Ecological character description:
Lake Pinaroo Ramsar site







Australian Government
Department of the Environment, Water, Heritage and the Arts

Department of Environment & Climate Change NSW

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Cover photos

Inset upper: Lake Pinaroo in flood, 1976 (DECC)
Aerial: Lake Pinaroo in flood, March 1976 (DECC)
Inset lower left: Blue-billed duck (R. Kingsford)
Inset lower middle: Red-necked avocet (C. Herbert)
Inset lower right: Red-capped plover (C. Herbert)

Summary

An ecological character description has been defined as 'the combination of the ecosystem components, processes, benefits and services that characterise a wetland at a given point in time'. Lake Pinaroo was listed as a Ramsar site on 19 March 1996. The Australian Government is required to describe the ecological character of a Ramsar site at the time of listing. This document summarises the ecological information available for this site.

Lake Pinaroo Ramsar site is located in Sturt National Park, in far north-western New South Wales. It is in the Lake Eyre drainage division, which is one of the largest systems in the world and is characterised by extreme climatic variability, which includes high rates of evaporation, erratic flood periods and extended dry periods. These conditions have promoted biodiversity in the region. A total of 193 bird, 31 mammal, 67 reptile and nine amphibian native species have been recorded in Sturt National Park. This Ramsar site has extremely high cultural values, with a large number of Aboriginal sites and remains from European exploration and settlement.

Lake Pinaroo is found within the Simpson–Strzelecki Dunefields biogeographic region and is listed as a rare wetland type. Lake Pinaroo is the largest terminal basin found within NSW in this biogeographic region. The size of the lake and its capacity to retain water for extended periods play an important role for the survival of many species of plants and animals in the immediate and surrounding areas. Twelve species of threatened fauna have been recorded at Lake Pinaroo.

This site is also important for migratory shorebirds, which are protected under international conventions and bird agreements. Lake Pinaroo acts as an important stopover site for migratory shorebirds during their non-breeding season, when they are travelling to and from their breeding sites in the northern hemisphere. Four migratory shorebird species have been recorded at Lake Pinaroo and seven species have been recorded within Sturt National Park. Lake Pinaroo acts as a drought refuge for at least 40 waterbird species; it is also important for waterbird breeding and can support populations of waterfowl during flood periods, including the Freckled Duck (*Stictonetta naevosa*) and Blue-billed Duck (*Oxyura australis*), both of which are threatened in NSW.

Key threats to the Lake Pinaroo Ramsar site are climate change and introduced plant and animal species. Compliation of this ecological character description was hindered by the lack of ecological data available for the Lake Pinaroo Ramsar site; the main recommendation is to address significant knowledge gaps for this wetland. Monitoring the extent and frequency of inundation and waterbird abundance are potential indicators for detecting negative changes to the ecological character of the Lake Pinaroo Ramsar site.

Ecological character description of the Lake Pinaroo Ramsar site

Site name	**Lake Pinaroo**
Location	The Lake Pinaroo Ramsar site is located in Sturt National Park, in far north-west NSW, approximately 80 km north-west of Tibooburra and 24 km south-east of Cameron Corner.
Grid coordinates	29°06'S, 141°13'E
Area	718.8 ha (total area was revised from 800 ha used in the original listing, as technology now allows for a higher resolution and more accurate determination of site area; the boundary of the site has not been changed from the time of listing)
Date of listing as a Ramsar site	19 March 1996
Ramsar criteria	Criteria 1, 2, 3 and 4
Date at which this description applies	The description is for the time of listing.
Management authorities	NSW National Parks and Wildlife Service (Western Region, Tibooburra District), Department of Environment and Climate Change NSW
Status of description	This is the first description of the ecological character of the Lake Pinaroo Ramsar site.
Name of compilers	Jennifer Spencer, John Porter, Joanne Ling, Kerrylee Rogers and Jane Jelbart Water and Catchments Section Department of Environment and Climate Change NSW 59–61 Goulburn Street Sydney NSW 2000
Date of compilation	June 2007
Reference for Ramsar Information Sheet	Lake Pinaroo Ramsar Information Sheet January 1998 Australian Wetlands Database: http://www.environment.gov.au/water/publications/environmental/wetlands/database/
Reference for management plan	NSW National Parks and Wildlife Service (1996). *Sturt National Park Plan of Management*. NSW National Parks and Wildlife Service, Tibooburra Office

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Abbreviations

AusRivAS	Australian Rivers Assessment Scheme
BOM	Bureau of Meteorology
CAMBA	China–Australia Migratory Bird Agreement
DECC	Department of Environment and Climate Change NSW
DSE	Department of Sustainability and Environment Victoria
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
GIS	Geographic Information System
IUCN	International Union for the Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreement
NPWS	National Parks and Wildlife Service
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
TSC Act	*Threatened Species Conservation Act 1995* (NSW)

1 Introduction

Ramsar sites are wetlands of international importance, particularly as waterfowl habitat, listed under the Ramsar Convention (Ramsar, Iran, in 1971). The broad aim of the Convention is to stop the worldwide loss of wetlands and to conserve those that remain through sustainable use and management. Australia addresses its obligations under the Convention through the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Environment Protection and Biodiversity Conservation Regulations 2000, and national, state and territory, and local government wetland policies and natural resource management programs. As a Ramsar Convention signatory, Australia is expected to operate by a system designed to detect any threats that may alter the ecological character of a Ramsar wetland. Therefore, the description of the ecological character of a Ramsar wetland is necessary to establish the baseline condition of a site, so that management and monitoring can prevent negative changes occurring at the site.

1.1 Definition of ecological character

An ecological character description has been defined most simply as a document that describes the living and non-living components of a wetland and how they interact. For a given wetland, it also describes the natural variability and enables limits of acceptable change to be identified (Lambert and Elix 2006).

The Ramsar Convention (Resolution IX.1 Annex A, 9th meeting of the Conference of Parties to the Convention of Wetlands, Uganda, November 2005) defines ecological character and any change in ecological character as follows:

> Ecological character is a combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.
>
> Change in ecological character is the human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service.

Within this context, ecosystem benefits are defined in accordance with the Millennium Ecosystem Assessment (2003) as the benefits that people receive from ecosystems. This definition separates ecosystem services into provisioning, regulating and cultural services, which directly affect people, and supporting services needed to maintain these services (Figure 1).

As a part of the ecological character of a wetland, ecological processes are defined as the dynamic biotic and abiotic interactions within an ecosystem such as primary production, decomposition, carbon and nutrient cycling, sedimentation and provision of habitats for biota; these may or may not provide benefits or services to humans. Components are the physical, chemical and biological components of the system with the latter being defined as habitats, species and genes (Figure 2).

Due to the dynamic nature of wetland ecosystems, there is considerable overlap between the components and processes that make up a wetland's ecological character (see section 3.2).

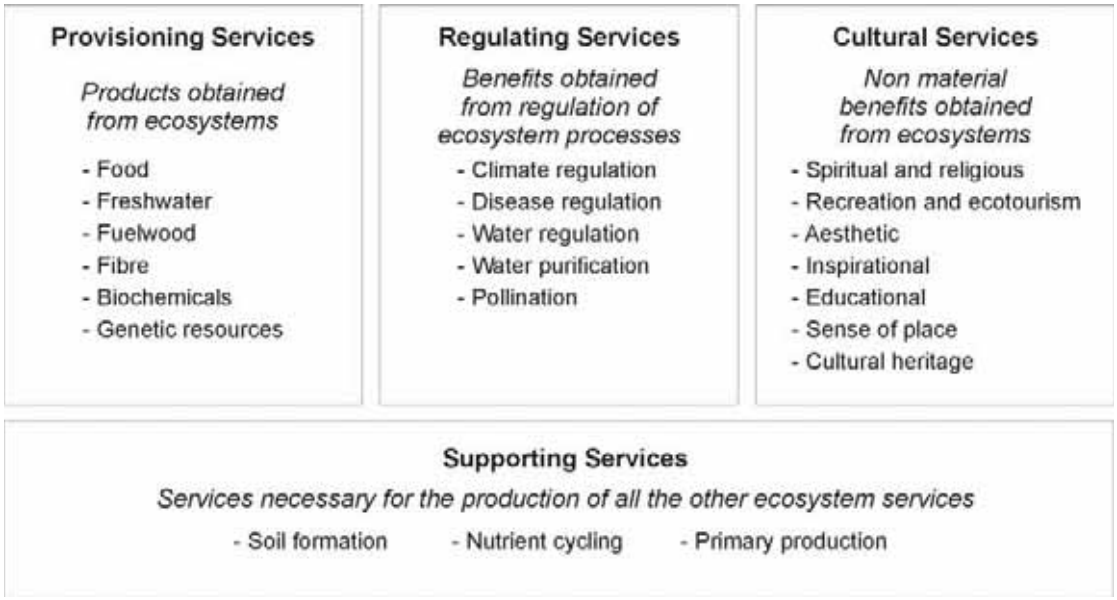


Figure 1: The Millennium Ecosystem Assessment (2003) summary of ecosystem services

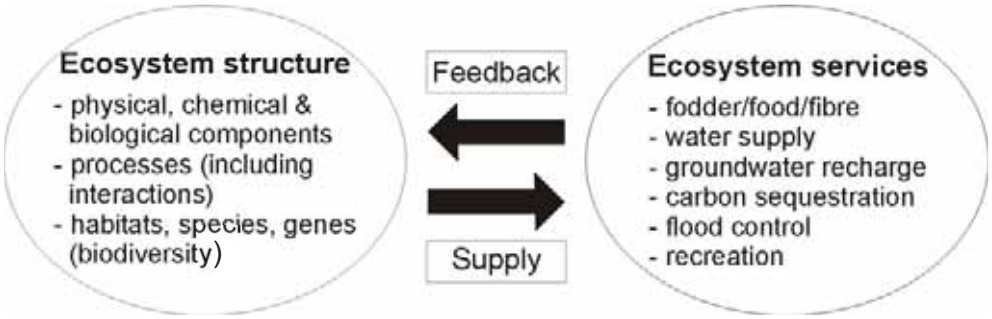


Figure 2: The Millennium Ecosystem Assessment (2003) description of ecosystems

1.2 Reasons for describing ecological character

In 2005, the Department of Sustainability and Environment Victoria (DSE) developed a framework for describing the ecological character of a Ramsar site, using the Barmah Forest Ramsar site as a case study (DSE 2005). Since the original pilot, the process of ecological character description has been underway in several states across a range of Ramsar site types (inland, estuarine and marine). The purpose of the development of ecological character descriptions for Ramsar sites is to assist in implementing Australia's obligations under the Ramsar Convention. In a legal review of the DSE (2005) framework, which has been used to compile subsequent ecological character descriptions, McGrath (2006) summarised these obligations as follows:

- to assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the Environment Protection and Biodiversity Conservation Regulations 2000 (Commonwealth): (a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia; and (b) to formulate and implement planning that promotes: (i) conservation of the wetland; and (ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem
- to assist in fulfilling Australia's obligation under the Ramsar Convention to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar list has changed, is changing or is likely to change as a result of technological developments, pollution or other human interference
- to supplement the description of the ecological character contained in the Ramsar Information Sheet submitted to the Ramsar Convention for each listed wetland, and collectively form an official record of the ecological character of the site
- to assist the administration of the EPBC Act, particularly: (a) to determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act; or (b) to assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland
- to assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval
- to inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

This ecological character description was produced to update the Ramsar Information Sheet for the Lake Pinaroo Ramsar site and to supplement the management plan and other planning documents for the site. This document also provides a condition report for the site and aims to direct future monitoring and management of the Lake Pinaroo Ramsar site.

1.3 Legislative framework

In addition to the protection afforded under the EPBC Act, migratory waterbirds in Australia are also protected under international legislation, which includes migratory bird agreements that Australia has with Japan, China and the Republic of Korea. Migratory species of cranes, Anatidae and shorebirds use the East Asian–Australasian Flyway, which stretches from New Zealand and Australia, through south-east Asia, China and Japan, and north to Siberia and Alaska. Legislation that protects these migratory birds includes the:

- Japan-Australia Migratory Bird Agreement (1981), between the Government of Australia and the Government of Japan (JAMBA)[1]
- China-Australia Migratory Bird Agreement (1988), between the Government of Australia and the Government of the People's Republic of China (CAMBA)[2]
- Republic of Korea–Australia Migratory Bird Agreement (2006), between the Government of Australia and the Government of the Republic of Korea (ROKAMBA)[3]
- Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention)[4], which aims to conserve terrestrial, marine and avian migratory species throughout their range
- Convention on Biological Diversity (Rio de Janeiro 1992),[5] which aims to promote conservation of biological diversity, the sustainable use of its components and the fair and equitable use of genetic resources.

The following NSW legislation also protects the Lake Pinaroo Ramsar site:

- *National Parks and Wildlife Act 1974:* provides for the care, control and management of all national parks, historic sites, nature reserves, reserves, Aboriginal areas and state game reserves. State conservation areas, karst conservation reserves and regional parks are also administered under the Act.
- *Threatened Species Conservation Act 1995* (TSC Act)*:* provides the legislative framework for protecting threatened species, communities and critical habitat in NSW.
- *Environmental Planning and Assessment Act 1979:* provides the legislative framework for the assessment of environmental impacts of proposed activities.

Additional NSW legislation also directs aspects of management within Sturt National Park and may influence management within the Lake Pinaroo Ramsar site. This includes the:

- *Rural Fires Act 1997*
- *Noxious Weeds Act 1993*
- *Rural Lands Protection Act 1998*
- *Heritage Act 1977*.

[1] http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html
[2] http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html
[3] http://www.aph.gov.au/HOUSE/committee/jsct/27february2007/treaties/korea_nia.pdf
[4] http://www.cms.int/
[5] http://www.cbd.int/

1.4 Approach taken

Five essential components were used to compile the ecological character description for the Lake Pinaroo Ramsar site. These were hydrology, geomorphology, climate, physicochemical factors and biota (flora and fauna). There is considerable overlap between these components and processes, which are outlined in more detail in section 3.2.

The approach adopted for the description of the Lake Pinaroo Ramsar site (Table 1) was determined after a review of previous ecological character descriptions compiled by DSE (2005), Phillips et al. (2005), Taylor–Wood and Jaensch (2005a, 2005b), and from a review of the outcomes of a workshop held in Canberra in May 2006 (Lambert and Elix 2006).

Table 1: Steps used in describing the ecological character of the Lake Pinaroo Ramsar site

Step	Section
1. Define ecological character and the reasons for describing the ecological character.	1
2. Describe the location, land use, the criteria used for listing the site and data availability.	2
3. Provide a summary of the ecological character.	3.1
4. Provide a conceptual model for the linkages between services, components and processes.	3.2
5. Describe ecosystem services.	3.3
6. Describe specific components and processes that support ecosystem services.	3.4
7. Determine limits of acceptable change in key components.	4
8. Identify key threats.	5
9. Identify key knowledge gaps and provide monitoring recommendations.	6
10. Provide recommendations for updating the Ramsar Information Sheet	6.1

2 Description of Lake Pinaroo Ramsar site

2.1 Site location

The Lake Pinaroo Ramsar site is located approximately 80 km north-west of Tibooburra and 24 km south-east of Cameron Corner, in north-western NSW, Australia (29°06′S, 141°13′E) (Figure 3). The Lake Pinaroo Ramsar site covers a total area of 718.8 ha. This area calculation was revised from the 800 ha used in the original site listing, as technology now allows for a higher resolution and more accurate definition of site boundary than was available at the time of listing. The boundary for the Lake Pinaroo Ramsar site is the 120 m contour. This site is in a remote area, over 1000 km north-west of Sydney. It lies within the arid zone (<250 mm annual rainfall) and the endorheic (closed) Lake Eyre drainage division (Williams 1975; Stafford-Smith and Morton 1990) (Appendix 1).

Lake Pinaroo, which is also known as the Fort Grey Basin, is located in Sturt National Park. Sturt National Park was established in 1972 and covers an area of approximately 325 329 ha, the largest conservation reserve in arid north-western NSW.

Lake Pinaroo is found within the Simpson–Strzelecki Dunefields biogeographic region (Appendix 1), and with only a small portion of this region in NSW, Lake Pinaroo is the largest terminal basin in NSW in this biogeographic region. The lake fills predominately from a single temporary watercourse, Fromes Creek, via Fromes Swamp, which contains a large area of Canegrass (*Eragrostis australasicus*), Lignum (*Meuhlenbeckia florulenta*) and Golden Goosefoot (*Chenopodium auricomum*) vegetation. A large temporary wetland, Telephone Lake, and several artificial water bores are located nearby, which also provide habitat for waterbirds and amphibians. Maps, aerial and satellite images of the Ramsar site and the Simpson–Strzelecki Dunefields bioregion are presented in Appendix 1.

2.2 Land tenure

Sturt National Park is dedicated under the *National Parks and Wildlife Act 1974* and was formed when pastoral leases were acquired from 1968 onwards. The majority of Lake Pinaroo was gazetted as a national park in 1975 and another smaller portion was gazetted in 1976. The site is managed under the *Sturt National Park Plan of Management* (NSW NPWS 1996). The lands adjacent to the Ramsar site are also national park or Crown land (travelling stock route) dedicated under the *Rural Lands Protection Act 1989*. Beyond the national park boundary the lands are Crown land dedicated under the *Western Lands Act 1901*.

Most of the land within the Ramsar site is permanently dedicated as national park and used as a nature conservation area. A small portion of land that overlaps the Ramsar site is Crown land and is used as a travelling stock route, which is nominally managed by the Milparinka Rural Lands Protection Board. Although this route is a public road designated for moving livestock, it has not been used since 1972 and is now completely overgrown and cannot be used for any form of normal travel (I. Witte 2006, pers. comm.). The remaining surrounding lands are permanently dedicated as national park. The population of the area surrounding the Ramsar site is approximately 160 and the majority of people live in Tibooburra and primarily service the town (Ramsar Information Sheet 1998).

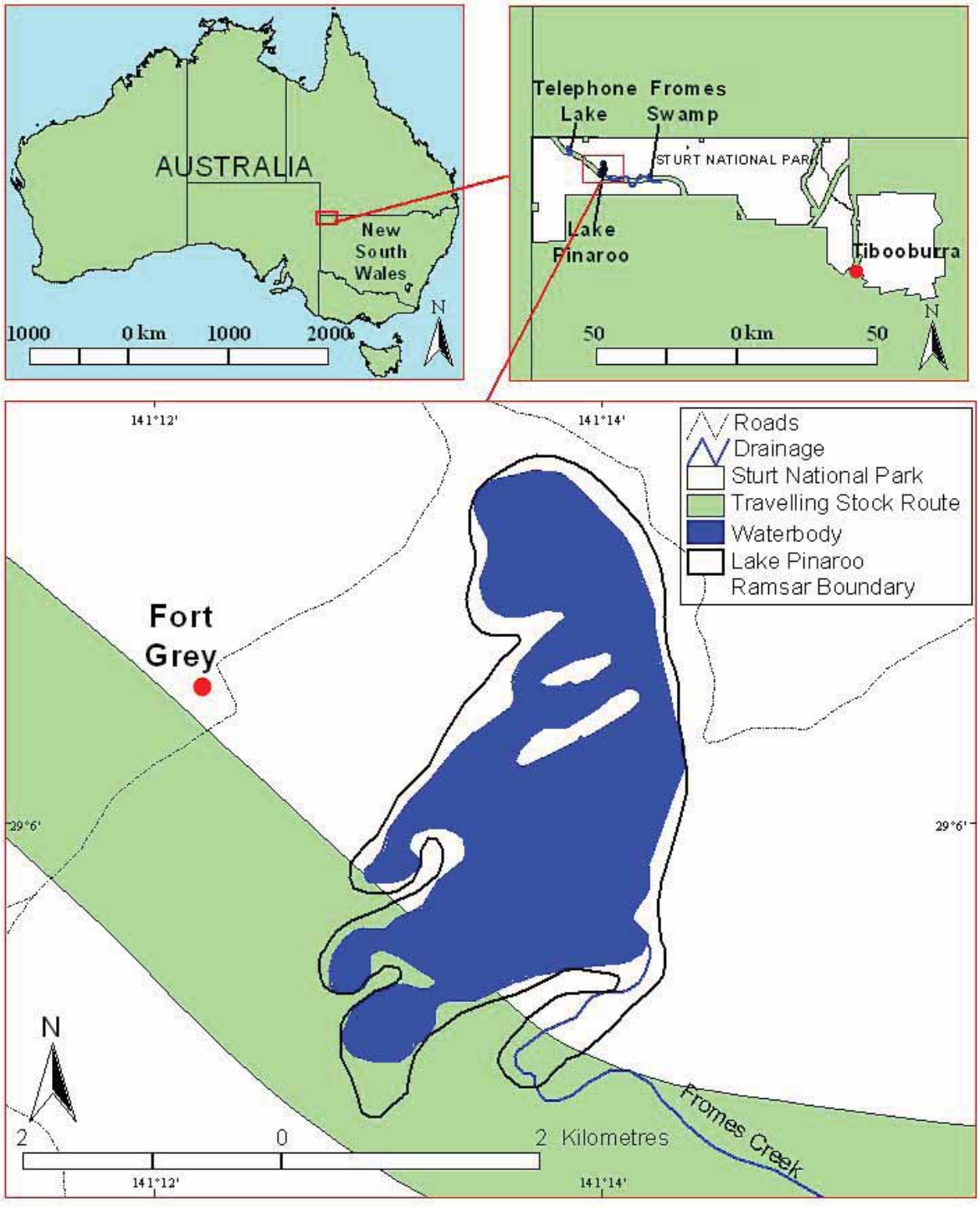


Figure 3: Location of the Lake Pinaroo Ramsar site

2.3 Criteria for listing as a Ramsar site

Lake Pinaroo was listed as a Ramsar site on 19 March 1996 after meeting the pre-1999 Ramsar criteria 1a, 2a, 2c, 2d and 3b (Ramsar Information Sheet 1998). These criteria now equate to the current Ramsar criteria 1, 2, 3 and 4 (see Glossary for a list of all Ramsar criteria).

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biodiversity of a particular biogeographic region.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

The ecosystem services listed in Table 2 were used as the basis for the ecological character description of the Lake Pinaroo Ramsar site. They include the ecosystem services that support the Ramsar criteria listed above.

Table 2: Ecosystem services used for the description of the Lake Pinaroo Ramsar site

Supporting services that relate to the Ramsar listing criteria *	Ramsar criteria
Supports a large terminal basin in the Simpson–Strzelecki Dunefields biogeographic region within NSW	1
Supports threatened species	2
Supports an abundance of waterbirds	3
Supports migratory shorebirds listed under the international treaties JAMBA, CAMBA and ROKAMBA during critical stages of their life cycles	4
Provides refuge for waterbirds and other fauna	4
Supports waterbird breeding	4

* These ecosystem services relate only to the Ramsar criteria used for the listing of Lake Pinaroo as a Ramsar site in 1996.

2.4 Data availability

Three issues restricted the description of the ecological character of the Lake Pinaroo Ramsar site and also any assessment of change since its time of listing in 1996:

- a lack of baseline biophysical and biological data for the site
- the extreme spatial and temporal variability associated with arid systems
- the remoteness of the area.

Lake Pinaroo is over 1200 km from Canberra and Sydney, where large research institutions are based. Further, Australian rivers are amongst the most variable in the world and even 100 years of records may not be sufficient to adequately describe flow variability (Puckridge et al. 1998; Young et al. 2001). These issues make it difficult to monitor and identify trends at the Lake Pinaroo Ramsar site.

In a review of the ecological character description process, Sorrell (2006) recommended that some interpretation be made from data from other similar sites if there is a lack of site-specific information on the components and processes for a given site. This ecological character description includes data collected at the Lake Pinaroo Ramsar site, but also includes information for species recorded in the wider area of Sturt National Park. Some additional comparisons are also made with other sites in the Western Division of NSW, including the Paroo River wetlands, which are influenced by similar processes and for which more comprehensive data sets are available (Timms 1997; Kingsford and Halse 1998; Kingsford et al. 1994; Timms and Boulton 2001; Nicol et al. 2003; Kingsford et al. 2004).

The Lake Pinaroo Ramsar site was also visited in May 2006 to record dominant vegetation communities, and elevation transects were carried out to estimate the area of inundation (see Appendix 2).

