
Aristida jerichoensis var. *jerichoensis*	42	59	100	43	87		55
**Avena fatua*	17			43		33	12
**Briza minor*	X						
**Bromus diandrus*	13				7		6
**Bromus molliformis*	92	71		43	20	33	61
Chloris truncata							
Chloris ventricosa[A]	50	29		14		33	33
Danthonia caespitosa		18			7	67	9
Danthonia duttoniana	33	6	100	14	27		22
Danthonia eriantha				14			1
Danthonia laevis	4	12		14	33		13
Danthonia linkii var. *fulva*	4	18		29	7		10
Danthonia linkii var. *linkii*	4	18		14	7		9
Danthonia setacea	25	41		57	73		42
Enteropogon ramosus					X	67	3
Eragrostis australasica					X		
**Eragrostis cilianensis*				14			1
Eulalia aurea		6		14			3
**Holcus lanatus*	25	24		86	40	67	36
Homopholis proluta	17	12		14	40	33	21
**Hordeum leporinum*	88	100		86	93	67	90
**Lolium rigidum*			X				
Monachather paradoxa	4					33	3
**Pentaschistis airoides*				14	27		7
**Phalaris aquatica*	17	6					7
**Rostraria cristata*	8	29			7		12
Sporobolus caroli[Vic]	4	6		71		33	12
Stipa aristiglumis	13	X		14			6
Stipa bigeniculata			100				1
Stipa eremophila	92	88		14	73		73

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
Stipa nodosa			X	14			1
Stipa setacea[Vic]			100				1
Themeda australis			100				1
Thyridolepis mitchelliana				14	7		3
**Vulpia bromoides*	17	6		14	7		10
**Vulpia muralis*	4	12			20		9
**Vulpia myuros*							
Polygonaceae		6		43			6
Rumex dumosus				14		33	3
Rumex tenax							
Portulacaceae	4						1
Calandrinia eremaea							
Primulaceae				14			1
**Anagallis arvensis*							
Proteaceae			100				1
Hakea tephrosperma[Vic]							
Ranunculaceae		X				33	1
Myosurus minimus var. *australis*	4						1
Ranunculus pachycarpus		6		43	7	67	10
Ranunculus pentandrus var. *platycarpus*				14			1
Ranunculus pumilio var. *politus*	4						1
Ranunculus sessiliflorus var. *pilulifer*							
Rosaceae	X			14			1
Aphanes australiana							
Rubiaceae	50	29		86	7		36
Asperula conferta							
Scrophulariaceae	29		100	43			16
**Parentucellia latifolia*						33	1
**Veronica peregrina*							
Sinopteridaceae	4		100				3
Cheilanthes sieberi subsp. *sieberi*							
Solanaceae	17	18			7		12
Solanum esuriale							
Stackhousiaceae			100				1
Stackhousia monogyna							
Stylidiaceae			100				1
Levenhookia dubia						33	1
Stylidium despectum							

Botanical Name	Grassland Community (number of sites)						Overall (67)
	1a (24)	1b (17)	2 (1)	3 (7)	4 (15)	5 (3)	
Thymelaeaceae			100				1
Pimelea micrantha							
Zygophyllaceae					7		1
Zygophyllum glaucum							

Appendix 3. Plant species recorded in 21 Plains-wanderer sites. Introduced species are indicated by an asterisk; species recorded as common in 186 Plains-wanderer sites by Baker-Gabb (1990) are indicated by B-G. Baker-Gabb also reported *Maireana cheelii, Sida trichopoda* and *Eriochlamys behrii* (none of which were recorded in this survey), and *Stipa variabilis* complex, which has been subsequently split into several *Stipa* species.

Botanical Name	No. Sites
Amaranthaceae	
Alternanthera denticulata	4
Ptilotus exaltatus var. *exaltatus*	14
Ptilotus spathulatus	4
Anthericaceae	
Arthropodium minus	4
Dichopogon fimbriatus	1
Apiaceae	
Daucus glochidiatus form G	14
Eryngium plantagineum	1
Eryngium rostratum	2
Asphodeliaceae	
Bulbine bulbosa	5
Bulbine semibarbata	2
Asteraceae	
Actinobole uliginosum	1
**Arctotheca calendula*	12
Brachycome curvicarpa	5
Brachycome lineariloba [B-G]	1
Calocephalus citreus	1
Calocephalus sonderi [B-G]	9
Calotis anthemoides	1
Calotis hispidula	2
Calotis scabiosifolia var. *scabiosifolia*	11
**Carthamus lanatus*	2
Chrysocephalum apiculatum	18
**Cirsium vulgare*	4
**Cotula bipinnata*	11
**Hedypnois rhagadioloides* subsp. *cretica*	7
Hyalosperma glutinosum subsp. *glutinosum*	14
**Hypochaeris glabra*	17
Isoetopsis graminifolia	9
Leptorhynchos elongatus	1
Leptorhynchos panaetioides	5
Leptorhynchos squamatus subsp. A	5
Leucochrysum molle	5
Myriocephalus rhizocephalus	9
**Onopordum acaulon*	1
Pogonolepis muelleriana	1
Rhodanthe corymbiflora [B-G]	20
Rhodanthe pygmaeum	6
**Sonchus asper* subsp. *glaucescens*	2