Knowledge gaps relating to other ecosystem services

Specific gaps in knowledge for the Lake Pinaroo Ramsar site in relation to other ecosystem services are:

- the role of Lake Pinaroo in organic carbon storage and in nutrient and sediment retention in the region
- the value of Lake Pinaroo in the maintenance and production of native fish populations
- the role of groundwater at Lake Pinaroo, incuding groundwater availability and recharge potential
- the role of Lake Pinaroo as a point of flood control in the region
- the extent of provisioning services, such as food, fuel and fresh water.

3 Description of the ecological character of Lake Pinaroo Ramsar site

This section describes each ecosystem service selected as the basis of this ecological character description (Table 2) and the components and processes that support each service (Table 3). The linkages between each of these elements are outlined in a detailed conceptual model for this wetland (Figure 4). Further information for critical components and processes, which support each service, will be discussed further in section 3.4. The ecosystem services, components and processes are specified, where data is available, as they were prior to or close to the time of the site's listing in 1996.

3.1 Summary of Lake Pinaroo ecological character description

Table 3: Ecosystem services provided by Lake Pinaroo Ramsar site and their key components and processes

Service		Examples relating to Lake Pinaroo	Source	Key components	Related processses
Regulating	Flood retention	Largest terminal basin in region	a, b	Hydrology and geomorphology	Geomorphological processes and climate
Cultural	Cultural heritage	Aboriginal heritage	b, c	Aboriginal artefacts and sites	Geomorphological processes and climate
		European historical sites	b	Evidence of early explorers, pastoral infrastructure (homesteads, shearing sheds and bores)	
	Recreation and tourism	Bird watching	b	Components related to maintenance of bird species (habitat, food and hydrology)	Biological interactions, geomorphological processes and climate
		Camping and touring	b	Camping infrastructure and access	Climate
Supporting	Wetland type	Supports a rare wetland type *	d	Geomorphology	Geomorphological processes and climate (rainfall and temperature regimes)
	Wildlife refuge	Supports threatened fauna species *	a, b, c, e, f, g, h	Fauna (birds, mammals, reptiles and amphibians), hydrology (flooding and drying regime), physicochemical (salinity and turbidity), habitat (vegetation type and structure), geomorphology, inundation, food availability (vegetation, invertebrates and fish)	Biological interactions (e.g. predation, competition and disease), geomorphological processes (sedimentation and erosion), climate and fire
		Supports migratory waterbirds listed under international treaties (JAMBA, CAMBA and ROKAMBA)	a, e, h		
		Provides drought refuge for waterbirds and other fauna *	a, g, h		
		Supports an abundance of waterbirds *	a, h		
		Supports waterbird breeding *	h, i	As above and habitat (suitable nest sites)	

* Services related to Ramsar listing. Sources: (a) Briggs (1980, 1982); (b) NSW NPWS (1996); (c) J. Spencer and J. Porter (2006, pers. obs.); (d) Thackway and Cresswell (1995); (e) NSW NPWS Atlas of NSW Wildlife; (f) R. Sadlier (2006, pers. comm.); (g) Denny (1975); (h) NSW Bird reports (1973–1996); (i) A. Lindsey (2006, pers. comm.)

3.2 Conceptual model for the Lake Pinaroo Ramsar site

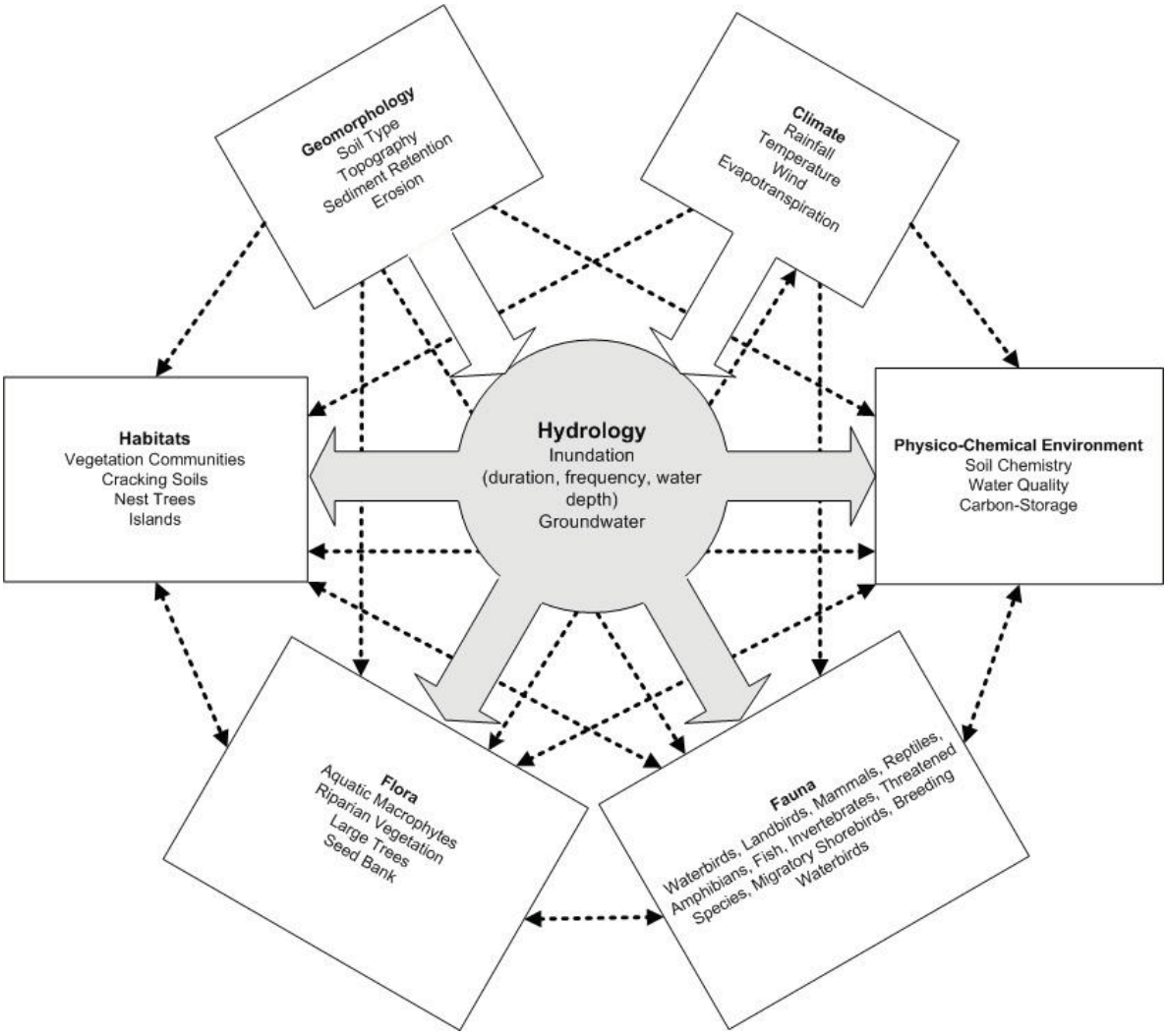


Figure 4: Conceptual model of the components and processes that support ecosystem services at the Lake Pinaroo Ramsar site

3.3 Ecosystem services

This section describes each ecosystem service selected for the Lake Pinaroo Ramsar site and identifies key components and processes that support each service (Table 3). Specific components and processes are discussed further in section 3.4.

Where data for the Lake Pinaroo Ramsar site is unavailable, information for the wider Sturt National Park area and other areas in the Western Division of NSW are presented. The rationale for including a broader species list is that species from the wider area, although not strictly wetland species, could use Lake Pinaroo as a source of food or as a drought refuge. Further, this site is also important for threatened species known from Sturt National Park, of which there are many (see section 3.3.5). Additional records of migratory shorebirds from inland regions are provided, as this group of birds has been poorly surveyed in inland Australia (see section 3.3.5).

3.3.1 Flood retention

Although the extent that Lake Pinaroo acts as a point of flood control in the region is undetermined, this wetland is the largest terminal basin in the region and can retain water for up to seven years (Briggs 1982), primarily because there is no point of outflow. The Lake Pinaroo–Fromes Swamp catchment is relatively large (77 706 ha) and bordered by the Grey Ranges to the east and south-east. Sixty-one per cent of Lake Pinaroo's catchment (47 233 ha) is contained within Sturt National Park. Lake Pinaroo receives low annual average rainfall but on rare occasions can experience intense rainfall events, especially during summer months (January–March) when up to 300 mm of rain can fall in a single month (Appendix 3).

3.3.2 Cultural heritage

Sturt National Park has high cultural values, with an exceptionally high density and variety of Aboriginal sites including hearths, middens, ceremonial sites, quarries and abundant stone artefacts. This suggests that a large Aboriginal population once occupied the area. The Wangkumara and Maljangapa tribes originally used the Sturt National Park area. No Aboriginal sites have been recorded at Lake Pinaroo; however, an open campsite and scarred tree are close by and artefact scatters (flakes and cores) are common around the fringing dunes.

Sturt National Park was also the setting for significant events in the history of early exploration of inland Australia. Charles Sturt, the most prominent of these early explorers, built a stockade next to Lake Pinaroo and named it Fort Grey. This served as a base camp for the explorer's party while he led smaller parties across what is now known as the Simpson Desert to the north and west.

Pastoral infrastructure was inherited from stations that were purchased to create the national park. A crutching shed, hut remains, steam engine relics, bore relics and remains of a stone homestead are present in the bed and surrounding margins of Lake Pinaroo. Nine historic places have been identified in the Fort Grey area including Sturt's tree, the Fort Grey homestead ruin, stockade, lake well, homestead and shearing complexes, bores and ground tanks, station fencing and yards (Rich 1985). The homestead ruin, shearing complex and lake well are subject to flooding and are damaged.

3.3.3 Recreation and tourism

Lake Pinaroo is a popular tourist destination and Sturt National Park is the third largest national park in NSW, attracting 30 000–40 000 visitors annually (I. Witte 2006, pers. comm.). The homestead and infrastructure, indigenous relics and Sturt's tree attract visitors to Lake Pinaroo.

There are also opportunities for bird watching, camping, bush walking and four-wheel driving. Rare bird species, such as the Brolga (*Grus rubincunda*), Grey Falcon (*Falco hypoleucos*) and Black-breasted Buzzard (*Hamirostra melanosternon*), and large flocks of unique desert birds such as the Budgerigar (*Melopsittacus undulatus*) also attract keen bird watchers.

Lake Pinaroo is also utilised during educational visits by school and university students and scientists. A loop walking track has been established at Lake Pinaroo, which takes in historical sites including an old hut, steam engine and Sturt's tree. Interpretive signage for these attractions has been erected. Camping facilities are available at this site and are used heavily (in comparison to other sites in the national park), especially during July and October (Ramsar Information Sheet 1998). Park camping operates on a permit system and gas barbecues, water and toilets are provided. There are two self-guided driving tours of Sturt National Park.

3.3.4 Wetland type

Lake Pinaroo supports a rare wetland type, as it is a large terminal basin within the Simpson–Strzelecki Dunefields biogeographic region. This bioregion covers an area of 29 722 724 ha and extends from the south-east of the Northern Territory through the north-east of South Australia, with small portions in NSW and Queensland (Appendix 1). The region is dominated by a hot, persistently dry desert climate and most of the dunefield is located in the Lake Eyre Basin. The Simpson–Strzelecki Dunefields are part of the Australian continental dunefields, which consist of a huge anti-clockwise whorl of linear dunes in central Australia. This bioregion is thought to be the largest example of a linear sand dune environment in the world and 5.8% (122 030 ha) is contained within Sturt National Park (NSW NPWS 2003).

3.3.5 Wildlife refuge

The Lake Pinaroo Ramsar site acts as a wildlife refuge in this area of north-western NSW since it:

- supports threatened species
- supports migratory shorebirds during critical stages in their life cycles
- provides drought refuge for waterbirds and other fauna
- supports waterbird breeding.

The flooding and drying cycle of the lake drives the succession of plant and animal communities that occur at the Lake Pinaroo Ramsar site. Changes in water quality, including salinity and turbidity, occur as a result of this cycle and influence the distribution and abundance of flora and fauna species. These interactions are discussed in further detail in section 3.4.

Supports threatened species

Lake Pinaroo provides valuable habitat in the region, particularly for threatened species. The size of the lake and its capacity to retain water are thought to play a crucial role in the survival of many species of plants and animals in the immediate and surrounding areas.

Of the fauna species recorded in Sturt National Park, 43 are listed under NSW threatened species legislation (TSC Act), two mammal and one bird species are listed under Commonwealth legislation (EPBC Act) and two mammal species are listed on the International Union for Conservation of Nature (IUCN) Red List (Table 4).

Twelve threatened fauna species have been recorded at Lake Pinaroo Ramsar site (Table 4; Table 5).

In January 1980, 153 Freckled Duck (*Stictonetta naevosa*) and 16 Blue-billed Duck (*Oxyura australis*) were recorded at Lake Pinaroo (Briggs 1980); both of these species are threatened in NSW (TSC Act). Although there are no records of Painted Snipe (*Rostratula benghalensis*) for Lake Pinaroo, this nationally threatened waterbird has been recorded at other locations in Sturt National Park (Appendix 4).

Several threatened mammal species, including the Striped-faced Dunnart (*Sminthopsis macroura*), Eastern Long-eared Bat (*Nyctophilus timoriensis*) (a nationally and internationally vulnerable species) and the Forrest's Mouse (*Leggadina forresti*) are known from Sturt National Park and have a restricted distribution within the Western Division of NSW (Table 4) (Dickman et al. 1993). Five threatened reptile species have been recorded at Lake Pinaroo including the endangered Intertior Blind Snake (*Ramphotyphlops endoterus*) (R. Sadlier 2006, pers. comm.) (Table 5).

Although plant species have been poorly surveyed at Lake Pinaroo, there are four threatened plant species known from Sturt National Park that *may* occur at Lake Pinaroo and Fromes Swamp, and an additional six threatened plant species are found in similar wetland habitats in NSW (TSC Act) (Table 6; Appendix 4).

Table 4: Threatened bird and mammal species recorded in Sturt National Park

Common Name	Species	Lake Pinaroo records	Status		
			TSC	EPBC	IUCN
Birds					
Australian Bustard	*Ardeotis australis*		E		
Painted Snipe	*Rostratula benghalensis*		E	V	
Plains-wanderer	*Pedionomus torquatus*		E		
Flock Bronzewing	*Phaps histrionica*		E		
Barking Owl	*Ninox connivens*		V		
Black-breasted Buzzard	*Hamirostra melanosternon*	a, b, c, d	V		
Black-tailed Godwit	*Limosa limosa*	e	V		
Blue-billed Duck	*Oxyura australis*	e, f	V		
Brolga	*Grus rubicunda*		V		
Freckled Duck	*Stictonetta naevosa*	e, f, g	V		
Grey Falcon	*Falco hypoleucos*	a, h	V		
Grey-crowned Babbler (eastern ssp.)	*Pomatostomus temporalis temporalis*		V		
Hall's Babbler	*Pomatostomus halli*		V		
Major Mitchell's Cockatoo	*Cacatua leadbeateri*		V		
Masked Owl	*Tyto novaehollandiae*		V		
Painted Honeyeater	*Grantiella picta*		V		
Pied Honeyeater	*Certhionyx variegatus*	a, i	V		
Redthroat	*Pyrrholaemus brunneus*		V		
Square-tailed Kite	*Lophoictinia isura*		V		
Mammals					
Fawn Hopping Mouse	*Notomys cervinus*		Ex		
Pig-footed Bandicoot	*Chaeropus ecaudatus*		Ex		Ex
Dusky Hopping Mouse	*Notomys fuscus*		E	V	V
Kultarr	*Antechinomys laniger*		E		
Inland Forest Bat	*Vespadelus baverstocki*		V		
Little Pied Bat	*Chalinolobus picatus*		V		
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*		V		
Forrest's Mouse	*Leggadina forresti*		V		
Long-haired Rat	*Rattus villosissimus*	j	V		
Sandy Island Mouse	*Pseudomys hermannsburgensis*		V		
Stripe-faced Dunnart	*Sminthopsis macroura*		V		
Eastern/Greater Long-eared Bat	*Nyctophilus timoriensis*		V	V	V

Sources of confirmed records at Lake Pinaroo Ramsar site: (a) NSW NPWS Atlas of NSW Wildlife; (b) J. Spencer and J. Porter (May 2006, pers. obs.); (c) Lindsey (1985); (d) A. Lindsey (2006, pers. comm.); (e) Lindsey (1981); (f) Briggs (1980); (g) Lindsey (1979, 1980); (h) Morris and Burton (1994); (i) A. Morris (2006, pers. comm.); (j) Denny (1991). Status under NSW (TSC Act), national (EPBC Act) and international (IUCN) legislation: Ex = presumed extinct, E = endangered, V = vulnerable

Table 5: Threatened reptile species recorded in Sturt National Park

Common Name	Species	Status
Lake Pinaroo/Fort Grey records		
Interior Blind Snake	*Ramphotyphlops endoterus* *	E
Wedge-snout Ctenotus	*Ctenotus brooksi* *	V
Centralian Blue-tongued Lizard	*Tiliqua multifasciata* *	V
Slender Blue-tongue	*Cyclodomorphus venustus* *	E
Yellow-tailed Plain-slider	*Lerista xanthura* *	V
Crowned Gecko	*Diplodactylus stenodactylus*	V
Fat-tailed Gecko	*Diplodactylus conspicillatus*	E
Other Sturt National Park records		
Ringed Brown Snake	*Pseudonaja modesta*	E
Narrow-banded Snake	*Simoselaps fasciolatus*	V
Stimson's Pyton	*Liasis stimsoni*	V
Collared Whip Snake	*Demansia torquata*	V
Woma	*Aspidites ramsayi*	V

* Reptiles recorded at Lake Pinaroo. Fort Grey records are from the Australian Museum records (supplied by R. Sadlier 2006). These reptiles are listed as threatened species in NSW (TSC Act): E = endangered, V = vulnerable.

Table 6: Threatened plant species recorded in Sturt National Park and similar wetland habitats in NSW

Common Name	Species	Status	
		TSC	EPBC
Sturt National Park			
Blue Trumpet (Yam)	*Dipteracanthus australasicus* ssp. *corynothecus*	E	
Desert Carpet Weed	*Glinus orygioides*	Ex	
Crumbweed	*Dysphania platycarpa*	E	
Water weed	*Osteocarpum pentapterum*	Ex	
Other sites in NSW			
Saltbush	*Atriplex infrequens*	V	V
Saltbush	*Atriplex sturtii*	E	
Burr-daisy	*Calotis moorei*	E	E
	Dentella minutissima	E	
	Goodenia nocoleche	E	
Stonewort	*Nitella partita*	E	

Threatened plant species which have either been recorded in Sturt National Park (see Appendix 4) or are known from similar habitats in the rest of NSW, and which may occur in Lake Pinaroo/Fromes Swamp. Status under NSW (TSC Act) and national (EPBC Act) legislation: Ex = presumed extinct, E = endangered, V = vulnerable.

Supports migratory shorebirds during critical stages in their life cycles

Lake Pinaroo Ramsar site supports migratory shorebird species which are listed under international bird agreements (JAMBA, CAMBA and ROKAMBA), the Bonn Convention and under the EPBC Act (Table 7). Migratory shorebirds visit Australia during their non-breeding season (August–April) and have breeding sites in Siberia and Alaska (Lane 1987).

In general, inland wetlands in Australia are only suitable for brief periods every few years, depending on the annual flooding and rainfall cycles. However, they are still thought to be of major importance to migratory shorebirds, which need to refuel at these sites along their migratory route (Thomas 1970; Smith 1991). Despite this fact, there is generally a poor representation of inland wetlands for shorebirds in the NSW reserve system (Smith 1991).

Although there have been few formal counts conducted at the Lake Pinaroo Ramsar site, four migratory shorebird species have been recorded at Lake Pinaroo since 1973. These include the Black-tailed Godwit (*Limosa limosa*), Marsh Sandpiper (*Tringa stagnatilis*), Common Greenshank (*Tringa nebularia*) and Red-necked Stint (*Calidris ruficollis*) (Table 7). Marsh Sandpipers and Sharp-tailed Sandpipers (*Calidris acuminata*) have also been recorded at Fromes Swamp (Morris and Burton 1992; NSW NPWS Atlas of NSW Wildlife 1999), and Common Greenshank, Marsh Sandpiper and Red-necked Stint have also been recorded at Telephone Lake (Briggs 1980).

It is probable that additional species also use Lake Pinaroo along their migratory path. For instance, a further 32 migratory shorebird species have been recorded in inland Australia (Lane 1987). Most of these records are of individuals stopping briefly during their migration or are occasional dropouts of species which normally fly over the inland region without stopping (Thomas 1970).

However, there are a number of migratory shorebird species which are regular inland inhabitants. For instance, the Sharp-tailed Sandpiper (*Calidris acuminata*), Marsh Sandpiper, Common Greenshank and Pectoral Sandpiper (*Calidris melanotos*) have all been recorded at individual inland sites in Australia with numbers over the 1% criterion (Smith 1991). Other species which use inland wetlands in NSW as regular habitat are the Wood Sandpiper (*Tringa glareola*), Common Sandpiper (*Actitis hypoleucos*), Latham's Snipe (*Gallinago hardwickii*), Curlew Sandpiper (*Calidris ferruginea*) and Ruff (*Philomachus pugnax*) (Lane 1987; Smith 1991).

Provides drought refuge for waterbirds and other fauna

Lake Pinaroo acts as a drought refuge for waterbirds and other fauna. Waterbirds tend to congregate at inland wetlands, often in response to a flood. As these areas dry out waterbirds and other wetland dependent species will move to areas which hold water for the longest period of time. As Lake Pinaroo is a terminal basin and the largest wetland in Sturt National Park, it acts as a drought refuge for these wetland species – when water is present it can support large numbers of waterbirds. Lake Pinaroo only fills when Fromes Swamp overflows during intense local rainfall events. Once full the lake can take up to seven years to become dry again (Briggs 1982).

At least 40 species of waterbird have been recorded at Lake Pinaroo (Appendix 4). Many waterbirds in western NSW, particularly ducks, breed on temporary waters and then move to more permanent waters to survive dry periods (Briggs 1994). For

instance, Grey Teal and the Pink-eared Duck, which have both been recorded at Lake Pinaroo, are known for their long distance movements, especially in times of drought (Braithwaite 1975).

Further, seven resident species of shorebirds have been recorded at Lake Pinaroo (Table 8). These include the Black-winged Stilt (*Himantopus himantopus*), Red-necked Avocet (*Recurvirostra novaehollandiae*), Banded Lapwing (*Vanellus tricolor*) and Masked Lapwing (*Vanellus miles*), and smaller shorebird species, the Red-kneed Dotterel (*Erythrogonys cinctus*), Black-fronted Dotterel (*Charadrius melanops*) and Red-capped Plover (*Charadrius ruficapillus*).

Table 7: Records of migratory shorebird species in inland Australia

Common name	Inland Australia	NW NSW	Sturt National Park	Lake Pinaroo	Fromes Swamp	Telephone Lake
Bar-tailed Godwit	11					
Black-tailed Godwit	23			1 (b)		
Broad-billed Sandpiper	1					
Common Greenshank	403	26	+	1 (c)		+
Common Sandpiper	174					
Curlew Sandpiper	132	70				
Eastern Curlew	2					
Great Knot	1					
Grey Plover	6					
Grey-tailed Tattler	4					
Large Sand Plover	1					
Latham's Snipe	–		+			
Lesser Golden Plover	24					
Little Curlew	18					
Marsh Sandpiper	157	70	+	(c)	10 (e,f)	+
Mongolian Plover	1					
Oriental Plover	43		8 (a)			
Oriental Pratincole	20					
Red Knot	4					
Red-necked Stint	212	200	+	1 (d)		+
Sanderling	1					
Sharp-tailed Sandpiper	437	7450	+		1000 (e,f)	
Whimbrel	5					
Wood Sandpiper	90		+			

+ recorded

Sources: Summary of shorebirds counts recorded in inland Australia were taken from the the Altas of Australian Birds Project (1977–81) (Lane 1987). Lane (1987) also summarised counts of shorebirds available for far north-west NSW. Six migratory shorebird species were recorded in Sturt National Park in the Sturt National Park bird species list (1990). Additional counts of migratory shorebirds in Sturt National Park and its wetlands are from: (a) Morris and Burton (1999); (b) Lindsey (1981); (c) Briggs (1980); (d) Cooper (1990); (e) NSW NPWS Atlas of NSW Wildlife (1999); (f) Morris and Burton (1992). Three migratory species were also recorded at Telephone Lake (Briggs 1980).

Large numbers of resident shorebirds have also been recorded in the Fromes Swamp and Telephone Lake wetlands, which are within 16 km of the Lake Pinaroo Ramsar site. An exceptionally large count of 100 000 Red-necked Avocets was recorded at Telephone Lake in 1979 (Lindsey 1980). This is the highest single count ever recorded for this species and represents almost all of the estimated Australian (global) population of 107 000 birds (Watkins 1993).

Lake Pinaroo is also an important source of water for other fauna species such as arid desert birds. For example, an estimated 40% of Australian desert land birds are thought to be water dependent (Fisher et al. 1972). These sites are also important for small mammals, such as the Long-haired Rat (*Rattus villosissimus*). This species has been recorded in high numbers at Lake Pinaroo during flood periods (Denny 1991) and is also capable of moving large distances to find water during drought periods (Finalyson 1961).

Supports waterbird breeding

Many waterbird species in Australia depend on inland wetlands for their reproduction and survival. Colonial nesting waterbirds are dependent on inland wetlands for breeding sites. Six species of ibis, heron and spoonbill, and at least 10 species of waterfowl have been recorded at the Lake Pinaroo Ramsar site (Appendix 4). Although few counts are available for the site, over 1964 Pink-eared Duck, 1174 Grey Teal, 153 Freckled Duck and 213 Hardhead (*Aythya australis)* were recorded in Lake Pinaroo in January 1980 (Briggs 1980). There is also a report of 'many thousands' of Freckled Duck at the Fort Grey Basin lakes from October to December 1979 (Lindsey 1980). Other duck species recorded at the site include the Pacific

Table 8: Records of resident shorebird species in inland Australia

Common Name	NW NSW	Sturt National Park	Lake Pinaroo	Fromes Swamp	Telephone Lake
Australian Pratincole		500 (a), 7 (b)			
Banded Stilt	60	+			
Banded Lapwing		+	+		
Black-fronted Dotterel	200	+	13 (d, e, f)		+
Black-winged Stilt	130	+	(d, f)		
Inland Dotterel		22 (b), 100 (c)			
Masked Lapwing		+	63 (d, f)		+
Painted Snipe		+			
Red-capped Plover	6800	+	1 (d, f)	100 (f)	+
Red-kneed Dotterel	50	+	103 (d)	500 (f)	+
Red-necked Avocet	6850	+	66 (d, e, f, g)	200 (f)	100 000 (h)

+ recorded.

Sources: Lane (1987) summarised counts of resident shorebirds available for far north-west NSW. All 11 resident species are listed in the Sturt National Park bird species list (1990). Additional counts for the Sturt National Park and its wetlands are from: (a) Rogers (1974); (b) Rogers (1976); (c) Morris and Burton (1999); (d) Briggs (1980); (e) A. Morris (2000, pers. comm.); (f) NSW NPWS Atlas of NSW Wildlife (1999); (g) Lindsey (1981); (h) Lindsey (1980). Additional records were available for Lake Pinaroo (NSW NPWS Atlas of NSW Wildlife 1999) and Telephone Lake (Briggs 1980).

Black Duck (*Anas superciliosa*), Australasian Shoveler (*Anas rhynchotis*), Musk Duck (*Biziura lobata*) and Australian Wood Duck (Briggs 1980). Lake Pinaroo also supports seven species of resident shorebirds that breed in Australia, including the Red-necked Avocet, Black-fronted Dotterel and Black-winged Stilt (Briggs 1980).

When filled to capacity, Lake Pinaroo holds water much longer than any other wetland within the region, providing a reliable breeding area for substantial numbers of waterbirds. Lake Pinaroo also provides an important non-breeding refuge for birds that have bred on other wetlands, particularly interdune swamps that hold water for relatively short periods (4–6 months). Lake Pinaroo is also considered to play an important role for birds migrating from other wetlands including Coongie Lakes, Bulloo River Lakes, Caryapundy Swamp, Salisbury Lake and the Paroo River wetlands (Ramsar Information Sheet 1998). Islands located in the centre of the lake and dead Coolibah trees around the periphery would provide some protection from predation by cats and foxes and provide attractive nesting sites for waterbird species (see Appendix 5).

3.4 Components and processes

This section describes the specific components and processes that support the ecosystem services identified at Lake Pinaroo Ramsar site. Biodiversity in this arid region is driven by unpredictable flooding and drying cycles. These areas are characterised by low topographic gradients and extreme climatic variability, including high evaporation and erratic floods and extended dry periods. In turn, this flooding and drying cycle affects water quality and the distribution and abundance of vegetation, waterbirds, fish and invertebrates.

3.4.1 Hydrology

The inundation pattern of wetlands relates to timing (when water is present), frequency (how often filling and drying occurs), duration (period of inundation), extent, depth (the area of inundation and water depth) and variability (the degree to which these features change at a range of time scales) of flooding (Boulton and Brock 1999).

Hydrology is the main abiotic determinant of structure and composition of aquatic plant (Brock and Casanova 1997; Casanova and Brock 2000; Bunn and Arthington 2002; Nicol et al. 2003), waterbird (Kingsford and Norman 2002; Kingsford et al. 2004), fish (Gehrke et al. 1995) and invertebrate (Boulton and Lloyd 1992; Boulton and Jenkins 1998; Jenkins and Boulton 2003) communities. The movement of water across the landscape acts as a natural disturbance in arid and temporary wetlands, creating and removing patches of habitat and driving processes of reproduction, recruitment and mortality (Brock and Casanova 1991; Grillas et al. 1993; Bonis et al. 1995; Casanova and Brock 1996; Grillas and Battedou 1998). Furthermore, variable flooding and drying patterns are a hallmark of arid wetlands where expansion and contraction of habitat occurs over large spatial and temporal scales.

According to the wetlands classification of Paijmans et al. (1985), Lake Pinaroo is an episodic lake which is dry most of the time with rare and very irregular wet phases in a terminal drainage basin. Lake Pinaroo is located in the most arid part of NSW and receives the second lowest recorded rainfall in the state (Cunningham et al. 1992). The basin fills when Fromes Swamp overflows during intense local rainfall which may occur any time throughout the year, but most frequently in summer months (see

section 3.4.3; Appendix 3). During flood periods, Lake Pinaroo consists of an open lake with muddy margins with very little vegetation.

Lake Pinaroo–Fromes Swamp catchment area is large (77 706 ha) (Table 9) and contains an area primarily enclosed by the Grey Ranges to the east and south-east. The maximum height of the Grey Ranges is approximately 260 m. Lake Pinaroo's catchment is very flat and consequently very small changes in elevation cause great changes in flooding extent. Sixty-one per cent of Lake Pinaroo's catchment is within the national park, and the remainder of the catchment is used for grazing domestic stock (Ramsar Information Sheet 1998).

Apart from accounts of water depth and extent of flooding (Briggs 1980, 1982), there has been no regular monitoring of inflows or water depth at Lake Pinaroo. There is also no information available on the extent of groundwater flow into or out of Lake Pinaroo. However, it appears from rainfall data collected at Fort Grey and the limited literature available (Briggs 1980, 1982) that Lake Pinaroo can retain water for up to seven years. For example, the lake filled in 1974 and had dried up completely in 1981; when full, the water depth in Lake Pinaroo is thought to be 0–2 m and can drop during summer months by over 60 cm (Briggs 1982).

Average annual rainfall at Fort Grey is 177.8 mm ± 14.7 s.e. based on complete records over the 60 years 1899–2006 (BOM 2006b). Records of monthly rainfall greater than 150 mm at Fort Grey (Table 10) coincide with historical records of flooding of Lake Pinaroo. Based on rainfall data, four major floods were recorded in February–March 1949, February–March 1956, January–February 1979 and January 1984, and two moderate floods were recorded in December 1950 and February 2000 (Table 10). These records coincide with some historic records of heavy rains in north-west NSW in 1886, 1911, 1949, 1950, 1955, 1956, 1974 and 1976 (Bell and Stanley 1991). However, there were significant gaps in rainfall records at Fort Grey during July 1914 – March 1945 and September 1973 – May 1978 (see Appendix 3). This coincided with two floods recorded in 1974 by Briggs (1982) and at Tibooburra Post Office rainfall gauge in January 1974 (384.8 mm) and January–February 1976 (228.6 mm and 178.4 mm) (BOM 2006b). Aerial photographs also show that the lake had water in March 1976 and in April 1989, and a satellite image from the Australian Centre for Remote Sensing also shows the lake with water in April 1990 (see Appendices 1 and 5).

Large rainfall events tend to occur in summer months (January–March) in this region (Table 10; section 3.4.3). These rainfall events are concentrated over one or more days in a single month (Table 10). For example, there were four days during the 1899–2006 period where maximum daily rainfall at Fort Grey exceeded 100 mm in a single day. These dates correspond with major floods recorded in 1979 (21 and 22 February) and in 1984 (14 and 26 January) (Table 10). The highest maximum

Table 9: Spatial attributes of Sturt National Park wetlands

Wetland/Catchment	Spatial attribute	
	Shoreline length (m)	Area (ha)
Lake Pinaroo	15 078	719
Fromes Swamp	20 804	928
Lake Pinaroo–Fromes catchment	169 310	77 706
Telephone Tank	7 743	265

daily rainfall of 139.2 mm was recorded at Fort Grey on 26 January 1984. Most recently, above average rainfall was recorded in 2003, but the most significant downpours were last recorded in the Fort Grey area in February 2000 (160.8 mm) (Table 10).

The natural water regimes of drying and flooding are critical in this temporary wetland as they determine the nature of species distribution. Most plant species in temporary or unpredictable habitats can produce seed banks (reserves of reproductive propagules, including the oospores of charophyte algae) that can survive prolonged drought and respond quickly when water is present (Grillas et al. 1993; Bonis et al.1995; Casanova and Brock 1996, 2000) (see section 3.4.5). The potential effects of the flooding and drying cycle on the flora and fauna found in the Lake Pinaroo Ramsar site and its surrounds are summarised in Table 11.

Table 10: Wet years at Fort Grey (1899–2006)

Year	Total annual rainfall (mm)	Number of wet months	Wettest month	Total rainfall in month (mm)	Max. daily rainfall in month (mm)	Total rain days in month
1907	187.2	6	Jan	68.6	68.6	1
1910	234.3	10	Jun	64.7	41.4	2
1947	208.1	8	Aug	43.2	29.0	5
1949	425.2	7	Mar	210.6	80.8	8
1950	304.3	6	Dec	159.6	34.0	9
1952	231.3	9	Aug	69.3	48.5	3
1954	224.8	9	Feb	72.7	39.4	2
1955	378.4	11	May	90.2	30.7	4
1956	529.5	7	Mar	180.4	57.9	7
1958	329.4	10	Mar	99.6	83.3	2
1960	258.6	7	Feb	80.5	79.2	2
1968	180.1	10	Nov	35.6	22.9	2
1979	542.2	12	Feb	221.8	115.0	2
1981	217.8	10	May	70.4	29.6	7
1984	419.4	11	Jan	298.4	139.2	6
1987	231.4	9	Dec	90.3	83.2	2
1988	279.2	10	Dec	83.8	81.0	2
1992	190.9	10	Dec	48.6	31.4	5
1993	202.4	10	Oct	50.8	24.0	4
1998	290.9	9	Sep	124.5	63.0	8
2000	379.0	10	Feb	160.8	78.8	3
2003	188.3	8	Feb	40.5	18.7	3

Source: BOM (2006b) (see Appendix 3). Wet years are years where annual rainfall was above average (177.8 mm) for Fort Grey (1899–2006). The data presented for total monthly rainfall, maximum daily rainfall and total rain days relates to the wettest month listed for that year. Significant flooding periods are shaded. The Tibooburra Post Office rainfall gauge also recorded major flooding in January 1974 and January 1976 (BOM 2006b). There are large gaps in rainfall records from July 1914 to March 1945 and from September 1973 to May 1978. Records are also missing for some months in 1968.

Table 11: Inundation effects on biotic components at Lake Pinaroo

Biotic component	On flooding	On drying
Soil	Pulse of nutrients, sedimentation	Nutrients locked up, soils crack
Aquatic plants: submerged **amphibious** **semi-terrestrial**	Germinate, grow and reproduce in water Aquatic form or seed bank Seed bank	Seed bank Seed bank Grow whilst damp areas exist
Phytoplankton	Photosynthesise in water column, but are light dependent; reproduce	Propagule bank of resistant spores
Birds	Waterbirds feed and nest in available habitat. Birds of prey feed on small mammals.	Waterbirds disperse to other wetlands. Birds of prey disperse to areas with greater prey resources.
Mammals	Move between dry areas and wetland for water and food supply. Some species migrate to wetland and reach large numbers.	Wetland dependent species disperse to other wetlands. Other species may remain in dry country.
Reptiles	Move between dry areas and wetland for water and food supply. Some species migrate to wetland and reach large numbers.	Some species will move to find food. Other species will remain in dry country.
Amphibians	Eggs in or near wetland, tadpoles grow, mature in water, many adults leave, return to lay.	Adults lay briefly resistant eggs in riparian vegetation. Some adults move to find water or aestivate.
Zooplankton	Feed and reproduce.	Propagule bank of resistant eggs
Benthic invertebrates	Many larval stages of aerial adults, aquatic larvae and adults	Terrestrial adults, resistant eggs
Micro-organisms	Process nutrients and organic matter.	Change from anaerobic to aerobic forms, resistant stages.

Adapted from Boulton and Brock (1999).

3.4.2 Geomorphology

Lake Pinaroo lies within the Great Artesian Basin, one of four geological provinces in NSW. The Great Artesian Basin comprises mainly quaternary sands of aeolian origin in the western sector (Cunningham et al. 1992). The area generally has a low relief and the arid nature of the country is reflected in a lack of permanent water courses in the region (Cunningham et al. 1992). Lake Pinaroo is 120 m above sea level (Ramsar Information Sheet 1998) and the Grey Ranges are the main areas of elevated land. As part of the NSW portion of the Simpson–Strzelecki Dunefields bioregion, Lake Pinaroo is the largest terminal basin in this bioregion in NSW (see Appendix 1). Much of this region is contained in the Lake Eyre Basin and the region is dominated by high linear dunes of red sand. The dunes and sandplains developed on tertiary and quaternary alluvial sediments and the dunes in NSW are thought to

have formed by a westerly wind (NSW NPWS 2003). Lake Pinaroo is enclosed between two parallel dunes on its western and eastern shores and may have formed through wind action, although it is unclear whether it is a true deflation basin (Timms 1992).

Soil type, slope and soil chemistry also have implications for vegetation distribution, plant growth and moisture availability. Sandy-textured soils provide more moisture to plants than clay textured soils through deeper wetting profiles and less soil-bound water on clay particles. Further, they have a greater infiltration capacity and are able to absorb storm rains at a faster rate than non-cracking clayey soils which may seal at the surface on wetting.

Lake Pinaroo itself has been classified in the Gnurntah wetland system which has cracking brown clays and crusty brown clays (Goodrick 1984). Fromes Swamp, approximately 16 km away, is classified in the Cuttaburra wetland system which has cracking grey clays and some gilgai (Goodrick 1984). Lake Pinaroo's bed has fine alluvial sediments which have accumulated to form cracking grey-brown clays. The cracking clays are likely to have higher nutrient levels and greater soil moisture retention than the loam and coarse sands in the surrounding dunes (Williams 1979; Stanley 1983). In dry conditions, large holes can form in these soils. During a site visit in May 2006, large cracks and holes in the bed of Lake Pinaroo that had formed after extended dry conditions were randomly sampled. These had an average depth of 67.3 cm (± 4.7 s.e.; n = 20) and reached a maximum depth of 103 cm.

The geomorphical features of this Ramsar wetland have implications for the distribution of flora and fauna. For instance, the shape of the lake and rates of rainfall runoff greatly affect the biological characteristics of this lake and its suitability for species such as shorebirds (Bayley and Williams 1973), which prefer gently sloping margins (Lane 1987). In the case of small mammals and reptiles, the cracks and holes in the lake bed can provide an important refuge with a cool, moist microclimate where they can shelter in summer months (Briggs et al. 2000). Dessication cracks can also act as seed traps, substantially altering spatial pattern and depth distributions which may in turn alter subsequent dormancy and germination responses (Elberling 2000).

3.4.3 Climate

Arid zone wetlands, such as Lake Pinaroo, are characterised by high temperatures and evaporation rates, and low annual rainfall that is both spatially and temporally unpredictable. This variability largely determines the distribution of fauna and flora species. For instance, numbers of nomadic avifauna such as migratory shorebirds will vary greatly from year to year and some small mammal populations explode in response to local rainfall.

Lake Pinaroo is located in the most arid part of NSW within the influence of the prevailing high pressure systems that circulate from west to east around the southern hemisphere throughout the year (Goodrick 1984). Subsiding air in each high pressure cell is responsible for maintenance of the tropical continental air mass over inland Australia with the associated dry, sunny weather that is characterisitic of these latitudes for much of the year.

Average annual rainfall is 177.8 mm (± 14.7 s.e.) but for much of the year little rainfall is recorded at Fort Grey (1899–2006) (BOM 2006b). In 25 469 days where rainfall was measured, 95% of records showed no rainfall. The driest year recorded was

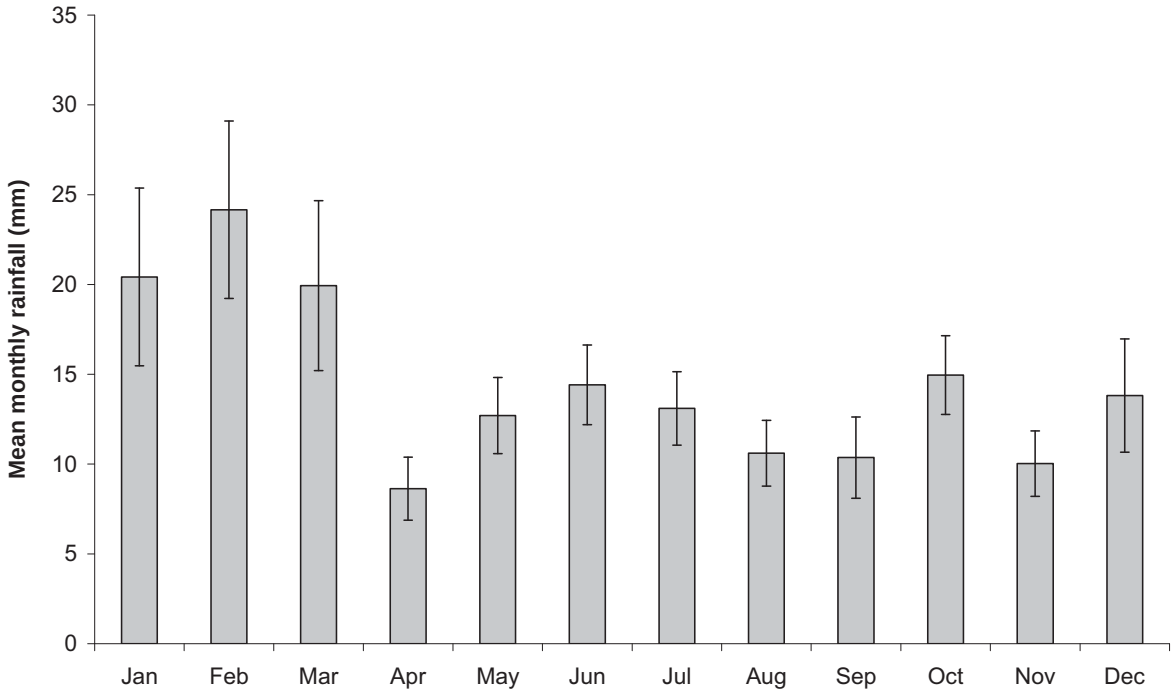
1905, when only 29 mm of rainfall was recorded at Fort Grey. Total rainfall was less than 14 mm over three days in that year. Generally, the highest monthly rainfall is recorded in summer months (January–March) although this is highly variable (Figure 5; Table 12). It is also common for above average rainfall to be recorded in December and June and occasionally in May, August, September, October and November (Figure 5; Table 10). Rain tends to fall in sudden downpours that can exceed 80 mm in one day. These rainfall events coincide with major flooding in the region (see section 3.4.1; Appendix 3).

A high frequency of one or two wet days reflects local convective storms in the area (Table 12). These events characteristically comprise brief bursts of high intensity rainfall lasting from a few minutes to one to two hours and are responsible for a considerable amount of runoff and soil erosion that occur in the north-west NSW region (Bell and Stanley 1991). In summer, the intrusion of tropical low pressure systems brings sporadic and often heavy rainfall from convectional thunderstorms. These may be followed on occasion by persistent and widespread rain. On rare occasions in summer tropical cyclones or degenerated tropical cyclones intruding inland bring heavy, often flood producing rain (Goodrick 1984).

High mean daily solar radiation input (>20 MJ per m^2 per day) is a distinctive feature of the Australian arid zone (Nix 1982). Average maximum temperature in summer months is 36.1°C at Tibooburrra Post Office (Table 12) (BOM 2006b). Evaporation is probably the main source of water loss from Lake Pinaroo and although no data is available for the lake itself, some extrapolation for the far north-west NSW region has been attempted. Bell and Stanley (1991) used data for Umberumberka near Broken Hill and interpolated values from maps of evaporation for the whole of Australia. Mean evaporation rates were considerably greater than mean rainfall in all months; the difference ranged from approximately 340 mm in summer months to 70 mm in winter, when the greatest variability in evaporation rates occurred (Bell and Stanley 1991). Annual average evaporation rate is high (2300–2800 mm) (BOM 2006a) while annual average surface runoff is extremely low (11 mm) compared to annual average rainfall (Smith 1998). Wind speeds are generally low with low erosion potential (annual averages 7–14 km per hour), although dust storms occur periodically (BOM 2006a). Dew, fog and mists are uncommon because of low atmospheric humidity (Williams and Calaby 1985).

3.4.4 Physicochemical environment

Water quality variables such as pH, salinity and turbidity have not been measured at Lake Pinaroo Ramsar site. This is a key knowledge gap for this site, as salinity and turbidity have a major influence on plant communities when flooding and subsequent drying concentrates salts and flocculates clay particles (Akhurst and Breen 1988; Boulton and Brock 1999; Porter 2002; Porter et al. 2007). Salinity levels also have implications for the distribution of faunal species. For instance, shorebird species tend to congregate on rapidly drying open, shallow lakes, with saline lakes generally being the most favoured sites (Smith 1991; Kingsford and Porter 1993).



Mean monthly rainfall (mm) recorded at Fort Grey rainfall gauge (1889–2006). Standard error bars are included. Note that there were large gaps in rainfall records for some months during 1889–2006 (see Appendix 3). Source: BOM (2006b)

Figure 5: Mean monthly rainfall recorded at Fort Grey

Table 12: Climate variables recorded at Tibooburra Post Office

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean daily max temp (°C)	36.1	35.2	32.1	27.0	21.9	18.3	17.8	20.3	24.5	28.3	32.0	34.9
Mean daily min temp (°C)	21.6	21.4	18.4	13.7	9.5	6.5	5.4	6.9	10.2	13.9	17.4	20.1
Mean monthly rainfall (mm)	27.3	29.7	23.7	15.0	18.1	16.4	16.6	12.0	12.2	18.7	15.9	22.2
Highest monthly rainfall (mm)	384.8	178.4	398.4	107.7	92.8	127.4	95.4	89.0	139.5	109.5	86.5	123.6
Highest recorded daily rainfall (mm)	178.8	124.7	85.9	62.5	53.3	69.9	73.9	51.3	50.3	51.6	77.0	69.2
Mean number of rain days	2.7	2.7	2.3	1.9	2.6	2.8	2.9	2.5	2.4	3.0	2.8	2.8

Source: Tibooburra Post Office (1886–2004) (BOM 2006b)

3.4.5 Vegetation

The vegetation of this arid part of NSW reflects the harshness of the environment through its paucity of cover and the morphological and physiological attributes that allow plant survival.

Vegetation community distribution is largely controlled by three processes, which have been discussed in more detail in previous sections:

- **inundation** (for example, the canegrass *Eragrostis australasica* can only survive shallow inundation to about 0.5 m)
- **geomorphology** (physical and chemical characteristics of the soil and in turn the distribution of soil types is a direct result of weathering and geomorphic factors which influence parameters such as surface drainage, soil depth and infiltration, and moisture-holding capacity)
- **climate** (controls plant recruitment, with fast growing annual species establishing more frequently in response to rainfall than slower growing perennials).