Botanical Name	No. Sites
**Sonchus oleraceus*	3
Stuartina muelleri	1
Triptilodiscus pygmaeus	11
Vittadinia cuneata var. *cuneata*	3
Vittadinia cuneata var. *hirsuta*	1
Boraginaceae	
**Echium plantagineum*	5
Brassicaceae	
**Rapistrum rugosum*	1
Campanulaceae	
Wahlenbergia gracilenta	2
Wahlenbergia gracilis	7
Wahlenbergia luteola	1
Wahlenbergia stricta subsp. *alterna*	2
Caryophyllaceae	
**Spergularia rubra* [B-G]	4
Chenopodiaceae	
Atriplex leptocarpa [B-G]	4
Chenopodium desertorum subsp. *virosum*	1
Maireana aphylla	9
Maireana excavata	15
Maireana pentagona [B-G]	19
**Salsola kali*	1
Sclerolaena muricata var. *semiglabra*	1
Sclerolaena muricata var. *villosa*	2
Colchicaceae	
Wurmbea dioica subsp. *dioica*	14
Convolvulaceae	
Convolvulus erubescens [B-G]	4
Crassulaceae	
Crassula colorata	15
Crassula decumbens var. *decumbens*	9
Euphorbiaceae	
Chamaesyce drummondii	8
Fabaceae	
**Medicago polymorpha* [B-G]	4
**Medicago truncatula*	14
Swainsona behriana	6
Swainsona murrayana	5
Swainsona plagiotropis	1
Swainsona procumbens	2
**Trifolium arvense*	6

Botanical Name	No. Sites
**Trifolium glomeratum*	5
**Trifolium hirtum*	1
**Trifolium subterraneum*	1
**Trifolium tomentosum*	2
Geraniaceae	
**Erodium cicutarium*	4
Erodium crinitum	10
Goodeniaceae	
Goodenia fascicularis [B-G]	13
Goodenia pinnatifida	2
Goodenia pusilliflora [B-G]	14
Hypoxidaceae	
Hypoxis glabella var. *glabella*	6
Iridaceae	
**Gynandriris setifolia*	2
**Romulea minutiflora*	2
**Romulea rosea*	7
Juncaceae	
**Juncus bufonius*	1
Juncus radula	2
Lamiaceae	
Teucrium racemosum	5
Linaceae	
Linum marginale	1
Lomandraceae	
Lomandra effusa	1
Lythraceae	
**Lythrum hyssopifolia*	1
Malvaceae	
Sida corrugata	15
Oxalidaceae	
Oxalis perennans	9
Plantaginaceae	
**Plantago coronopus* subsp. *commutata*	2
Plantago cunninghamii [B-G]	3
Plantago hispida	1
Plantago turrifera	3

Botanical Name	No. Sites
Poaceae	
Agrostis avenacea var. *avenacea*	2
**Aira elegantissima*	2
**Alopecurus geniculatus*	3
**Avena fatua*	14
**Briza minor*	3
**Bromus molliformis*	4
Chloris truncata [B-G]	13
Danthonia caespitosa [B-G]	8
Danthonia eriantha	8
Danthonia linkii var. *fulva*	2
Danthonia linkii var. *linkii*	1
Danthonia setacea	3
Enteropogon ramosus	10
Eulalia aurea	1
Homopholis proluta	9
**Hordeum leporinum* [B-G]	1
**Lolium rigidum*	19
**Pentaschistis airoides*	1
**Rostraria cristata*	3
Sporobolus caroli [B-G]	1
Stipa aristiglumis	3
Stipa bigeniculata	3
Stipa nodosa	17
Stipa setacea	1
**Vulpia bromoides*	1
**Vulpia muralis*	4
**Vulpia myuros* [B-G]	3
Polygonaceae	
Rumex dumosus	1
Ranunculaceae	
Ranunculus pachycarpus	1
Ranunculus pentandrus var. *platycarpus*	3
Ranunculus pumilio var. *politus*	1
Rosaceae	
Aphanes australiana	1
Rubiaceae	
Asperula conferta	9
Scrophulariacea	
**Parentucellia latifolia*	6
Sinopteridaceae	
Cheilanthes sieberi subsp. *sieberi*	1
Solanaceae	
Solanum esuriale	2