The Lake Pinaroo Ramsar site is located in the Fort Grey vegetation system, a lignum–canegrass alliance in a Playas and Basins land system (Milthorpe 1991). There is generally only sparse vegetation on the bed of Lake Pinaroo but this is highly variable and dependent on time since flooding and soil moisture. After flooding, short-lived herbs, shrubs and grasses such as Neverfail (*Eragrostis setifolia)* may dominate. Coolibah (*Eucalyptus coolabah* ssp*. arida*) regrowth is found on the high ground around the lake margins. The surrounding sand dune country is vegetated with Hopbush (*Dodonaea attenuata*), Turpentine (*Eremophila sturtii*), Saltbush (*Atriplex* spp.), Budda (*Ermophila mitchellii*) and Whitewood (*Atalaya hemiglauca*). Edible plants found in or surrounding Lake Pinaroo include Ruby saltbush (*Enchylaena tomentosa*), Purslane (*Portulaca* spp.) and Nardoo (*Marsilea* spp.) (Cunningham et al. 1992).

Although vegetation is sparse at Lake Pinaroo and its surrounds, there is a large dormant seed bank which persists when the lake is dry. As there was no information on the aquatic plant species found at Lake Pinaroo or Fromes Swamp, the aquatic plant community was sampled by examining the sediment seed bank during a visit to the site in May 2006 (see Appendix 2 for methods). Seed banks are an appropriate way to sample aquatic plant communities in arid wetlands and enable comparisons through all phases of erratic flooding and drying patterns (Brock et al. 2003).

Lake Pinaroo seed bank density in May 2006 was highly variable at 0–5517 seeds per m^2, with an average of 929 seeds per m^2 ($\pm$ 349 s.e.). A total of 14 taxa were detected from the germination assay but because of the short duration only one species, *Myriophyllum verrucosum,* was identified from the samples. At least one species of charophyte algae was also present (Appendix 4). In Fromes Swamp, mean seed bank density was 22 225 seeds per m^2 ($\pm$ 2337 s.e.) and seven taxa were detected in total. Species identified included the fern *Marsilea drummondii* and a sedge *Scheonoplectus dissachanthus* (Appendix 4). These results show that the aquatic plant communities of Lake Pinaroo and Fromes Swamp are more abundant and diverse than previously recognised.

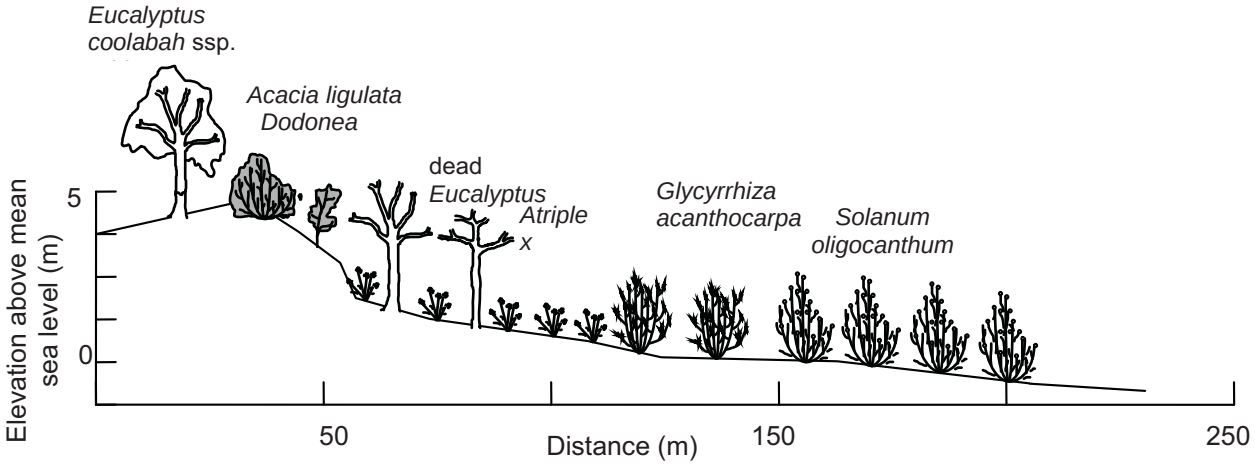
Above ground vegetation at Lake Pinaroo was sampled in May 2006 using linear transects to record presence or absence of species and the cover and abundance of dominant species (see Appendix 2 for methods). Severe and prolonged drought conditions throughout the area had reduced the number and abundance of species

recorded, particularly for grasses and other herbaceous annuals. Bare ground cover was 80–98% of the sample areas. Overall, 58 plant species were identified. Three broad habitat categories were used to describe the vegetation: dune, lake margins and lake bed. The dune system on the western edge of Lake Pinaroo supported a narrow belt of *Eucalyptus coolabah* ssp*. arida* trees (to 12 m height; <1–15% foliar cover; mean circumference at breast height 56.8 cm ± 6.0 s.e.; n = 20) confined to the dune crest.

The understorey was sparse and consisted of low shrubs including *Rhagodia spinescens, Enchylaena tomentosum* and *Atriplex stipitata*, and occasional *Einadia nutans, Podolepis capillaris* and *Brachycome ciliaris* var. *lanuginosa*. The western slopes of the dune system supported sparse shrubland to 3 m height dominated by *Acacia ligulata*, *Dodonea viscosa* ssp. *angustissima, Eremophila sturtii, Myoporum montanum*, *Senna f. 'filifolia'* and *Senna pleurocarpa* var*. pleurocarpa.* Forbs and groundcover species (to 0.5 m height) in this habitat included *Glycine canescens*, *Sclerolaena bicornis* var. *bicornis*, *Sida corrugata* and *Teucrium racemosum* (Figure 6)*.* Large Coolibahs on the western side of the lunette were dead, presumely as a result of the large flood in the late 1970s and early 1980s (see section 3.4.1). These dead Coolibahs start at approximately 100 m from the top of the dune crest (Figure 6; Appendix 5). Extended drought periods are a natural feature of the region and only the most severe droughts will kill well-established trees and shrubs (Cunningham et al. 1992).

The lake margins in May 2006 supported a relatively diverse mix of low shrubs (<1 m), forbs and grasses dominated by *Atriplex stipitata, Enchylaena tomentosum, Sclerolaena diacantha, Sclerolaena divaricata, Sclerolaena intricata, Sclerolaena patenticuspis, Olearia meulleri, Aster subulatus, Crotalaria eremea* ssp*. eremea, Brachycome ciliaris* var*. lanuginosa, Sesbania cannabina* var*. cannabina, Psoralea australasica, Portulaca oleracea, Zehneria micrantha, Pterocaulon sphacelatum, Senecio cunninghamii* var*. cunninghamii, Heliotropium supinum, Glinus lotoides, Centipeda cunninghamii, Calotis hispidula, Ditrichia graveoloens, Epaltes australis* and *Sporobolus mitchelii.* The lake margin habitat included the inflow of Fromes Creek (Appendix 5), which was notable for its high species richness. This was probably due to variable soil types (sandy loam to cracking clay), microtopographic variation, and higher frequency and duration of inundation.The lake bed with cracking clay and rocky clay soils supported low shrubland with low species richness that was dominated by *Solanum oligocanthum, Glyccyrhiza acanthocarpa*, *Maireana aphylla* and *Enchylaena tomentosum* with forbs including *Portulacca oleracea*, *Zehneria micrantha* and the grass *Sporobolus mitchelii.*

These vegetation communities provide important habitat and food supply for faunal species; for example, almost 35% of Freckled Ducks' gut contents sampled in Lake Pinaroo contained seeds of the *Portulaca* plant (Briggs 1982), while large Coolibah trees can be utilised as nest sites by waterbirds and birds of prey. Large areas of Canegrass can be found at Fromes Swamp (Appendix 5), which would provide cover for birds and small mammals.



Vegetation not drawn to vertical scale. West–east transect from dune crest to lake bed. Elevation transect is based on most the representative sample of transects measured in May 2006 (see Appendix 2 for methods).

Figure 6: Elevation profile and dominant perennial vegetation at Lake Pinaroo

3.4.6 Waterbirds

Variable rainfall and flooding patterns determine the availability of waterbird habitat (Braithwaite 1975; Roshier et al. 2002). Many waterbirds in western NSW, particularly ducks, breed on temporary waters and then move to more permanent waters to survive dry periods (Briggs 1994). For instance, Grey Teal and Pink-eared Duck are known for their long distance movements, especially in times of drought (Braithwaite 1975).

A total of 195 bird species and subspecies has been reported from Sturt National Park and 61 of these are waterbird species (Appendix 4). Five of these waterbird species are listed under international bird agreements (JAMBA, CAMBA and ROKAMBA) (Appendix 4). Only a limited number of direct counts have been recorded for the Lake Pinaroo Ramsar site, primarily by Briggs (1980, 1982) and in NSW bird reports (1978–1980) (Lindsey 1979, 1980, 1981). Briggs (1982) studied Freckled Duck, Grey Teal and Pink-eared Duck feeding behaviour and invertebrate prey availability in Lake Pinaroo in January 1980. These species fed primarily on invertebrates (see section 3.4.12) and also plant species from the families Chenopodiaceae (C*henopodium* ssp.*),* Fabaceae (*Trifolium* spp.)*,* Malvaceae, Polygonaceae (*Polygonium* spp.)*, Rumex* ssp*.* and filamentous algae (Briggs 1982). The Freckled Duck and Blue-billed Duck are both listed as vulnerable in NSW (TSC Act). These species are threatened primarily by wetland habitat loss, altered flow regimes (Kingsford and Thomas 1995; Kingsford 2000), clearing, introduced pest species and pollution (Garnett and Crowley 2000).

For most waterfowl species, breeding occurs in seasonal or temporary to semi-permanent freshwater habitats (Braithwaite 1975). Breeding in waterfowl is limited by habitat availability (availability for breeding and timing), natural environmental fluctuations (rainfall), physiological limitations (breeding timing/photoperiod), behavioural limitations (territory availability and bird mobility) and mortality

(Braithwaite 1975). Generally, the species and number of birds that can be supported by a wetland changes as the water level drops and alongside corresponding changes in vegetation and macroinvertebrate communities (Braithwaite 1975; Briggs and Maher 1985). Some species of waterfowl, for instance, the Grey Teal *(Anas gracilis)* and Pink-eared Duck (*Malacorhynchus membranaceus*), actually lack an annual physiological cycle and can breed at any time that their environment permits (Braithwaite 1975).

From these early reports, it appears that Lake Pinaroo Ramsar site can support high numbers of waterfowl species during prolonged flood periods; for example Briggs (1980) describes 'hundreds to thousands of duck, coot and grebe' being seen in November 1979, 'with probably 200–400 Freckled Duck, but few waders' (other waterfowl species are listed in Appendix 4). The highest concentration of birds was seen near Fromes Creek inflow on the mudflats and shallow areas. The Red-kneed Dotterel, Black-fronted Dotterel, Black-winged Stilt and Marsh Sandpiper were also recorded here (Briggs 1980).

Surrounding wetlands near Lake Pinaroo also supported high numbers of waterbirds in 1979 (Briggs 1980). Telephone Tank supported large numbers of Red-necked Avocet, Eurasian Coot, Pacific Black Duck, Grey Teal, Red-kneed Dotterel, Masked Lapwing, Yellow-billed Spoonbill, Wood Duck, Black Swan, Freckled Duck and Hardhead in November 1979 (Briggs 1980).

Many processes affect the distribution and number of waterbird species in inland lakes, including salinity and turbidity (hydrology) and water depth (inundation). These processes are particularly important for determining shorebird distribution as they primarily determine the distribution of prey (vegetation, fish and invertebrates), which in turn determines the distribution of birds. Inland wetlands are unsuitable for most shorebird species when dry and also when flooded (Kingsford and Porter 1993). For example, more shorebirds were present at the wetland when the water level dropped between November 1979 and January 1980 (Briggs 1980). Freshly exposed mudflats and their abundant invertebrate populations are the chief attraction and large, open, shallow lakes generally provide the most extensive habitat. The pattern is complicated by differences in habitat requirements of individual species and by factors such as salinity, which may vary greatly between wetlands and at different stages of the flooding cycle. Saline wetlands are generally most favoured, but not by all species (Smith 1991).

Most of the shorebirds that migrate to Australia are transequatorial migrants that breed in central and north-eastern Asia in June and July and migrate to Australia to spend their non-breeding season (Lane 1987). Some migratory shorebird species are known to use inland wetlands during their northern and/or southern migrations (Lane 1987) (Table 13). For the migratory species, the time of year when this habitat is available is an important factor, as the greatest numbers of birds are present in Australia during their non-breeding season (September–April) (Lane 1987). Shorebirds that use inland wetlands tend to be very mobile in order to respond to changes in wetland availability (Watkins 1993). The Sharp-tailed Sandpiper, Red-necked Stint and Curlew Sandpiper are the most commonly recorded migratory species in inland NSW (Lane 1987). Migratory shorebird species that have been recorded at Lake Pinaroo Ramsar site and Fromes Swamp include the Sharp-tailed Sandpiper, Red-necked Stint, Marsh Sandpiper, Common Greenshank and Black-tailed Godwit (Table 7). The Black-tailed Godwit is listed as vulnerable in NSW (TSC Act).

Resident shorebirds generally either operate on a cycle of 'coastal movement', whereby birds move to the coast in summer and return inland during the winter if uninterrupted by a drought cycle, or by an 'inland flood cycle', in which they fly from the coast to breed in recently filled wetlands far inland (Lane 1987). Australian resident shorebird species, which use inland wetlands almost exclusively, include the Red-kneed Dotterel, Black-fronted Dotterel, Banded Stilt (*Cladorhynchus leucocephalus*), Red-necked Avocet and Painted Snipe (Lane 1987) (Table 13). Excluding the Painted Snipe, all of these species have been recorded at the Lake Pinaroo Ramsar site (Table 7; Appendix 4). Further, approximately 500 Australian Pratincole (*Stiltia isabella*) were recorded in the 'Sturt Lakes' during 1970–1990, which represents 1% of the Australian population for this species (Smith 1991) (Table 7).

Although the Grey Grasswren (*Amytornis barbatus barbatus*) has not been officially recorded in this area, it is listed as nationally vulnerable (EPBC Act) and endangered in NSW (TSC Act). It has very specific habitat requirements, preferring Canegrass swamps, large stands of which are located in the Bulloo River overflow (Smith et al. 1995). Similar stands of dense tussock Canegrass are found at Fromes Swamp near the Lake Pinaroo Ramsar site (Appendix 5) and this area could potentially support Grey Grasswren populations. Further monitoring is needed to determine whether this species is present in the area (see section 6.2).

3.4.7 Land birds

Many bird species are nomadic visitors whose numbers in the park vary with local conditions. Thirteen species of land birds, known from Sturt National Park, are listed as vulnerable and three as endangered in NSW (TSC Act). The Australian Bustard (*Ardeotis australis*), Plains-wanderer (*Pediomomus torquatus*) and Flock Bronzewing (*Phaps histrionica*) are all listed as endangered in NSW (TSC Act) (Table 4).

Limited monitoring of bird populations has been carried out at Lake Pinaroo, although the DECC Tibooburra District office carries out regular raptor monitoring within the national park. Sturt National Park has a diverse raptor population (Angus 1992), with 18 species of diurnal birds of prey and three owl species recorded in the park (Appendix 4). Four of these raptors are listed as threatened in NSW (TSC Act) including the Grey Falcon, Black-breasted Buzzard, Masked Owl (*Tyto novaehollandiae*) and Barking Owl (*Ninox connivens*) (Table 4). Declines in these species are thought to be related primarily to habitat degradation through overgrazing and declines in prey populations (Smith et al. 1994; Garnett and Crowley 2000) (see section 5). The Grey Falcon, which has been recorded at Lake Pinaroo (Morris and Burton 1994; NSW NPWS Atlas of NSW Wildlife 2006), nests along watercourses even when they are dry. Its breeding range is thought to be confined to the arid zone (Olsen and Olsen 1986).

Arid species, such as the Budgerigar (*Melopsittacus undulatus*), are also very common in Sturt National Park and 13 parrot species have been recorded within the park (Appendix 4). The park also provides ideal habitat for large numbers of Emu (*Dromaius novaehollandiae*). Bird species that have increased in the western region include the introduced House Sparrow (*Passer domesticus*), Common Starling (*Sturnus vulgaris*) and native colonisers such as the Banded Whiteface (*Aphelocephala nigricincta*) and Little Corella (*Cacatua sanguinea*) (Smith et al. 1994).

Table 13: Shorebird species occurrence and status in NSW

Migratory shorebirds	Route	Occurrence	Status	Australian-breeding shorebirds	Occurrence	Status
Bar-tailed Godwit	N, S	a		Australian Pratincole	c	
Black-tailed Godwit	N	b	V	Banded Stilt	d	
Broad-billed Sandpiper	N		V	Black-fronted Dotterel	d	
Common Greenshank	N, S *	a		Black-winged Stilt	d	
Common Sandpiper	N, S *			Inland (Australian) Dotterel	d	
Curlew Sandpiper	S *	a		Painted Snipe	d	E
Eastern Curlew	S	a		Red-capped Plover	d	
Great Knot	N		V	Red-kneed Dotterel	d	
Grey Plover	N, S	a		Red-necked Avocet	d	
Grey-tailed Tattler	N			Banded Lapwing	c	
Large Sand Plover	N			Masked Lapwing	e	
Latham's Snipe						
Lesser Golden Plover	S *	a				
Little Curlew	N	b				
Marsh Sandpiper	N, S*					
Mongolian Plover	N					
Oriental Plover		b				
Oriental Pratincole		b				
Red Knot	N	a				
Red-necked Stint	S *	a				
Sanderling	N, S	a	V			
Sharp-tailed Sandpiper	S *	a				
Whimbrel	N					
Wood Sandpiper	N, S *					

Migratory shorebirds can use inland wetlands on their northern (N) and southern (S) routes to and from their breeding grounds in the northern hemisphere (* probable transAustralian migrants).

Occurrence: (a) common on the southern coast; (b) common in inland northern Australia; (c) almost exclusively inland away from wetlands; (d) almost exclusively inland wetland species; (e) ubiquitous (adapted from Lane 1987).

Status (TSC Act): E = endangered, V = vulnerable.

3.4.8 Mammals

Thirty-one native and six introduced mammal species have been recorded in Sturt National Park (Appendix 4). Many mammal species in this area have experienced a reduction in distribution and numbers in the Western Division of NSW (Dickman et al. 1993). The Dusky Hopping Mouse (*Notomys fuscus*) and Eastern/Greater Long-eared Bat are listed as vulnerable on the IUCN Red List and under the EPBC Act (Table 4). Other small mammals found in Sturt National Park include the Forrest's Mouse, Sandy Island Mouse (*Pseudomys hermannsburgensis*), Fat-tailed Dunnart (*Sminthopsis crassicaudata*), Paucident Planigale (*Planigale gilesi*), Long-haired Rat, Echidna (*Tachyglossus aculeatus*) and a number of bat species, including the White-striped Mastiff Bat (*Tadarida australis*), Little Cave Bat (*Eptesicus pumilus*), Gould's Wattled Bat (*Chalinolobus gouldii*) and Lesser Long-eared Bat (*Nycotophilus geoffroyi*) (Appendix 4). The park also provides ideal habitat for Red Kangaroo (*Macropus rufa*). Other mammal species may visit this wetland to drink, graze littoral vegetation or hunt prey.

The distribution of mammal species is largely dependent on available watering points, shade, prevailing winds, food quality and availability (Denny 1991). Small mammals generally prefer cracking soils with some vegetation cover for shelter from both the elements and predators (Denny 1991). Although most of these small mammal species are well adapted to living in arid conditions, the Lake Pinaroo Ramsar site may also provide supplementary watering and feeding points for these species, especially in times of drought. Tibooburra District DECC staff have established pitfall traps near the Ramsar site to monitor changes in small animal populations.

In surveys of Sturt National Park in 1974 (during a flood period), numbers of small mammals varied considerably, especially species associated with periodic flooding (Denny 1975). A common small mammal, the Paucident Planigale, uses cracking soils and has been found near creeks or low flooding areas and Canegrass during flood periods (Denny 1975). The distribution of the Long-haired Rat and Water Rat (*Hydromys chrysogaster*) are most closely linked to water resources (Denny 1991). The Long-haired Rat was seen in large numbers near Lake Pinaroo after heavy rains in 1974 and 1976 (Denny 1991). This species is known to undergo rapid increases in populations, primarily as a result of immigration after large rainfall events (Predavec and Dickman 1994). This species of rat is listed as vulnerable in NSW (TSC Act) and further monitoring is required at the Ramsar site (see section 6.2) to determine whether the wetland could support greater than 1% of this species during flood periods. This would qualify Lake Pinaroo to be listed as a Ramsar site under Criterion 9 of the Ramsar Convention:

> a wetland that regularly supports 1% of the individuals in a population of one species or subspecies of wetland dependent non-avian animal species.

3.4.9 Reptiles

Sixty-seven species of reptiles have been recorded in Sturt National Park (Appendix 4). The Australian Museum collected reptiles from Lake Pinaroo Ramsar site and surrounds from May 1978 to November 1999 (Appendix 4). Over this period, five threatened reptile species were recorded at Lake Pinaroo and Fort Grey (Appendix 4) (R. Sadlier 2006, pers. comm.). The Interior Blind Snake (*Ramphotyphlops endoterus*) is endangered in NSW (TSC Act) and was recorded in Lake Pinaroo in September 1998 (Appendix 4). Other reptile species have restricted distributions in this part of north-west NSW. For instance, the Yellow-tailed Plain-slider (*Lerista* xanthura) is thought to have isolated populations in the far west region and the Mallee Dragon (*Ctenophorus fordi*) relies on the western region for its survival with more than 50% of its national range in the western region (Sadlier 1994). Most of these reptiles are dry country species and are not thought to qualify as wetland dependent species (R. Sadlier 2006, pers. comm.). However, during flood periods the Lake Pinaroo Ramsar site may support prey populations for some reptile species.

Although there has been some small animal trapping near the Lake Pinaroo Ramsar site, further monitoring is needed to establish whether the wetland supports other reptile species known from Sturt National Park (see section 6.2).

3.4.10 Amphibians

The amphibians of the north-west of NSW are amongst the least known faunal group (Tyler 1994); however, nine species have been recorded in Sturt National Park (Appendix 4). The Australian Museum collected four species of frogs at Lake

Pinaroo in September 1998 (Appendix 4) (R. Sadlier 2006, pers. comm.). These amphibian species are generally widespread species in NSW. Most are ephemeral species, which are dependent on water sources for their breeding and capable of surviving dry periods by burrowing underground. Only the Desert Tree Frog (*Litoria rubella*) is truly restricted to areas with permanent above-ground water sources. None of these amphibians is listed as threatened species or is likely to be found in numbers greater than 1% of their populations at the Lake Pinaroo Ramsar site (M. Mahony 2006, pers. comm.).

3.4.11 Fish

There are no records of fish species in Lake Pinaroo during flood periods. Fish depend on water and only a few species have mechanisms for surviving dry periods (Boulton and Brock 1999). Fish would provide a source of food for waterbirds in flood periods in the Lake Pinaroo Ramsar site. The presence of fish-eating birds such as the Australian Pelican (*Pelecanus conspicillatus*) and Cormorants (*Phalacrocorax* spp.) at the wetland during wet periods suggests that Lake Pinaroo may support some species of fish. Large catches of Golden Perch (*Macquaria ambigua*) were recorded from other wetlands in the north-west of NSW, the Bulloo Overflow and Yantara and Bancannia Lakes, after extremely high summer rains recorded in 1971, 1974 and 1976 (Stanley 1991). Further monitoring is needed to address this knowledge gap for the Lake Pinaroo Ramsar site (see section 6.2).

3.4.12 Invertebrates

Insects and crustaceans have resting stages resistant to desiccation and grow and reproduce opportunistically when water becomes available, becoming briefly abundant and productive as wetlands fill and then evaporate (Timms 1997, 2001). Beetles (Coleoptera), dragonflies (Odonata), flies (Diptera), moths (Lepidoptera), bugs (Hemiptera), grasshoppers (Odonata) and spiders (Arachnida) were observed during a visit to Lake Pinaroo in May 2006. It is highly likely that these invertebrates would be found in higher numbers at the site in times of flood. Invertebrates would provide a major food source for mammal, bird, reptile and amphibian species in the area. Crustaceans and aquatic insects are important food sources for waterbirds, such as herons, egrets, ducks and spoonbills, especially during the large breeding events that may follow a large flood (NSW NPWS 2000).

Although there have been no dedicated studies of invertebrate communities in Lake Pinaroo Ramsar site, Briggs (1982) recorded invertebrate prey availability for the Pink-eared Duck and Freckled Duck. These duck species were primarily inverterbrate feeders in Lake Pinaroo (Briggs 1982). During this study, Ostracods, Ceratopogonids and Chironomid families were collected from the substrate and ostracods and micronecta species were most common in the very shallow water (less than 4 cm deep) and corixids, notonectids, caddis-flies, beetles and cladocerans were found in deeper water (11–50 cm deep) (Briggs 1982). Further observations of invertebrates were made opportunistically in October 2001 when Lake Pinaroo was very turbid, fresh and shallow (perhaps up to 20–40 cm deep) and the zooplankton was dominated by the copepod *Boeckella triarticulata* (B. Timms 2006, pers. comm.). Remains of the yabby (*Cherax destructor*) were observed at the site in May 2006 (J. Spencer and J. Porter pers. obs.). The yabby is a prized recreational and commercial fishing species. The yabby and small aquatic crustaceans, including water fleas (cladocerans), ostracods (seed shrimps), conchostracans (clam shrimps), copepods and amphipods are sometimes abundant after flooding events in the Paroo River wetlands in north-western NSW (NSW NPWS 2000).

4 Limits of acceptable change

The ecological character of a declared Ramsar wetland is specified in the EPBC Act as a matter of national environmental significance. The principal mechanism through which the EPBC Act operates is by prohibiting actions that may cause a significant impact on matters protected by the Act unless assessed and approved under the Act. It was recommended that limits of acceptable change be included in the ecological character description of Ramsar wetlands to provide a basis for recommending thresholds of change in key components (Lambert and Elix 2006). These thresholds should be sensitive enough to trigger when detrimental changes occur in a Ramsar wetland's ecological character.

In the case of Lake Pinaroo, thresholds need to be robust enough to account for inherent variability associated with this arid system and still conservative enough to trigger management action in response to negative changes to the site. The limits of acceptable change system has been used previously in a management framework sense, whereby quantitative standards have been used to trigger appropriate actions to prevent further change from occurring (Stankey et al. 1985). The actual application of the limits of acceptable change system is difficult, as defining the desired condition and establishing measurable standards for ecosystem attributes, which change in unpredictable ways, is problematic (Merigliano et al. 1998).

Key indicators

Due to the high degree of variability and lack of comprehensive ecological data sets available for the Lake Pinaroo Ramsar site, only general recommendations can be made on suitable components that could be used as a basis for future assessment of change in the ecological character of this site. In order to undertake such a task, several monitoring initiatives would have to be implemented first.

The wetland risk assessment framework adopted by Resolution VII.10 of the Ramsar Convention recommends the use of biological responses as an early warning system to detect adverse change in a wetland. This framework also highlights the need to consider the ecological relevance of an early warning indicator. After a review of the critical components and processes that relate to the Lake Pinaroo Ramsar site in section 3, monitoring at this site should focus on:

- the extent of inundation and water depth
- the health of major inflows
- waterbird populations and their breeding success.

These monitoring programs would provide some basis for determining the size of waterbird populations supported during floods. An attempt to estimate thresholds for changes in these key indicators could be undertaken once baseline information is established over a sufficient time scale to incorporate natural temporal variability.

Recommended indicators for setting limits of acceptable change and examples of how they could be applied to detect change and trigger management actions at the Lake Pinaroo Ramsar site are summarised in Table 14. Key threats to the Ramsar site and recommended monitoring strategies are described in more detail in sections 5 and 6.

Table 14: Potential indicators and monitoring methods for detecting changes at Lake Pinaroo Ramsar site

Indicator	Potential monitoring methods	Potential triggers for management action
Water depth and flooding extent	Regular on-ground measurements Aerial photograph analysis	No major floods (>150 mm monthly rainfall) recorded in a 50 year period
Health of major inflows	Rapid bio-assessment protocols	AusRivAS indicators
Waterbird abundance and species diversity	Annual census (ground/aerial-based)	Absence of selected bird species at the wetland Less than 100 waterbirds during a flood period Reduction in species diversity or abundance

Suitable species should be selected for setting limits of acceptable change. For example, in the case of waterbird numbers, it may be more useful to use a species whose life history and distribution are well known at a regional level. This could provide some information on the relative condition of the site compared to other wetlands in NSW and arid areas of Australia. If inundation frequency and duration are used as indicators, this component has merits for determining the duration and total rainfall needed to produce a flood that is large enough to support waterbird breeding and non-avian wetland dependent species at the Ramsar site.

Eight floods (>150 mm total monthly rainfall) were recorded in the Lake Pinaroo region in 1899–2006: in 1949, 1950, 1956, 1974, 1976, 1979, 1984 and 2000 (see section 3.4.1). Although there were some gaps in the rainfall records over this period, it appears that the minimum threshold for major flooding to occur would be a total monthly rainfall of 150 mm or greater at the Fort Grey rainfall gauge (Table 10; Appendix 3). Further monitoring of wetland inundation is required to determine if this 150 mm threshold is accurate (see section 6).

5 Key threats

This section relates specifically to potential threats for key components and processes identified for the Lake Pinaroo Ramsar site.

Table 15: Potential threats to the Lake Pinaroo Ramsar site

Potential threat	Potential effect	Threat status	Management actions/ monitoring undertaken
Climate change (reduced rainfall and high average temperatures)	Reduced flooding frequency impacts on flora and fauna distribution, e.g. waterbird breeding	Major	Weather station measurements only, no monitoring of water levels or waterbird counts
Fire	Negative impact on regenerating vegetation	Minor	Draft fire management plan for Sturt NP
Noogorra Burr (*Xanthium occidentale*)	Reduces waterbird breeding habitat	Major	Weeds removed from Fromes Swamp, a potential source of this burr
Athel Pine (*Tamarix aphylla)*	Spreads vegetatively	Minor	Athel Pine removed
Rabbits and goats	Overgrazing	Minor	Pest control as needed, exclusion plots established
Introduced predator species	Reduced small animal breeding and survival	Minor	Pest control as needed
Native animals	Overgrazing	Minor	Exclusion plots to monitor the impact
Dog proof fence	Impedes movement of native and feral grazing animals	Minor	Exclusion plots to investigate effects of overgrazing on native vegetation regeneration
Sedimentation	Siltation (increased turbidity)	Unknown	None
Erosion	Loss of top soil	Unknown	None
Travelling stock route	Spreads weeds	Minor	Unsuccessful attempts by DECC to acquire land from Milparinka Rural Lands Protection Board
Other land uses (agriculture, mining)	Introduction of weeds and chemicals into wetland	Unknown	None
Tourism	Use of walking track erodes lake bed, of camp sites introduces litter and fire threat, four wheel drive vehicles cause erosion.	Minor	Camp fires removed from site

There are also specific threats that relate to threatened bird species recorded at the Lake Pinaroo Ramsar site (Table 4), species that are wetland-dependent and are known to occur within Sturt National Park and threatened bird species from similar habitats (Table 16). The key threats identified for the Lake Pinaroo Ramsar site (Table 15) and for threatened bird species (Table 16) will be discussed in more detail in the remainder of this section.

5.1 Climate change

The NSW Scientific Committee declared human-caused climate change to be a key threatening process in NSW (TSC Act). Although there is a limited understanding on how future climate change may affect arid areas in Australia, this process may be a major threat to the Lake Pinaroo Ramsar site. Australia has experienced greater temperature anomalies, higher than mean maximum temperatures and lower rainfall since 2002 (BOM 2006a). It is thought that the 'enhanced' greenhouse effect is increasing the severity of droughts in Australia, as higher temperatures are increasing evaporation rates (Nicholls 2004).

As rainfall is the key to sustaining the flooding regime for this wetland, further climate change may have determinantal effects on the distribution of flora and fauna at Lake Pinaroo. The indirect effects of climate change on vegetation cover have also been linked to tree deaths in some areas of NSW (Milthorpe 1991) and the reduction in habitat availability for fauna has been implicated in the reduction of small mammal (Reid and Fleming 1992) and bird populations in arid NSW (Smith et al. 1994). For many waterbirds the main implications of climate change will be a reduction in the number of breeding opportunities (Chambers et al. 2005). Changes to the natural patterns of flooding, such as increased durations between major floods and lower periods of inundation as a consequence of lower rainfall, may also affect recruitment of some biota, such as amphibians, fish and macroinvertebrates, which rely on flooding as a spawning cue.

Table 16: Specific threats to threatened bird species recorded at Lake Pinaroo Ramsar site, in Sturt National Park and similar habitats

Species	Habitat	Threats
Threatened species recorded at Lake Pinaroo		
Black-breasted Buzzard	O, E	a, b, c, d
Black-tailed Godwit	W	a, e
Blue-billed Duck	W	a, e, f
Freckled Duck	W	a, e, f, g
Grey Falcon	O, E	a, b, c, d
Threatened species known to use wetland habitats and recorded in Sturt National Park		
Brolga	W	a, e
Painted Snipe	W	a, e
Plains-wanderer	W	a, e, h
Threatened species known to occur in similar habitats		
Grey Grasswren	W	a, e, i

Source: Smith et al. (1994); Garnett and Crowley (2000); NSW NPWS threatened species summaries.
Habitat: O = open country, E = eucalypt woodland, W = wetland
Threats: (a) effects of overgrazing and clearing; (b) reduced prey populations; (c) taking of eggs for falconry and egg collections; (d) removal of suitable nest trees; (e) drainage of wetlands; (f) salinisation and lowering of the water table; (g) hunting; (h) predation by foxes; (i) fire.

5.2 Fire

As a consequence of climate change, the frequency of fire in arid NSW may increase. The impact of fire on vegetation in this region is unclear as fire frequency and its effect on vegetation has not been well studied; however, fire has been observed to cause great change (at least in the short term) to some vegetation types (Milthorpe 1991). Fire occurrence is very low in Sturt National Park. The most recent localised fires were recorded in 1976 and 1977, which were not in the vicinity of the Lake Pinaroo Ramsar site (NSW NPWS 2005). This is primarily due to low fuel loads in the area. The vegetation is generally sparse and dense vegetation is only found on major ephemeral creek lines. A fire action plan (NSW NPWS 2005) has been prepared and is reviewed annually. Fireplaces using wood at the camping ground at Lake Pinaroo have also been phased out.

5.3 Introduced plants

Introduced plant species are thought to be relatively uncommon in the park, despite there being a long-term high grazing pressure in Sturt National Park before it was gazetted, and since it still borders pastoral lands (Oliver et al. 2004). The *Noxious Weeds Act 1993* states that public authorities have an obligation to control noxious weeds and prevent them from spreading to adjoining lands. Two non-native plants, the Athel Pine (*Tamarix aphylla*) and Noogoora Burr (*Xanthium occidentale*), were identified as threats to the Lake Pinaroo Ramsar site in the Sturt National Park Draft Plan of Management (NSW NPWS 1996); the Athel Pine has since been removed and there has been some weeding of Noogoora Burr at Fromes Swamp.

Noogoora Burr is thought to be a major threat to Lake Pinaroo as it occurs in the upper catchment and has a great potential to spread. This species has also been identified as a threat to other inland wetlands, such as the Nocoleche Nature Reserve in far north-western NSW (NSW NPWS 2000). Noogoora Burr is a serious weed of agriculture, riparian and wetland areas worldwide (Van Klinken and Julien 2003). It is highly toxic to many animals and is thought to affect the survival of native plants and (indirectly) animals through competition and allelopathic effects. It proliferates when water is drying back in floodplains, wetlands and channels (NSW NPWS 2000; CSIRO 2006). Herbicide is the most effective control method, and it must be used with caution to ensure minimal impacts on the wetland environment. The use of herbicide to control Noogoora Burr, however, requires further study, as the impacts of various herbicides on amphibians, invertebrates and other wetland biota are generally poorly understood (NSW NPWS 2000).

5.4 Introduced animals

An introduced animal species is defined in this document as an animal species which is not native to Sturt National Park. Many mammal species have been introduced into this part of NSW, including foxes (*Vulpes vulpes*), pigs (*Sus scrofa*), cats (*Felis catus*), wild dogs (*Canis lupis dingo*), rabbits (*Oryctolagus cuniculus*), goats (*Capra hircus*) and house mice (*Mus musculus*). These introduced species can have a number of negative impacts on native flora and fauna, including predation, competition, habitat destruction and disease. These effects have been most notable for native small mammal populations of north-western NSW, which have suffered major declines in their numbers in the Western Division of NSW (Dickman et al. 1993). This has largely been caused by predation by foxes and cats, and competition for food and habitat resources with rabbits and goats. Introduced predators also have negative impacts on waterbird breeding success (Kingsford and Norman 2002) and reduce prey populations for raptors (Smith et al. 1994). Feral

cats probably increase in numbers when wetlands contain water and birds are breeding (NSW NPWS 2000). Rabbits and goats compete with small mammals, such as the Planigale (*Planigale gilesi*), for food resources and habitat and limit the regeneration of native vegetation. For example, goats may have contributed to the extinction of the Yellow-footed Rock Wallaby (*Petrogale xanthopus*) from the Western Division of NSW (Denny 1991; Wilson et al. 1976).

The wider Sturt National Park area was first altered when European settlement began in the 1830s, with high stocking rates of sheep maintained from 1850 to the 1870s (Smith and Smith 1994). Although all agricultural activities have ceased in the national park since it was gazetted, there has been limited regeneration of vegetation surrounding Lake Pinaroo (Ramsar Information Sheet 1998). Recent research indicates that lack of vegetation around permanent water sources may be attributed to past sheep grazing, which ceased more than 20 years ago (Montague-Drake and Croft 2004).

The abundance of introduced animal species in Sturt National Park may increase rapidly in response to flood conditions (I. Witte 2006, pers. comm.). For example, house mice populations exploded after floods in Lake Pinaroo in 1974 (Denny 1975). Pest species are actively controlled by staff of the DECC Tibooburra office. The wild dog fence is maintained through the Wild Dog Destruction Board. Rabbit numbers were also reduced in the 1980s as a result of the introduction of myxomatosis (Denny 1991) and in the 1990s after the introduction of calicivirus (I. Witte 2006, pers. comm.).

5.5 Overgrazing by native animals

Despite the removal of domestic stock after the national park was gazetted, the presence of permanent water sources, such as man-made earth dams, is thought at times to maintain high numbers of kangaroos within Sturt National Park (Oliver et al. 2004). It has been suggested that the rabbit and wild dog fence impedes the movement of native animals and that Red Kangaroos can reach high densities within Sturt National Park (Denny 1991). However, Red Kangaroos are capable of ranging over large distances and will naturally vary in density in response to forage and rainfall conditions (Low et al. 1981). Although this potential threat is minor it remains a knowledge gap for the site and warrants further study (see recommendations in 6.2).

5.6 Sedimentation and erosion

As there is no data available for rates of sedimentation or erosion for the Lake Pinaroo Ramsar site, it is difficult to predict whether either process is negatively impacting the site. Erosion in the Fort Grey land system is thought to be negligible with only small areas of scalding and water sheeting (Milthorpe et al. 1991). However, the effect of intense rainfall and wind at Lake Pinaroo could potentially remove soil from the system. Increased sedimentation at the site has implications for water quality variables, such as turbidity, and for plant growth in the wetland. There is increasing evidence to suggest tubidity plays an important role in determining the composition and abundance of aquatic plants in Australian arid wetlands (Timms and Boulton 2001; Porter 2002; Porter et al. 2007). This is a significant knowledge gap for the Lake Pinaroo Ramsar site. Rates of sedimentation and erosion should be monitored during wet and dry periods at this Ramsar site to determine the importance of both processes (see recommendations in 6.2).

5.7 Travelling stock route

The stock route that passes through the Lake Pinaroo Ramsar site is thought to be a minor threat to the wetland, as it has only been used once since Sturt National Park was gazetted in 1972 (I. Witte 2006, pers. comm.). However, if the stock route was reopened it could have negative impacts on the wetland through the introduction of weeds and overgrazing by stock. This threat could be removed by terminating the agreement with local landowners, through the Milparinka Rural Lands Protection Board.

5.8 Other land uses

As almost 40% of Lake Pinaroo's catchment is outside the boundary of Sturt National Park, other land uses on the remaining catchment could have direct impacts on Lake Pinaroo. For example, the effects of grazing and clearing in the unprotected part of the catchment could increase runoff rates and siltation of Lake Pinaroo, and the use of agricultural chemicals, including fertilisers and pesticides, also have implications for the water quality of the Lake Pinaroo Ramsar site.

5.9 Tourism

The impact of tourism and recreation at the Lake Pinaroo Ramsar site is difficult to estimate. If visitor numbers continue to increase in Sturt National Park, there is some potential for negative impacts at the Lake Pinaroo Ramsar site. This could result in greater use of the interpretive trail on the lake bed to Sturt's tree and greater use of the surrounding sand dunes. Although four-wheel drive access is only permitted on public roads and is excluded from Lake Pinaroo, this may need to be enforced if visitor numbers increase. The impact of tourism at the Lake Pinaroo Ramsar site remains a knowledge gap and requires further monitoring.

6 Recommendations

This section describes the main outcomes of this ecological character description of the Lake Pinaroo Ramsar site. The Ramsar Information Sheet for this wetland will be updated with additional information gathered in this description. A summary of key knowledge gaps and recommended monitoring programs is also provided.

6.1 Updating the Ramsar Information Sheet

The main recommendations for updating the Ramsar Information Sheet are to:

- update general statistics about the site by reducing the total area of the Ramsar site from 800 ha to 718.8 ha (total area was revised from 800 ha used in the original listing, as technology now allows for a higher resolution and more accurate determination of site area; the boundary of the site has not been changed from the time of listing) and increasing the catchment contained with the national park to 61% (this was based on examination of 1:100 000 topographical maps using ArcView 3.3 GIS and checked against Landsat satellite and aerial photographic images)
- change the Ramsar criteria for which the site was listed in 1996 from the pre-1999 criteria (1a, 2a, 2c, 2d, 3b) to the current criteria used in the EPBC Act (1, 2, 3, 4)
- change the description of the justification for the site's listing so that there is more emphasis on Lake Pinaroo's support of species during critical stages in their life cycles and its importance as a drought refuge (Ramsar Criterion 4)
- update the climate description with the most recent data supplied by the Bureau of Meteorology in 2006
- include the names of the Aboriginal Wangkumara and Maljangapa tribes known from Sturt National Park in the cultural values section
- update the threat section by noting that the introduced Athel Pine has been removed from the Ramsar site and note that it is presently unknown whether native animals are overgrazing vegetation at the wetland
- include detail on how the threat of climate change is the most major threat to the ecological character of the Lake Pinaroo Ramsar site
- increase the total area of Sturt National Park from 310 364 to the most recent gazetted area of 325 329 ha (I. Witte 2006, pers. comm.)
- increase the estimate of total number of visitors to the national park to 30 000 – 40 000 per year (this estimate is based on car traffic measured at the park) (I. Witte 2006, pers. comm.)
- amend the species lists contained in Appendix 4 to include an additional 28 bird, 11 mammal, 20 reptile and three amphibian species that are absent from the original lists – these extra species were listed in the NSW NPWS Atlas of NSW Wildlife in 2006 and NSW Bird Reports 1973–1996 (Rogers 1974, 1976; Lindsey 1979, 1980, 1981, 1985; Cooper 1989, 1990; Morris and Burton 1992, 1994, 1999).

6.2 Knowledge gaps and recommended monitoring strategies

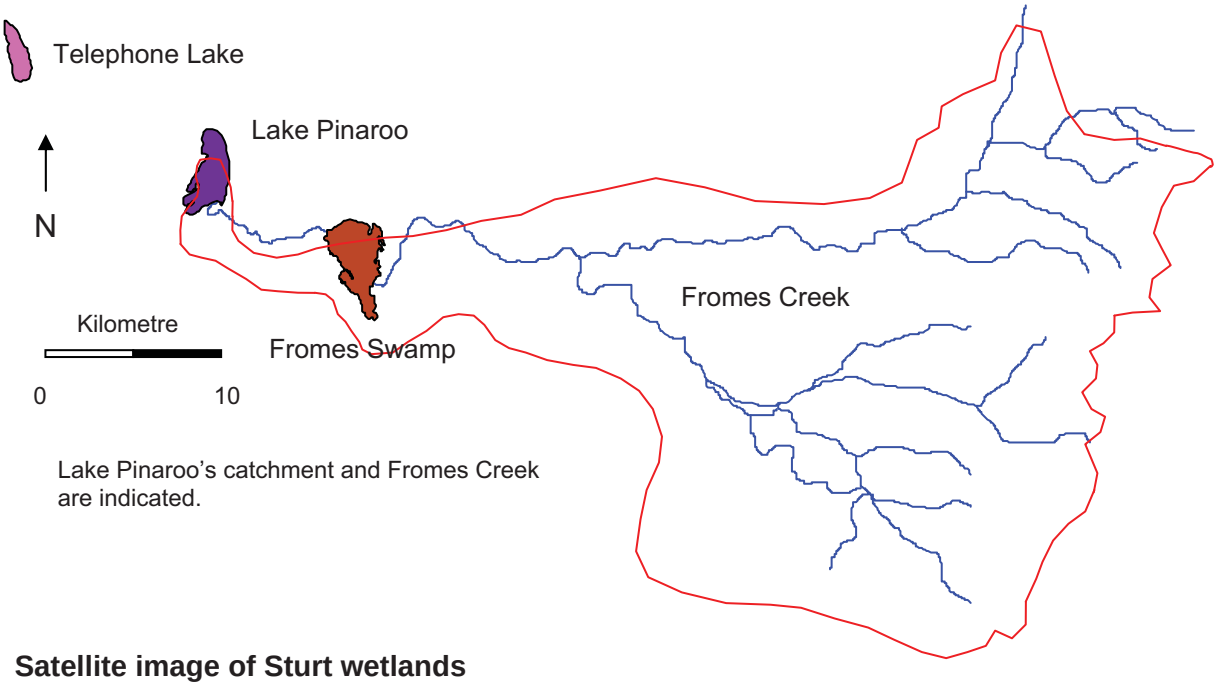
In order to effectively manage a Ramsar site it is essential to understand the range of natural variation in ecosystem components, processes and services. There are considerable knowledge gaps for the Lake Pinaroo Ramsar site in relation to the hydrology, geomorphological processes, vegetation diversity and distribution, faunal species occurrence and habitat use, presence of threatened species and their habitat requirements, and the impacts of introduced species on native flora and fauna. The key gaps in knowledge and recommendations for addressing these gaps are summarised in Table 17.

Table 17: Key knowledge gaps and recommended monitoring strategies

Key knowledge gaps		Recommended monitoring
Culture	Location of Aboriginal sites	Ground surveys of wetland to locate Aboriginal sites
Hydrology	Inundation records for the wetland have only been recorded opportunistically.	Aerial photographs of flood events. Measure water depth at monthly intervals. Maintain weather station at Fort Grey.
	Baseline water quality data needed.	Sampling during flood periods and to coincide with annual waterbird surveys of Lake Pinaroo
	Extent of groundwater flow contributions	Install bores with data loggers to monitor groundwater levels.
Geomorphology	Lack of detailed digital elevation model for the site	Construct a digital elevation map of the Ramsar site.
	Rates of sedimentation and erosion	Study rates of deposition and erosion.
Vegetation	Vegetation distribution	Use aerial photographs to map vegetation patterns and detect human induced impacts.
	Aquatic vegetation occurrence	Further seed bank germinations and sampling during flood periods
	Extent of overgrazing by introduced and native mammal species	Revisit vegetation exclusion plots established in 1980s.
Fauna	Lack of detailed waterbird census data during flood periods	Annual surveys of waterbirds at Lake Pinaroo
	Information on waterbird diet preferences for the Ramsar site	Encourage research institutions to undertake studies of waterbirds alongside macroinverterbrate monitoring.
	Limited knowledge of macroinvertebrates found at site	Sampling to coincide with annual waterbird surveys
	Limited knowledge of mammalian species that use wetland in both flood and dry periods	Increased number of pitfall traps and road transects for mammal species around the periphery of Lake Pinaroo
	Limited knowledge of reptile and amphibian species	Increased number of pitfall traps near Ramsar wetland
	No information on whether fish species are found at wetland site	Explorative fish sampling during flood periods
Threatened species	Long-haired Rat population numbers and dependence on Lake Pinaroo	Increased trapping during flood events to estimate population size
	Presence of Grey Grasswren at Fromes Swamp	Bird surveys extended to Fromes Swamp
	Distribution and feeding habits of the Eastern Long-eared Bat	Surveys of bat calls to determine whether this bat species is found near the wetland and encourage institutions to undertake research of species habitat requirements
Introduced animals	Overgrazing of native vegetation	Revisit vegetation exclusion plots established in 1980s.
	Impact of feral predators on native small animal populations	Scat and remains analysis

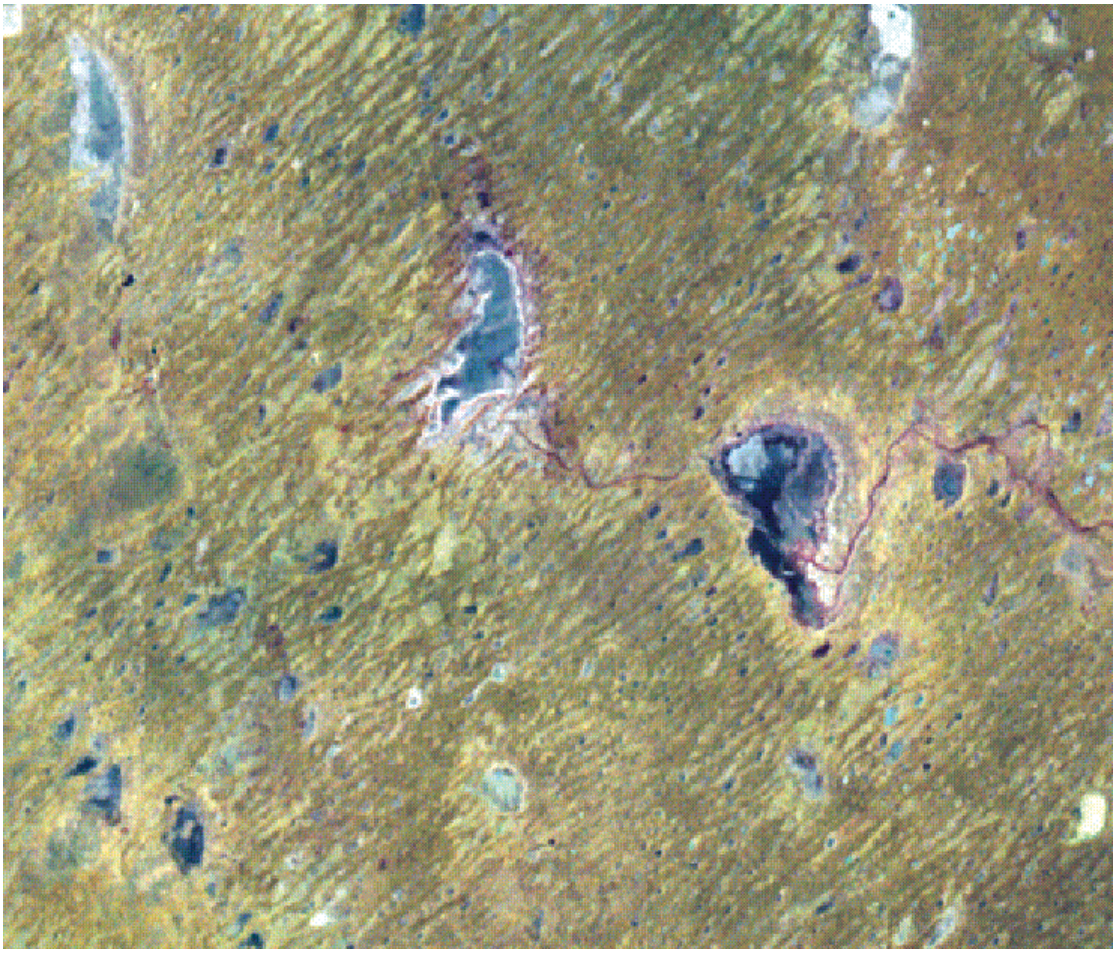
Appendix 1: Maps and images

Location of Lake Pinaroo, Fromes Swamp and Telephone Lake



Lake Pinaroo's catchment and Fromes Creek are indicated.

Satellite image of Sturt wetlands

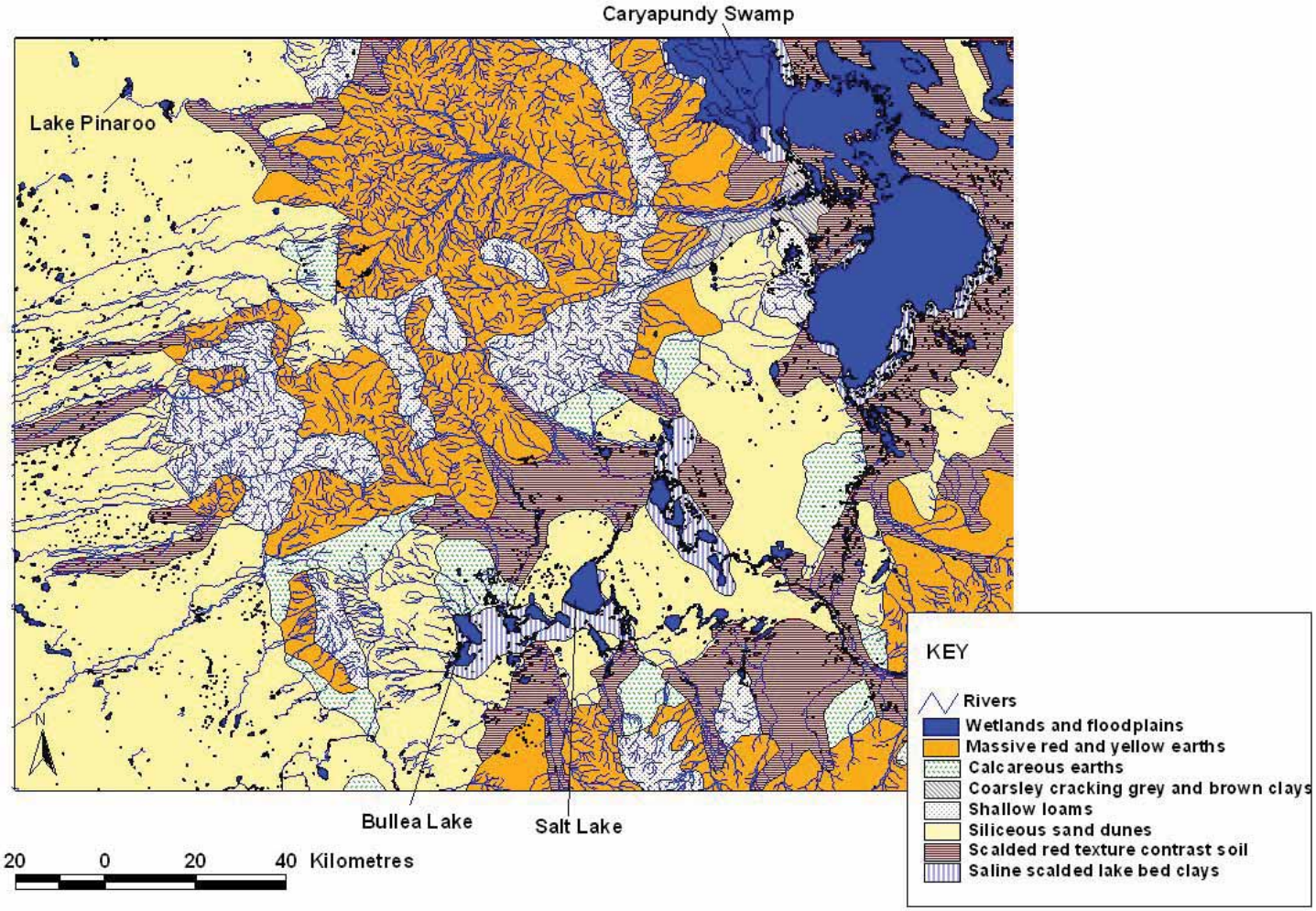


Sturt National Park wetlands: Telephone Lake (upper left), Lake Pinaroo (centre) and Fromes Swamp (lower right). ©Commonwealth of Australia – ACRES, Geoscience Australia 29 April 1990

Aerial photo of Lake Pinaroo in flood

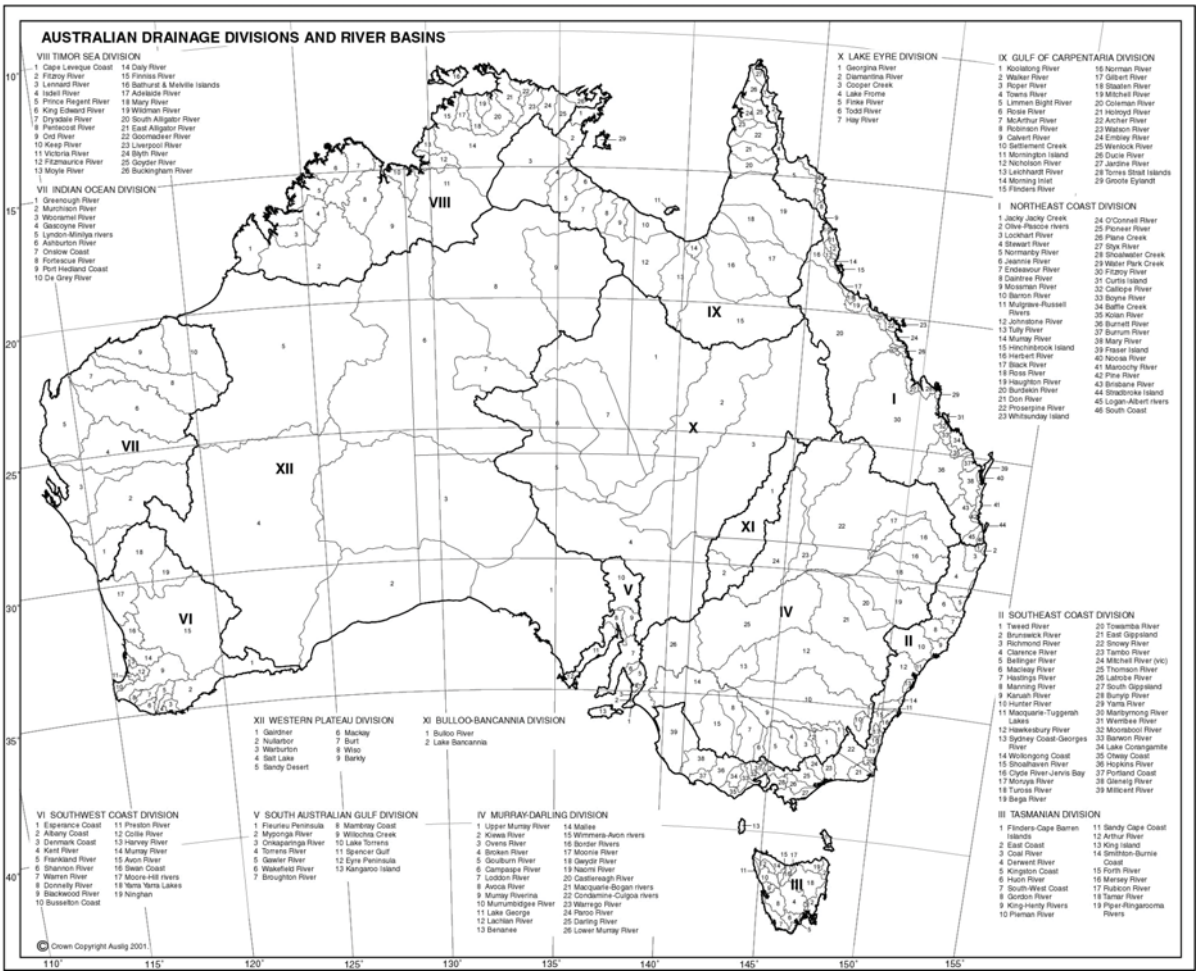
DECC Tibooburra District, April 1989

Soil types in north-western NSW



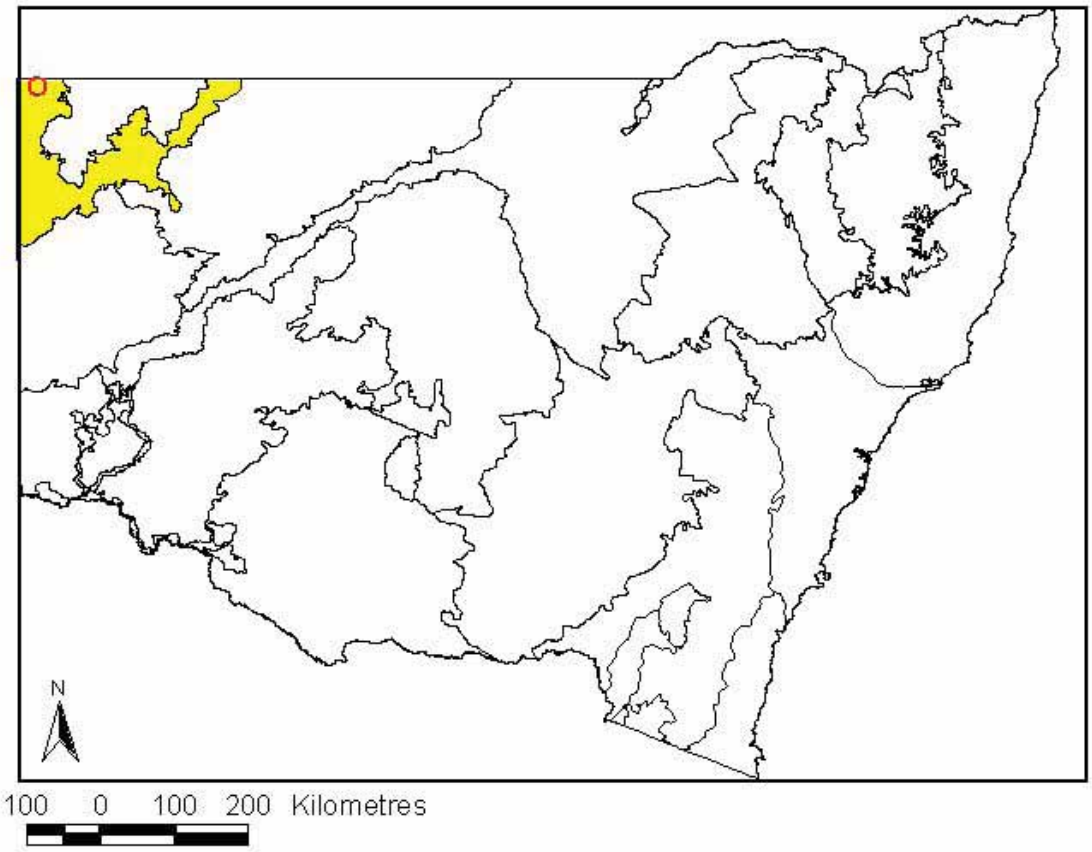
Lake Pinaroo's location in relation to soil types and other significant lakes and floodplain wetlands of north-western NSW

Australian Drainage Divisions and River Basins (ADDRB)



Source: Auslig (2001)

The NSW Simpson–Strzelecki Dunefields Biogeographic Region



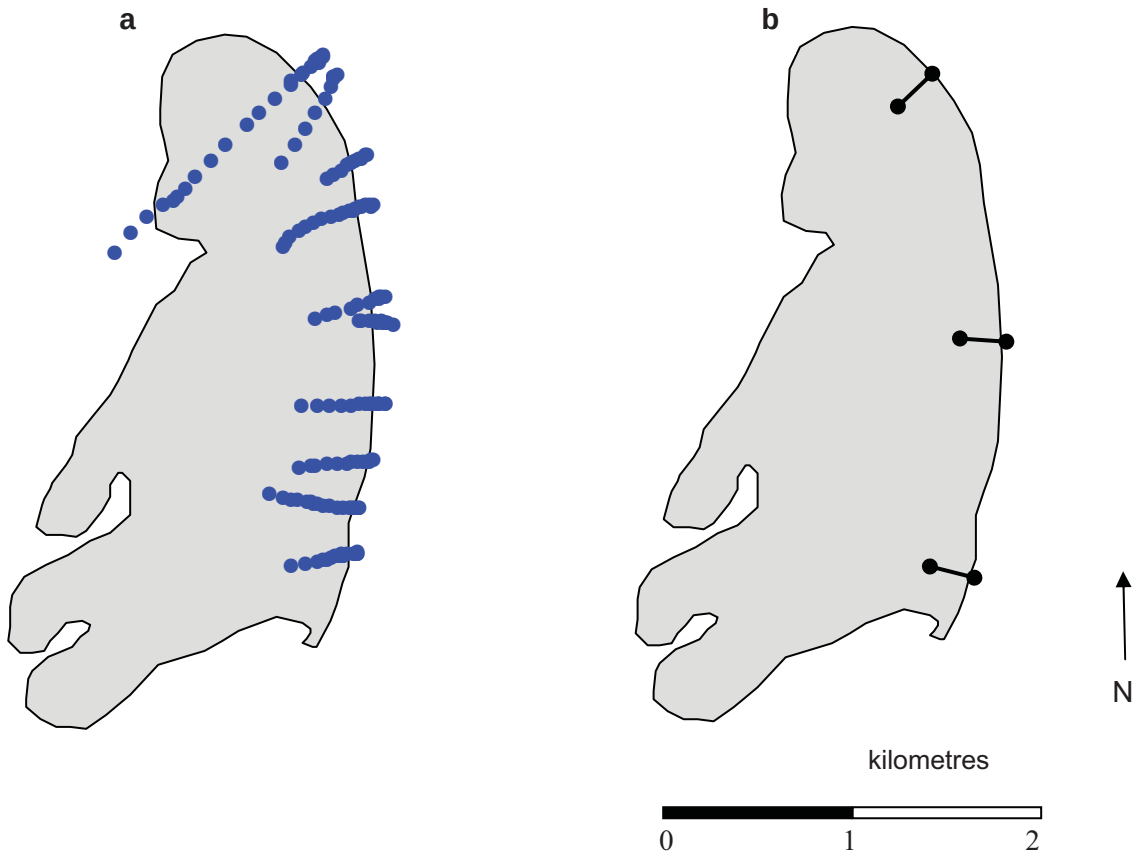
The Simpson–Strzelecki Dunefields biogeographic region is located in north-west NSW (shaded). Lake Pinaroo's position is circled in red.

Appendix 2: Methods used in site visit

Stratified sampling was used to describe the major vegetation communities of Lake Pinaroo in May 2006 following the methods of Keith and Myerscough (1993). Three habitat categories were defined a priori – dune, margin and lake bed – that coincided with a gradient in soil composition, elevation and frequency of inundation. Three belt transects of contiguous 10 m x 10 m quadrats were made, in which the presence or absence of all vascular plant species and cover abundance of dominant species were recorded. This data was summed to give frequency scores for each species. Transects were positioned at right angles to the elevation gradient and within patches visually uniform in soil type and vegetation structure. These were supplemented with ad hoc collection of plants wherever possible. Elevation gradients were measured using a surveyor's level (Sokkisha C3E) along 10 transects placed at right angles to the elevation gradient. Geographic locations were recorded using a handheld Global Positioning System (Garmin GPS III).

The non-dormant seed banks of Lake Pinaroo and Fromes Swamp were also sampled in May 2006. Fromes Swamp was sampled qualitatively from a bulked (aggregate) sediment sample, while Lake Pinaroo was sampled quantitatively, following the methods of Brock et al. (1994) by collecting sediment cores. Six aggregate sediment samples were collected from three randomly selected sites across the dry lake bed (n = 18). Each sample (surface area 0.012 m^2) comprised six cores of diameter 5 cm, depth 2.5 cm. Sediment cores were placed in shallow plastic trays for storage, transport and subsequent germination. All samples were flooded with tap water to a depth of 30 cm in four 80 L perspex tanks and monitored for several weeks. The tanks were located outdoors (at Hazelbrook, 70 km west of Sydney) in full sun and covered with a light fibreglass mesh (c. 15% shading) to exclude debris. Germinants were identified using a stereomicroscope or hand lens, counted and removed weekly. The germination experiment ran from 9 May to 12 June 2006. The number of individual germinations emerging from each sample was used to estimate mean seed densities. Due to time limitations, data collection ended on 12 June despite ongoing germinations. Data reported here is therefore incomplete and must be regarded as exploratory. Only a few of the species present could be positively identified to species level.

Position of (a) elevation transects and (b) vegetation transects carried out at Lake Pinaroo



Fieldwork was carried out in May 2006.

Appendix 3: Rainfall records from Fort Grey

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1899	*	*	*	*	*	*	*	3.6	0	0.8	5.3	0	*
1900	21.6	0	76.7	0	0	9.4	1.5	0.5	*	*	*	*	*
1901	11.7	18.5	0	0	0	7.9	13	55.3	7.1	0	0	0	113.5
1902	5.1	8.9	0	0	0	0	0.8	0	9.1	17	28.8	55.7	125.4
1903	7.6	7.6	0	44.1	0	0	0	*	16.2	10.4	0	40.6	126.5
1904	8.9	26.9	0	0	0	0	20.3	8.4	53.3	65.2	0	0	183
1905	0	0	0	13.7	0	5.1	10.2	0	0	0	0	0	29
1906	0	16.3	76.5	0	2	0	0	0	21.6	10.7	0	31.8	158.9
1907	68.6	0	26.4	0	10.9	33	0	19.1	0	0	0	29.2	187.2
1908	0	0	14.5	0	0	0	27.9	35.6	0	19.1	1.3	24.2	122.6
1909	3.8	0	0	12.4	9.9	79.5	0	5.3	0	5.6	0	0	116.5
1910	42.4	0	42.7	6.4	19.1	64.7	5.6	0	2.8	15	16.8	18.8	234.3
1911	2.5	85.9	0	0	19.1	0	0	0	3.3	0	*	36.8	147.6
1912	0	0	15.2	0	0	64.8	26.7	0	0	*	33	4	143.7
1913	7.6	0	11.7	0	0	0	0	0	5.3	17.8	*	*	42.4
1914	0	0	21.1	0	0	20.3	*	*	*	*	*	*	*
No data for July 1915 – March 1945													
1945	*	*	*	0	2	19.4	25.6	4.6	8.1	13.8	0	1.5	75
1946	55.4	14.7	0	2.5	0	2	0	0	14.5	0	3	2	94.1
1947	0	37.6	36.1	0	0	0	28.5	43.2	38.1	14.2	2.5	7.9	208.1
1948	3.8	35.7	0	0	0	22.6	0	0	0	0	0	53.1	115.2
1949	5.8	116	210.6	3.6	25.4	0	0	0	34.3	29.5	0	0	425.2
1950	0	27	26.7	0	19.8	0	0	0	0	20	51.2	159.6	304.3
1951	20.3	10.2	0	0	0	26.9	0	2.5	24.4	0	8.4	0	92.7
1952	0	16.5	3.8	28.7	13.7	21.3	13.2	69.3	22.9	41.9	0	0	231.3
1953	47.4	0	0	8.7	0	0	0	14.3	0	17.1	0	0	87.5
1954	41.6	72.7	0	6.6	0	12.2	12.2	4.6	0	52.1	7.6	15.2	224.8
1955	25.1	83	13.8	10.4	90.2	8.6	43	34.3	7.6	54.8	7.6	0	378.4
1956	0	150.4	180.4	11.1	24.9	55.4	68.1	0	0	39.2	0	0	529.5
1957	0	13.5	0	8.6	0	25.9	5.6	0	0	0	0	9.3	62.9
1958	11.4	27.9	99.6	0	20.2	0	15.3	61.8	3.3	37.4	51.5	1	329.4
1959	0	0	0	0	26.7	0	2.5	8.1	12.7	77.1	12.7	0	139.8
1960	51.9	80.5	0	0	21.8	0	28.7	34.8	0	0	39.1	1.8	258.6
1961	20.4	0	0	44.9	21.6	7.4	10.2	0	0	0	0	0	104.5
1962	82.3	0	2.8	0	17.8	6.6	30.2	0	0	0	0	31.4	171.1
1963	14.9	4.8	28.2	3	18.5	17.2	0	9.4	0	0	0	0	96
1964	9.9	13.2	0	5.6	8.4	2.3	9.6	9.7	28.4	12.9	0	2.4	102.4
1965	4.1	0	3.8	0	12.5	7.3	0	16.5	0	5.8	0	21.2	71.2
1966	20.9	47	0	0	9.7	0	10.7	7.1	6.9	10.9	21.6	18.1	152.9
1967	0	12.5	16.5	0	10.2	64	0	0	0	4.8	0	0	108
1968	41	0	8.9	31.6	*	0.8	28.7	13.2	9.6	3.6	35.6	7.1	180.1

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1969	0	16.3	31.8	4.6	4.3	8.4	4.9	0	18.7	2.3	0	1.8	93.1
1970	0	0	0	29.5	3.6	0	0	2.5	3.8	9.1	1	0	49.5
1971	0	28.2	92.5	9.7	4.4	12.4	4.1	2.8	4.1	0	14.1	2.8	175.1
1972	56.6	0	0	5.3	0.3	1.3	0	7.4	2	4.3	0	0	77.2
1973	9.4	31.5	6.1	37.9	0	25.2	18.6	39.2	*	*	*	*	*
No data for September 1973 – May 1978													
1978	*	*	*	*	*	38	19.6	10.3	30	42.6	10	0.2	*
1979	132	221.8	1.4	27.2	52.6	22.6	3	15	51.6	5.2	3.2	6.6	542.2
1980	*	0	0	61	5	2.4	14.8	22.4	0	0	1	4	110.6
1981	25.8	0	0.6	0.6	70.4	7.8	58.8	0	19.4	4	20	10.4	217.8
1982	0	4.6	38.4	0	2.6	0	0	0	2	0	0	4.2	51.8
1983	16.4	0.6	3.2	19.6	0.2	4.2	9.6	22.4	0	29.4	19.4	2.6	127.6
1984	298.6	7.8	10.2	4.2	0	18.6	31.4	6.4	1.4	33.8	3.4	3.6	419.4
1985	0	9	0	0	8.8	20	0	9.2	0	34	65	12	158
1986	0	3	0	2.2	13.9	0	50.8	6.9	1	22.4	2.8	35.2	138.2
1987	9	49.4	10.2	0	7	37.2	0	11.1	10.6	0	6.6	90.3	231.4
1988	0	1.4	63.6	32.4	24.6	14.2	24.2	9.4	21	0	4.6	83.8	279.2
1989	0	0	87.2	0	16.6	7	25.4	1.8	0	13.4	26	0	177.4
1990	36.2	3.4	0	11.4	63	3	6.9	1	0	23.8	0	0	148.7
1991	3	3.9	0	0	1.4	12	10.4	0	0	0	14.4	0	45.1
1992	0	47.8	0	5	27	0.6	17.8	22.8	8.5	7.8	5	48.6	190.9
1993	45.4	6.4	6	0	35.6	7.4	12.6	3.8	8	50.8	0	26.4	202.4
1994	0	*	0	0	4.2	15.4	0	0	0	6.8	19.4	0	45.8
1995	40.3	0	0	0	18.2	8	2	5	28.4	24.2	39.3	6.6	172
1996	3	6	9	0	8	9.6*	54.4	0	42.2	0	0	2.6	134.8
1997	44.4	50.6	0	0	4.4	3.2	0	1.8	1.2	0	38.2	2.4	146.2
1998	17.8	8.2	0	9	14	17.2	76.8	6.6	124.5	0	16.8	0	290.9
1999	0	0	25.4	0	0	3.2	6.2	7.4	0	50	0	23.6	115.8
2000	0	160.8	53.2	31	48	2.4	5	31	0	20	26	1.6	379
2001	23	3.6	20.8	0	0	55	13.2	0	0	31.2	0	4.6	151.4
2002	6.2	34	0	3.4	7.5	0	0	0	0.8	0	2	6.8	60.7
2003	0	40.5	0	65	9.9	31.2	3.4	25.6	0	6.5	6.2	0	188.3
2004	0	13.8	0	11.4	29.2	18	3	17.2	6	4.8	4.8	0	108.2
2005	0	0	*	1	0	42.8	15.2	2.8	10.6	9	6.8	0	88.2
2006	26.2	11.4	*	*	*	*	*	*	*	*	*	*	*

* missing data

Source: BOM (2006b). Total monthly precipitation (mm) recorded at Fort Grey for the period August 1899 – February 2006. Note that only one record was recorded for June 1996.

Appendix 4: Species lists

Plant species recorded at Lake Pinaroo

Family	Common name	Scientific name	Collection type
Characeae		*Nitella* sp.	seed bank
Aizoaceae	Water weed	*Osteocarpum acropterum* var. *acropterum*	extant
Amaranthaceae	Joyweed	*Alternanthera nodiflora*	extant/seed bank
Asteraceae	Bushy starwort	*Aster subulatus**	extant/seed bank
	Variable daisy	*Brachycome ciliaris* var. *lanuginosa*	extant
	Common sneezeweed	*Centipeda cunninghamii*	extant/seed bank
	Bogan flea	*Calotis hispidula*	extant/seed bank
	Stinkwort	*Ditrichia graveoloens**	extant
	Spreading nut-heads	*Epaltes australis*	extant/seed bank
	Mueller's daisy bush	*Olearia muelleri*	extant
	Invisible plant	*Podolepis capillaris*	extant
	Fruit salad plant	*Pterocaulon sphacelatum*	extant
	Shrubby groundsel	*Senecio cunninghamii* var. *cunninghamii*	extant
Boraginaceae	Spreading heliotrope	*Heliotropium supinum*	extant
	Hairy carpet weed	*Glinus lotoides*	extant
Chenopodiaceae		*Atriplex paludosa*	extant
	Bitter saltbush	*Atriplex stipitata*	extant
	Ruby saltbush	*Enchylaena tomentosa*	extant
	Cottonbush	*Maireana aphylla*	extant
	Water weed	*Osteocarpum acropterum* var. *acropterum*	extant
	Climbing saltbush	*Einadia nutans*	extant
	Thorny saltbush	*Rhagodia spinescens*	extant
	Buckbush	*Salsola kali* var. *kali*	extant
	Goathead burr	*Sclerolaena bicornis* var. *bicornis*	extant
	Grey copperburr	*Sclerolaena diacantha*	extant
	Pale povert bush	*Sclerolaena divaricata*	extant
	Tangled poverty bush	*Sclerolaena intricata*	extant
	Spear fuit copperburr	*Sclerolaena patenticuspis*	extant
Convolvulaceae	Australian bindweed	*Convolulus erubescens*	extant
Curcubitceae	Desert cucumber	*Zehneria micrantha*	extant
Euphorbiaceae	Lagoon spurge	*Phyllanthus lacunarius*	extant
Fabaceae	Sandhill wattle	*Acacia ligulata*	extant
	Loose flowered rattlepod	*Crotalaria eremaea* ssp. *eremaea*	extant
	Silky glycine	*Glycine canescens*	extant
	Native liquorice	*Glycyrrhiza acanthocarpa*	extant
		Senna filifolia	extant
	Smooth cassia	*Senna pleurocarpa* var. *pleurocarpa*	extant
		Senna sturtii	extant

Family	Common name	Scientific name	Collection type
Fabaceae	Yellow pea bush	*Sesbania cannabina* var. *cannabina*	extant
Haloragaceae	Red water milfoil	*Myriophyllum verrucosum*	seed bank
Lamiaceae	Grey germander	*Teucrium racemosum*	extant
Malvaceae	Mallow leaf lantern flower	*Abutilon malvifolium*	extant
	Malvastrum	*Malvastrum americanum* *	extant
	Corrugated sida	*Sida corrugata*	extant
Marsiliaceae	Nardoo	*Marsilea drummondii*	seed bank
Myoporaceae	Turpentine	*Eremophila sturtii*	extant
	Western boobialla	*Myoporum montanum*	extant
Myrtaceae	Tar vine	*Boerhavia diffusa*	extant
Nyctaginaceaa		*Plantago* sp.	extant
Plantaginaceae	Coolibah	*Eucalyptus coolabah* ssp. *arida*	extant
Poaceae	Rat's tail couch	*Sporobolus mitchellii*	extant
	Grass species 1		seed bank
Portulacaceae	Pigweed	*Portulaca oleracea*	extant
Proteaceae	Straggly corkbark	*Hakea eyreana*	extant
Ranunculaceae	Mouse tail	*Myosurus minimus* var. *australis*	extant
Sapindaceae	Hop bush	*Dodonea viscosa* ssp. *attenuata*	extant
Scrophulariaceae	Mudmat	*Glossostigma diandrum*	seed bank
		Mimulus repens	seed bank
	Blue rod	*Stemodia floribunda*	extant
Solanaceae	Nicotine	*Nicotinia* sp.	extant
	Desert nightshade	*Solanum oligocanthum*	extant
Verbenaceae	Rough verbena	*Verbena hispida*	extant
Unidentified	unkown taxa 1,2,3		seed bank

Source: Species recorded during site visit in May 2006. Nomenclature for species names follows the Flora of New South Wales (Harden 1990–1993). Common names follow Cunningham et al. (1992).
* introduced species

Plant species recorded at Fromes Swamp

Family	Common name	Scientific name	Collection type
Marsileacae	Nardoo	*Marsilea drummondii*	seed bank
Poaceae	Canegrass	*Eragrostis australasicus*	extant
		Scheonoplectus dissachanthus	seed bank
Cyperaceae		*Cyperaceae* sp. *1*	seed bank
Portulacaceae	Pigweed	*Portulaca* spp.	seed bank
Scrophulariaceae	Mudmat	*Glossostigma diandrum*	seed bank
		Mimulus repens	seed bank
Unidentified	unknown taxa		seed bank

Source: Species recorded during site visit in May 2006. Nomenclature for species names follows the Flora of New South Wales (Harden 1990, 1991, 1992, 1993). Common names follow Cunningham et al. (1992).

Plant species list for Sturt National Park

Family	Common name	Scientific name
Acanthaceae	Blue trumpet, Blue Yam	*Dipteracanthus australasicus* ssp. *australasicus*
	Blue Trumpet	*Dipteracanthus australasicus* ssp. *corynothecus*
		Rostellularia adscendens ssp. *ascendens*
Adiantacaeae	Rock Fern	*Cheilanthes austrotenuifolia*
	Woolly Cloak Fern	*Cheilanthes lasiophylla*
	Mulga Fern	*Cheilanthes sieberi*
		ssp. *sieberi*
Aizoaceae	Hairy Carpet-Weed	*Glinus lotoides*
	Desert Carpet-Weed	*Glinus orygioides*
	Twin-leafed Pigface	*Gunniopsis papillata*
	Sturt's Pigface	*Gunniopsis quadrifida*
	Wire-stem Chickweed	*Molluga cerviana*
	New Zealand Spinach, Native Spinach	*Tetragonia eremaea*
	Warrigal Spinach, Dryland Spinach	*Tetragonia tetragonioides*
	Small hogweed	*Trianthema triquetra*
Amaranthaceae	Lesser Joyweed	*Alternanthera denticulata*
	Common Joyweed	*Alternanthera nodiflora*
	Boggabri Weed	*Amaranthus mitchellii*
	Crimson Foxtail, Silver Tails	*Ptilotus atriplicfolius* var. *atriplicifolius*
	Showy Foxtail, Tall Mulla Mulla,	*Ptilotus exaltatus* var. *exaltatus*
	White Fox Tail, Tangled Mulla Mulla	*Ptilotus latifolius* var. *latifolius*
	Square Headed Foxtail, Green Pussy Tail	*Ptilotus macrocephalus*
	Regal Foxtail, Yellow Tails	*Ptilotus nobilis*
	Silver Tails, Cat's Paw	*Ptilotus obovatus* var. *obovatus*
	Shrubby Foxtail	*Ptilotus parvifolius* var. *laetus*
	Long Tails, Pussy Tails	*Ptilotus polystachyus* var. *polystachyus*
		Ptilotus semilanatus
Amaryllidaceae	Garland Lily, Wilcannia Lily	*Calostemma purpureum*
	Darling Lily, Native Crinum	*Crinum flaccidum*
Anacardiaceae	Pepper Tree, Peppercorn	*Schinus areira* *
Apiaceae	Australian Carrot, Native Carrot	*Daucus glochidiatus*
	Wild Parsnip, Wild Carrot	*Trachymene glaucifolia*
Asclepiadaceae	Desert Cynanchum, Native Pear	*Cynanchum floribundum*
	Native Pear, Bush Banana, Doubah	*Marsdenia australis*
	Caustic Vine/Bush, Milk Bush	*Sarcostemma australe*
Asphodelaceae (Liliaceae)	Leek Lily, Native Leek	*Bulbine alata*
	Native Leek, Bulbine Lily	*Bulbine bulbosa*
	Wild Onion, Leek Lily	*Bulbine semibarbarta*
Asteraceae	Flannel Cudweed, Cotton Weed	*Actinobole uliginosum*
	Rock Everlasting	*Anemocarpa podolepidium*
	Variable Daisy	*Brachyscome ciliaris*
	Showy Daisy	*Brachyscome ciliocarpa, B. eriogona*
	Lobed-seed Daisy, Tall White Daisy	*Brachyscome dentata*
	Hard-headed Daisy, Dwarf Daisy	*Brachyscome lineariloba*
	Pale Beauty-heads, Yellow	*Calocephalus sonderi*

Family	Common name	Scientific name
	Poverty weed	
	Showy Burr-daisy	*Calotis cymbacantha*
	Bogan Flea	*Calotis hispidula*
	Fluffy Burr-daisy	*Calotis inermis*
Asteraceae	Leafy Burr-daisy	*Calotis latiuscula*
	Woolly-headed Burr-daisy	*Calotis plumulifera*
	Saffron Thistle	*Carthamus lanatus* *
	Common Sneezeweed	*Centipeda cunninghamii*
	Desert Sneezeweed	*Centipeda thespidioides*
	Hill Everlasting	*Chrysocephalum ambiguum*
	Yellow Buttons, Common Everlasting	*Chrysocephalum apiculatum*
	Perennial Sunray	*Chrysocephalum pterochaetum*
	Hill Everlasting	*Leiocarpa semicalva*
	Ground Heads	*Chthonocephalus pseudevax*
		Dichromochlamys dentatifolia
	Japanese Cudweed, Common Cudweed	*Euchiton sphaericus*
	Cobbler's Tack	*Glossogyne tannensis*
	Erect Yellow-heads	*Gnephosis arachnoidea*
	Native Camomile, Mat Yellow-heads	*Gnephosis eriocarpa*
		Gnephosis tenuissima
	Orange Sunray	*Hyalosperma semisterile*
	Grass Cushions	*Isoeptopsis graminifolia*
	Silverton Daisy	*Ixiochlamys cuneifolia*
	Small Fuzzweed	*Ixiochlamys nana*
	Plains Plover-daisy, Flat Billy-buttons	*Ixiolaena brevicompta*
	Small Plover-daisy	*Ixiolaena chloroleuca*
	Stalked Plover-daisy	*Ixiolaena leptolepis*
	Wires-and-wool, Wires-a-wool	*Lemooria burkittii*
		Leptorhynchos baileyi
	Hoary Sunray	*Leucochrysum molle*
	Creeping Millotia	*Millotia greevesii* ssp. *glandulosa*
	Broad-leaf Millotia	*Millotia greevsii* ssp. *greevsii*
	Annual Minuria	*Minuria annua*
	Bush Minuria	*Minuria cunninghamii*
	Smooth Minuria	*Minuria integerrima*
	Minnie Daisy	*Minuria leptophylla*
	Bowl Daisy	*Pluchea dentex*
	Pink Plains-bush	*Pluchea dunlopii*
	Invisible Plant, Wiry Podolepis	*Podolepis capillaris*
	Poached Eggs	*Polycalymma stuartii*
	Jersey Cudweed	*Pseudognaphalium luteo-album*
	Fruit-salad Plant, Apple Bush	*Pterocaulon sphacelatum*
	Golden Billy-buttons, Yellow Drumsticks	*Pycnosorus chrysanthes*
	Soft Billy-buttons	*Pycnosorus pleiocephalus*
	Common White Sunray	*Rhodanthe floribunda*
	Clustered Sunray	*Rhodanthe microglossa*
	Musk Sunray	*Rhodanthe mocshata*
	Pigmy Sunray	*Rhodanthe pyhmaea*
	Slender Sunray	*Rhodanthe stricta*
	Western Sunray	*Rhodanthe troedelii*
	Woolly Sunray	*Rhodanthe uniflora*
	Grey Wrinkle-wort	*Rutidosis helichrysoides*

Family	Common name	Scientific name
	Dainty Everlasting	*Schoenia ramosissima*
	Bushy Groundsel	*Senecio cunninghamii*
	Slender Groundsel	*Senecio glossanthus*
	Fleshy Groundsel	*Senecio gregorii*
	Variable Groundsel	*Senecio lautus* ssp. *dissectifolius*
	Cotton Fireweed	*Senecio quadridentatus*
Asteraceae	Common Sowthistle, Milk Thistle	*Sonchus oleraceus* *
	Desert Daisy	*Streptoglossa adscendens*
	Wertaloona Daisy	*Streptoglossa liatroides*
	Hooked Cudweed	*Stuartina hamata*
	Woolly Yellow-heads	*Trichanthodium skirrophorum*
	Fuzzweed	*Vittadinia arida*
	Fuzzweed	*Vittadinna blackii*
	Fuzzweed	*Vittadinna cuneata* var. *hirsuta*
		Vittadinna eremaea
		Vittadinna sulcata
	Noogoora Burr, Cockle Burr	*Xanthium occidentale* *
	Bathurst Burr	*Xanthium spinosum* *
		Xanthium strumarium *
Boraginacea	Rough Heliotrope	*Heliotropium asperrimum*
	Bushy Heliotrope	*Heliotropium moorei*
	Spreading Heliotrope, Creeping Heliotrope	*Heliotropium supinum* *
	Burr Stickseed	*Omphalolappula concava*
	White Forget-me-not.	*Plagiobothrys plurisepaleus*
	Cattle Bush	*Trichodesma zeylanicum*
Brassicaceae	Priddiwalatji	*Arabidella eremigena*
	Yellow Cress	*Arabidella nasturtium*
	Shrubby Cress	*Arabidella trisecta*
	Wild turnip, Mediterranean Turnip	*Brassica tournefortii* *
	Hairy-pod Cress	*Harmsiodoxa blennodioides*
	Scented Cress	*Harmsiodoxa puberula*
	Green Peppercress	*Lepidium oxytrichum*
	Warty Peppercress	*Lepidium papillosum*
	Veined Peppercress	*Lepidium phlebopetalum*
	Fine-leaf Peppercress	*Lepidium sagittulatum*
	Smooth Mustard	*Sisymbrium erysimoides*
	London Rocket	*Sisymbrium irio*
Campanulaceae	Tall Bluebell	*Wahlenbergia stricta* ssp. *alterna*
	Bluebell	*Wahlenbergia tumidifructa*
Capparaceae	Wild Orange, Native Orange	*Capparis mitchelli*
Caryophyllaceae		*Polycarpaea arida*
		Polycarpaea corymbosa var.*minor*
Casuarinaceae	Black Oak, Belah	*Casuarina pauper*
Chenopodiaceae	Fan Saltbush	*Atriplex angulata*
		Atriplex conduplicata
	Gibber Saltbush	*Atriplex fissivalvis*
	Pop Saltbush	*Atriplex holocarpa*
	Slender-fruited Saltbush	*Atrilpex leptocarpa*
	Spreading Saltbush	*Atriplex limbata*
	Eastern Flat-top Saltbush	*Atriplex lindleyi*
	Old Man Saltbush	*Atriplex nummularia*
	Mealy Saltbush	*Atriplex pseudocampanulata*
	Kidney Saltbush	*Atriplex quinni*
	Pop Saltbush	*Atriplex spongiosa*

Family	Common name	Scientific name
	Bitter Saltbush, Mallee Saltbush, Kidney Saltbush	*Atriplex stipitata*
		Atriplex sturtii
		Atriplex turbinata
	Bladder Saltbush	*Atriplex vesicaria*
	Bladder Saltbush	*Atriplex vesicaria* ssp. *calcicola*
	Bladder Saltbush	*Atriplex vesicaria* ssp. *macrocystidia*
Chenopodiaceae	Bladder Saltbush	*Atriplex vesicaria* ssp. *sphaerocarpa*
	Golden Goosefoot, Queensland Bluebush	*Chenopodium auricomum*
	Crested Goosefoot, Crested Crumbweed	*Chenopodium cristatum*
	Cottony Saltbush	*Chenopodium curvispicatum*
	Desert Goosefoot, Frosted Goosefoot.	*Chenopodium desertorum* ssp. *desertorum*
	Black Crumbweed	*Chenopodium melanocarpum*
	Twin Horned Copperburr	*Dissocarpus biflorus* var. *biflorus*
	Cannon-ball Burr	*Dissocarpus paradoxus*
		Dysphania platycarpa
	Climbing Saltbush, Nodding Saltbush	*Einadia nutans* ssp. *eremaea*
	Climbing Saltbush, Nodding Saltbush	*Einadia nutans* ssp. *nutans*
	Ruby Saltbush, Barrier Saltbush, Plum Puddings, Berry Cottonbush	*Enchylaena tomentosa*
	Brown-headed Samphire	*Halosarcia indica* ssp. *leiostachya*
	Cottonbush, Leafless bluebush	*Maireana aphylla*
	Low Bluebush, Southern bluebush	*Maireana astrotricha*
	Crown Fissure-weed	*Maireana coronata*
	Woolley Bluebush	*Maireana eriantha*
	Satiny Bluebush	*Maireana georgei*
		Maireana integra
	Black Bluebush	*Maireana pyramidata*
		Maireana schistocarpa
	Pearl Bluebush	*Maireana sedifolia*
		Maireana spongiocarpa
	Three-winged Bluebush	*Maireana triptera*
		Maireana turbinata
	Soft Horns, Goat Head, Soft-horned Saltbush, Three-horned Saltbush, Star Saltbush, Woolley Saltbush	*Malacocera tricornis*
	Soda Bush	*Neobassia proceriflora*
	Waterweed	*Osteocarpum acropterum* var. *acropterum*
	Waterweed	*Osteocarpum acropterum* var. *deminuta*
		Osteocarpum dipterocarpum
		Osteocarpum pentapterum
	Buckbush, soft roly-poly, prickly roly-poly, tumbleweed	*Salsola kali* var. *kali*
		Salsola tragus
	Goathead burr, woolly copperburr	*Scleroleana bicornis*
	Goathead burr	*Scleroleana bicornis var bicornis*
	Black's copperburr	*Scleroleana blackiana*
	Short-winged copperburr	*Scleroleana brachyptera*
	Red copperburr	*Scleroleana calcarata*

Family	Common name	Scientific name
	Tall copperburr	*Scleroleana convexula*
	Green copperburr	*Scleroleana decurrens*
	Grey copperburr	*Scleroleana diacantha*
	Pale poverty-bush	*Scleroleana divaricata*
	Silky copperburr	*Scleroleana eriacantha*
	Anderson's copperburr	*Scleroleana glabra*
	Tangled poverty-bush	*Scleroleana intricata*
	Jonsonson's copperburr	*Scleroleana johnsonii*
	Woolly copperburr	*Scleroleana lanicuspis*
Chenopodiaceae	Long-spined poverty-bush	*Scleroleana longicuspis*
	Black roly-poly	*Scleroleana muricata*
	Limestone copperburr	*Scleroleana obliquicuspis*
	Western copperburr	*Scleroleana parallelicuspis*
	Streaked poverty bush	*Scleroleana tricuspis*
	Salt copperburr	*Scleroleana ventricosa*
Convolvulaceae	Bindweed, wild morning glory	*Convolvulus arvensis* *
	Australian bindweed, pink bindweed	*Convolvulus remotus*
	Dodder	*Cuscuta victoriana*
	Silky bindweeed	*Evolvulus alsinoides*
	Common cow-vine	*Ipomea lonchophylla*
Crassulaceae	Dense stonecrop	*Crassula colorata*
	Australian stonecrop	*Crassula sieberiana*
Cucurbitaceae	Camel Melon, Wild Melon, Bitter Melon	*Citrullus lanatus* var. *lanatus* *
	Paddy melon, gooseberry cucumber	*Cucumis myriocarpus* ssp.*leptodermis**
	Desert cucumber	*Zehneria micrantha*
Cyperaceae		*Cyperus gilesii*
		Cyperus victoriensis
	Pale spike-rush	*Eleocharis pallens*
	Common fringe-rush	*Fimbristylis dichotoma*
Elatinaceae	Water-fire	*Bergia ammannioides*
Euphorbiaceae	Hairy caustic weed	*Chamaesyce australis*
	Caustic weed	*Chamaesyce drummondii*
	Wheeler's spurge	*Chamaesyce wheeleri*
	Desert Spurge	*Euphorbia eremophila*
	Rough-seeded spurge	*Euphorbia parvicaruncula*
	Bottle-tree spurge	*Euphorbia stevenii*
	Sand spurge	*Phyllanthus fuernrohrii*
	Lagoon spurge	*Phyllanthus lacunarius*
Fabaceae subfamily: Caesalpinioideae	Silver Cassia	*Senna* form taxon '*artemisioides'*
		Senna form taxon '*coriacea'*
	Grey Cassia	*Senna* form taxon '*sturtii'*
		Senna form taxon '*filifolia'*
	Blunt-leaved cassia	*Senna* form taxon '*helmsii*'
	Blunt-leaved cassia	*Senna* form taxon '*oligophylla'*
	Woody cassia	*Senna* form taxon '*petiolaris'*
		Senna form taxon '*zygophylla'*
		Senna form taxon *'pruniosa'*
	Fire bush	*Senna pleurocarpa* var. *pleurocarpa*
Fabaceae subfamily: Faboideae	Bluebush pea, loose-flowered rattlepod	*Crotolaria eremaea* ssp*. eremaea*
	Tall verbine	*Cullen australasicum*
	Annual verbine	*Cullen cinereum*
	Native lucerne	*Cullen graveolens*
	Bullamon lucerne	*Cullen patens*

Family	Common name	Scientific name
	Silky glycine	*Glycine canescens*
	Native liquorice	*Glycyrrhiza acanthocarpa*
	Desert indigo	*Indigofera brevidens*
	Rusty indigo	*Indigofera calutea*
	Red-flowered trefoil, red-flowered lotus	*Lotus cruentus*
	Burr medic	*Medicago polymorpha* *
	Rhynco	*Rhynchosia minima*
	Sesbania pea, Yellow pea bush	*Sesbania cannabina* var. *cannabina*
	Pea flower	*Swainsona campylantha*
		Swainsona extrajacens
	Sturt's desert pea	*Swainsona formosa*
		Swainsona oligophylla
Fabaceae subfamily: Faboideae	Kneed darling pea	*Swainsona oroboides*
		Swainsona phacoides
	Purple Darling Pea	*Swainsona purpurea*
	Silky swainsona pea	*Swainsona sericea*
	Orange darling pea	*Swainsona stipularis*
	Downy darling pea	*Swainsona swainsonioides*
	Mulga trefoil	*Tephrosia sphaerospora*
	Cooper clover	*Trigonella suavissima*
	Spurred vetch, square-stemmed vetch	*Vicia monantha* *
Fabaceae subfamily: Mimosoideae	Mulga	*Acacia aneura*
	Umbrella mulga	*Acacia brachystachya*
	Gidgee	*Acacia cambagei*
	Cabbage-tree wattle	*Acacia cana*
	Sandhill wattle	*Acacia ligulata*
	Murray's wattle	*Acacia murrayana*
	Miljee	*Acacia oswaldii*
	Horse mulga	*Acacia ramulosa*
	Cooba	*Acacia salicina*
	River cooba	*Acacia stenophylla*
	Bastard mulga	*Acacia chamaeleon*
	Dead finish	*Acacia tetragonophylla*
	Prickly wattle, Victoria wattle	*Acacia victoriae*
Frankeniaceae	Bristly sea-heath	*Frankenia serpyllifolia*
Gentianaceae	Spike centaury, australian centaury	*Centaurium spicatum*
Geraniaceae	Common crowfoot	*Erodium cicutarium* *
	Blue crowfoot, blue storksbill	*Erodium crinitum*
	Oval crowfoot	*Erodium malacoides* *
Goodeniaceae	Streaked goodenia	*Goodenia calcarata*
	Serrated goodenia	*Goodenia cycloptera*
	Sliky goodenia	*Goodenia fascicularis*
	Hairy goodenia	*Goodenia lunata*
	Common fan-flower	*Scaevola aemula*
	Skeleton fan-flower	*Scaevola depauperata*
	Bushy fan-flower	*Scaevola parvibarbata*
	Spiny fan-flower	*Scaevola spinescens*
Haloragaceae	Rough raspwort	*Haloragis aspera*
	Grey raspwort	*Haloragis glauca f. glauca*
	Red water-milfoil	*Myriophyllum verrucosum*
Lamiaceae	Jockey's cap, streaked mint-bush	*Prostanthera striatiflora*
	Grey germander	*Teucrium racemosum*

Family	Common name	Scientific name
Lobeliaceae	Rock isotome	*Isotome petraea*
Loranthaceae	Pale-leaf mistletoe	*Amyema maidenii*
	Pale-leaf mistletoe	*Amyema maidenii* ssp. *maidenii*
	Fleshy mistletoe	*Amyema miraculosum* ssp. *boormaniii*
	Wire-leaf mistletoe	*Amyema preissii*
	Grey mistletoe	*Amyema quandang* var. *bancroftii*
	Grey mistletoe	*Amyema quandang* var. *quandang*
	Coolibah mistletoe	*Diplatia grandibractea*
	Harlequin Mistletoe	*Lysiana exocarpi* ssp. *exocarpi*
Loranthaceae	Northern mistletoe	*Lysiana subfalcata*
Malvaceae	Dwarf lantern-flower	*Abutilon fraseri*
	Plains lantern-bush	*Abutilon halophilum*
	Lantern-bush	*Abutilon leucopetalum*
	Mallow-leaf lantern-flower, green lantern-bush	*Abutilon malvifolium*
	Desert chinese-lantern	*Abutilon otocarpum*
Malvaceae	Low hibiscus	*Hibiscus brachysiphonius*
	Hill hibiscus	*Hibiscus sturtii* var. *grandiflorus*
	Australian hollyhock	*Malva australiana*
	Small-flowered mallow	*Malva parviflora* *
	Malvastrum, spiked malvastrum	*Malvastrum americanum* *
	Ridge sida	*Sida cunnignhamii*
	Pin sida	*Sida fibulifera*
	Twiggy sida	*Sida intricata*
	Rock sida	*Sida petrophila*
	High sida	*Sida trichopoda*
Marsileaceae	Common nardoo	*Marsilea drummondii*
	Swayback nardoo	*Marsilea exarata*
	Short-fruit nardoo	*Marsilea hirsuta*
Meliaceae	Colane, Gruie, Emu apple, moalie apple, sour plum	*Owenia acidula*
Myoporaceae	Eurah	*Eremophila bignoniiflora*
	Silver turkey-bush	*Eremophila bowmanii*
	Harlequin fuchsia-bush	*Eremophila duttonii*
	Rock fuchsia-bush	*Eremophila freelingii*
	Green turkey-bush	*Eremophila gilesii*
	Tar bush	*Eremophila glabra*
	Purple fuchsia bush	*Eremophila goodwinii*
	Crimson turkey bush	*Eremophila latrobei*
	Emubush	*Eremophila longifolia*
	Spotted fuchsia	*Eremophila maculata*
	Weeooka	*Eremophila oppositifolia*
	Flowering lignum	*Eremophila polyclada*
	Green fuchsia-bush	*Eremophila serrulata*
	Turpentine	*Eremophila sturtii*
	Western boobialla	*Myoporum montanum*
Myrtaceae	Western bloodwood, Tjuta joolta	*Corymbia terminalis* (*C. tumescens, C. opaca, Eucalyptus terminalis, E. centralis, E. macropoda, E. opaca, E. orientalis, E. pyrophora*)
Myrtaceae: subgenus Symphyomyrtus, section Exsertaria	River red gum	*Eucalyptus camaldulensis*
Myrtaceae: subgenus	Coolibah, Coolabah	*Eucalyptus coolabah* ssp. *arida*
	Desert paper-bark	*Melaleuca glomerata*

Family	Common name	Scientific name
Symphyomyrtus, section Adnataria	Broombush	*Melaleuca interioris*
Nyctaginaceae	Tarvine	*Boerhavia dominii*
Oleacea	Native jasmine, Desert jasmine	*Jasminum lineare*
Oxalidaceae	Oxalis	*Oxalis perennans*
Papavaraceae	Mexican poppy, prickly poppy, golden thistle	*Argemone ochroleuca* ssp. *ochroleuca**
Pittosporaceae	Butterbush, weeping pittosporum	*Pittosporum angustifolium*
Plantaginaceae	Sago-weed	*Plantago cunninghamii*
	Dark sago-weed	*Plantago drummondii*
		Plantago multiscapa
Poaceae	Pale wiregrass	*Aristida anthoxanthoides*
	Kerosene grass	*Aristida contorta*
	Tall Wiregrass	*Aristida echinata*
Poaceae	Erect kerosene grass	*Aristida holathera* var. *holathera*
	Feathertop wiregrass	*Aristida latifolia*
	Curly mitchell grass	*Astrebla lappacea*
Poaceae	Barley mitchell grass	*Astrebla pectinata*
	Sand brome	*Bromus arenarius*
	Birdwood grass	*Cenchrus setiger* *
	Comb windmill grass, comb chloris	*Chloris pectinata*
	Silky heads	*Cymbopogon obtectus*
	Button grass	*Dactyloctenium radulans*
	Queensland bluegrass	*Dichanthium sericeum*
	Cotton panic grass	*Digitaria brownii*
	Common bottlewashers	*Enneapogon avenaceus*
	Jointed bottlewashers, jointed nineawn	*Enneapogon cylindricus*
	Tall bottlewashers,	*Enneapogon intermedius*
	Canegrass	*Eragrostis australasica*
	Mulka, Love grass, mallee lovegrass	*Eragrostis dielsii*
	Woollybutt, neverfail	*Eragrostis eriopoda*
	Weeping lovegrass	*Eragrostis parviflora*
	Neverfail	*Eragrostis setifolia*
	Knotty butt neverfail,	*Eragrostis xerophila*
	Broad-leaf wanderrie grass	*Eriachne aristidea*
	Sliky browntop	*Eulalia fulva*
	Small flinders grass	*Iseilema membranaceum*
	Umbrella canegrass	*Leptochloa digitata*
	Native millet	*Panicum decompositum*
	Hairy panic	*Panicum effusum*
	Tiny bristlegrass	*Rostaria pumila* *
	Katoora grass	*Sporobolus actinocladus*
		Austrostipa nitida
	Kangaroo grass	*Themeda triandra*
	Mulga grass	*Thyridolepis mitchelliana*
	Small burr grass	*Tragus australianus*
	Lobed spinifex	*Triodia basedowii*
	Purple plume grass	*Triraphis mollis*
Polygonaceae	Wild hops, rosy dock, pink dock	*Acetosa vesicaria* *
	Spiny emex	*Emex australis* *
	Lignum	*Muehlenbeckia cunninghamii*
	Small knotweed	*Polygonum plebeium*

Family	Common name	Scientific name
Portulacaceae		*Anacampseros australiana*
	Broad-leaf parakeelya	*Calandrinia balonensis*
	Small purslane	*Calandrinia eremaea*
	Creeping parakeelya	*Calandrinia ptychosperma*
	Common pigweed	*Portulaca oleracea*
Primulaceae	Pimpernel, scarlet pimpernel, blue pimpernel	*Anagallis arvensis* *
Proteaceae	Flame spider-flower	*Grevillea kennedyana*
	Sandhill spider-flower	*Grevillea stenobotrya*
	Beefwood	*Grevillea striata*
		Hakea ednieana
	Straggly corkbark	*Hakea eyreana*
	Needlewood	*Hakea leucoptera*
Ranunculaceae	Smooth buttercup	*Ranunculus pentandrus* ssp*. platycarpus*
Rubiaceae	Native current	*Canthium latifolium*
Rubiaceae		*Synaptantha tillaeacea*
Santalaceae	Leafless cherry	*Exocarpus aphyllus*
	Sandalwood	*Santalum lanceolatum*
Sapindaceae	Rosewood	*Alectryon oleifolius* ssp*. canescens*
Sapindaceae	Whitewood	*Atalaya hemiglauca*
	Green hopbush	*Dodonaea petiolaris*
	Narrow-leaf hopbush	*Dodonaea viscosa* ssp*. angustissima*
Scrophulariaceae		*Orobanche cernua* var*. australiana*
	Blue-rod	*Stemodia florulenta*
Solanaceae	African boxthorn	*Lycium ferocissimum* *
	Tobacco bush, tree tobacco, wild tobacco	*Nicotiana glauca* *
	Native tobacco, wild tobacco	*Nicotiana simulans*
	Goosefoot potato-bush	*Solanum chenopodinum*
	Velvet potato-bush, wild gooseberry, tomato bush, potato bush	*Solanum ellipticum*
	Quena, tomato plant, potato bush	*Solanum esuriale*
	Spiny potato-bush	*Solanum ferocissimum*
	Lagoon nightshade, Desert nightshade	*Solanum lacunarium*
	Black-berry nightshade, Black nightshade, potato bush	*Solanum nigrum*
	Desert nightshade	*Solanum oligacanthum*
	Thargomindah nightshade, sturt's nightshade	*Solanum sturtianum*
Stackhousiaceae	Slender stackhousia	*Stackhousia viminea*
Thymelaeaceae	Desert rice-flower	*Pimelea simplex* ssp*. simplex*
	Spiked rice-flower	*Pimelea trichostachya*
Verbenaceae	Mayne's pest	*Verbena aristigera* *
	Trailing vernea	*Verbena supina*
Zygophyllaceae	Cat-head, caltrop	*Tribulus terrestris* *
	Sand twinleaf	*Zygophyllum ammophilum*
	Shrubby twinleaf, native hop	*Zygophyllum aurantiacum*
	Small-fruit twinleaf	*Zygophyllum humillimum*
	Violet twinleaf	*Zygophyllum iodocarpum*
	Square-fruit twinleaf	*Zygophyllum prismatothecum*

* introduced species

Source: Montgomery (2006); Sturt National Park Flora List. Parks and Wildlife, Tibooburra. Nomenclature follows Harden (1990–1993), the NSW NPWS Atlas of NSW Wildlife Internal List Report for Sturt National Park and the Australian Plant Name Index (APNI) at www.anbg.gov.au/cgi-bin/apni.

Bird species list for Lake Pinaroo

Family	Common name	Scientific name	Source
Dromaiidae	Emu	*Dromaius novaehollandiae*	a, b
Phasianidae	Brown Quail	*Coturnix ypsilophora*	a
Pelecanidae	Australian Pelican	*Pelecanus conspicillatus*	a
Phalacrocoracidae	Little Black Cormorant	*Phalacrocorax sulcirostris*	e
	Little Pied Cormorant	*Phalacrocorax melanoleucos*	e
	Pied Cormorant	*Phalacrocorax varius*	e
Podicipedidae	Australasian Little Grebe	*Tachybaptus novaehollandiae*	e
	Hoary-headed Grebe	*Poliocephalus poliocephalus*	a, e
Anatidae	Australasian Shoveler	*Anas rhynchotis*	e
	Australian Wood (Maned) Duck	*Chenonetta jubata*	b, e
	Black Swan	*Cygnus atratus*	a, e
	Blue-billed Duck	*Oxyura australis*	d, e
	Freckled Duck	*Stictonetta naevosa*	d, e
	Grey Teal	*Anas gracilis*	a, c, e
	Hardhead (White-eyed Duck)	*Aythya australis*	a, c, e
	Musk Duck	*Biziura lobata*	a, d, e
	Pacific Black Duck	*Anas superciliosa*	a, e
	Pink-eared Duck	*Malacorhynchus membranaceus*	a, e
Rallidae	Australian Spotted Crake	*Porzana fluminea*	d, e
	Black-tailed Native Hen	*Gallinula ventralis*	a, e
	Eurasian Coot	*Fulica atra*	a, e
Ardeidae	Pacific (White-necked) Heron	*Ardea pacifica*	a, b
	White-faced Heron	*Egretta (Ardea) novaehollandiae*	a, b, e
Threskiornidae	Australian White Ibis	*Threskiornis molucca (T. aethiopica)*	e
	Glossy Ibis	*Plegadis falcinellus* C	e
	Straw-necked Ibis	*Threskiornis spinicollis*	a, e
	Yellow-billed Spoonbill	*Platalea flavipes*	a, e
Scolopacidae	Black-tailed Godwit	*Limosa limosa* JCR	d
	Common Greenshank	*Tringa nebularia* JCR	d, e
	Marsh Sandpiper	*Tringa stagnatilis* JCR	e
	Red-necked Stint	*Calidris ruficollis* JCR	d
Charadriidae	Banded Lapwing	*Vanellus tricolor*	a
	Black-fronted Dotterel	*Elseyornis (Charadrius) melanops*	a, c, e
	Masked Lapwing	*Vanellus miles*	a, e
	Red-capped Plover	*Charadrius ruficapillus*	a, e
	Red-kneed Dotterel	*Erythrogonys cinctus*	e
Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	a, e
	Red-necked Avocet	*Recurvirostra novaehollandiae*	a, c, d, e
Laridae	Caspian Tern	*Sterna caspia* C	d, e
	Gull-billed Tern	*Sterna nilotica*	b, e
	Silver Gull	*Larus novaehollandiae*	a, b, e
	Whiskered (Marsh) Tern	*Chlidonias hybridus*	e
Accipitridae	Black Kite	*Milvus migrans*	a, b, c
	Black-breasted Buzzard	*Hamirostra melanosternon*	b, d
	Brown Goshawk	*Accipter fasciatus*	a
	Little Eagle	*Hieraaetus morphnoides*	a, b, c
	Spotted Harrier	*Circus assimilis*	a
Accipitridae	Wedge-tailed Eagle	*Aquila audax*	a, b

Family	Common name	Scientific name	Source
	Whistling Kite	*Haliastur (Milvus) sphenurus*	a
Falconidae	Brown Falcon	*Falco berigora*	a, b, c
	Grey Falcon	*Falco hypoleucos*	a, d
	Nankeen (Australian) Kestrel	*Falco cenchroides*	a, b, c
Columbidae	Crested Pigeon	*Ocyphas (Geophaps) lophotes*	a, b, c
	Diamond Dove	*Geopelia cuneata*	a, b, c
	Peaceful Dove	*Geopelia placida*	a, b, c
Psittacidae	Galah	*Eolophus (Cacatua) roseicapillus*	a, b, c
Psittacidae	Little Corella	*Cacatua sanguinea*	a, b, c
Playtcercinae	Blue Bonnet	*Northiella haematogaster*	a, b, c
	Bourke's Parrot	*Neopsephotus bourkii*	a, c
	Budgerigar	*Melopsittacus undulatus*	a, b, c
	Cockatiel	*Nymphicus hollandicus*	a, b
	Mallee Ringneck	*Barnardius zonarius*	a
	Mulga Parrot	*Psephotus varius*	a, c
	Red-rumped Parrot	*Psephotus haematonotus*	b
Cuculidae	Horsfield's Bronze-Cuckoo	*Chalcites (Chrysococcyx) basalis*	c
	Pallid Cuckoo	*Cuculus pallidus*	a
Aegothelidae	Australian Owlet-nightjar	*Aegotheles cristatus*	a, c
Halcyonidae	Red-backed Kingfisher	*Todiramphus pyrrhopygia*	a, c
Meropidae	Rainbow Bee-eater	*Merops ornatus*	a, b
	Sacred Kingfisher	*Todiramphus sanctus*	a
Climacteridae	Brown Treecreeper	*Climacteris picumnus*	a
Maluridae	Variegated (Purple-backed) Fairy-wren	*Malurus lamberti*	a
	White-winged Fairy-wren	*Malurus leucopterus*	a, b
Pardalotidae	Chestnut-rumped Thornbill	*Acanthiza uropygialis*	a, b, c
	Red-browed Pardalote	*Pardalotus rubricatus*	a, b
	Southern Whiteface	*Aphelocephala leucopsis*	a, c
	Striated Pardalote	*Pardalotus striatus*	a
Meliphagidae	Crimson Chat	*Epthianura tricolor*	a
	Orange Chat	*Epthianura aurifrons*	a
	Pied Honeyeater	*Certhionyx variegatus*	a, c
	Singing Honeyeater	*Lichenostomus virescens*	a, b, c
	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	a, b
	White-plumed Honeyeater	*Lichenostomus penicillatus*	a, b, c
	Yellow-throated Miner	*Manorina flavigula*	a, c
Cinclosomatidae	Chirruping Wedgebill	*Psophodes cristatus*	a, c
Pomatostomidae	Chestnut-crowned Babbler	*Pomatostomus ruficeps*	a, c
	White-browed Babbler	*Artamus superciliosus*	a
Petroicidae	Mistletoebird	*Dicaeum hirundinaceum*	a
	Red-capped Robin	*Petroica goodenovii*	a, e
Pachycephalidae	Crested Bellbird	*Oreoica gutturalis*	a, c
	Rufous Whistler	*Pachycephala rufiventris*	a
Dicruridae	Grey Fantail	*Rhipidura fuliginosa*	a
	Magpie-lark	*Grallina cyanoleuca*	a, b, c
	Restless Flycatcher	*Myiagra inquieta*	a
	Willie Wagtail	*Rhipidura leucophrys*	a, b, c
Campephagidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	a
Campephagidae	Ground Cuckoo-shrike	*Coracina maxima*	a
	White-winged Triller	*Lalage sueurii*	a, b, c

Family	Common name	Scientific name	Source
Artamidae	Australian Magpie	*Gymnorhina tibicen*	a, b, c
	Black-faced Woodswallow	*Artamus cinereus*	a, b, c
	Masked Woodswallow	*Artamus personatus*	a, b
	White-backed Swallow	*Cheramoeca leucosternus*	a
	White-breasted Woodswallow	*Artamus leucorynchus*	a, b, c
	White-browed Woodswallow	*Artamus superciliosus*	a, c
Corvidae	Australian Raven	*Corvus coronoides*	a, b, c
	Little Crow	*Corvus bennetti*	a, b, c
Corcoracidae	Apostlebird	*Struthidea cinerea*	c
Hirundinidae	Fairy Martin	*Hirundo ariel*	a, b
	Tree Martin	*Hirundo nigricans*	a, b, c
	Welcome Swallow	*Hirundo neoxena*	a, b, c
Motacillidae	Richard's (Australian) Pipit	*Anthus novaesseelandiae*	b
Alaudiadae	Brown Song Lark	*Cincloramphus cruralis*	a
	Rufous Songlark	*Cincloramphus mathewsi*	a
Ploceidae	Zebra Finch	*Taeniopygia guttata*	a, b, c

Species listed under migratory bird agreements: J = JAMBA, C = CAMBA, R = ROKAMBA
Source: (a) NSW NPWS Atlas of NSW Wildlife (b) A. Lindsey (2006, pers. comm.); (c) A. Morris (2006, pers. comm.); (d) NSW Bird reports 1978–1983 (Lindsey 1979, 1980, 1981, 1985); (e) Briggs (1980).
Nomenclature follows Simpson and Day (1999).

Bird species list for Fromes Swamp

Family	Common name	Scientific name	Source
Dromaiidae	Emu	*Dromaius novaehollandiae*	a
Ardeidae	Pacific (White-necked) Heron	*Ardea pacifica*	a
Threskiornidae	Glossy Ibis	*Plegadis falcinellus* C	a, b
Gruidae	Brolga	*Grus rubicunda*	a
Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis* JCR	a, b
	Sharp-tailed Sandpiper	*Calidris acuminata* JCR	a, b
Charadriidae	Red-capped Plover	*Charadrius ruficapillus*	a
	Red-kneed Dotterel	*Erythrogonys cinctus*	a
Recurvirostridae	Red-necked Avocet	*Recurvirostra novaehollandiae*	a
Laridae	Silver Gull	*Larus novaehollandiae*	a, b
Accipitridae	Black Kite	*Milvus migrans*	a
	Black-breasted Buzzard	*Hamirostra melanosternon*	a
	Wedge-tailed Eagle	*Aquila audax*	a
Columbidae	Diamond Dove	*Geopelia cuneata*	a
Psittacidae	Galah	*Eolophus (Cacatua) roseicapillus*	a
	Little Corella	*Cacatua sanguinea*	a
Playtcercinae	Bourke's Parrot	*Neopsephotus bourkii*	c
Maluridae	White-winged Fairy-wren	*Malurus leucopterus*	a
Pardalotidae	Chestnut-rumped Thornbill	*Acanthiza uropygialis*	a
	Southern Whiteface	*Aphelocephala leucopsis*	a
Meliphagidae	Black Honeyeater	*Certhionyx niger*	a
	Crimson Chat	*Epthianura tricolor*	a
	Orange Chat	*Epthianura aurifrons*	a
	Singing Honeyeater	*Lichenostomus virescens*	a
	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	a
	Yellow-throated Miner	*Manorina flavigula*	a
Artamidae	Australian Magpie	*Gymnorhina tibicen*	a
	White-browed Woodswallow	*Artamus superciliosus*	a
Corvidae	Australian Raven	*Corvus coronoides*	a
	Little Crow	*Corvus bennetti*	a
Hirundinidae	Fairy Martin	*Hirundo ariel*	a
Motacillidae	Richard's (Australian) Pipit	*Anthus novaesseelandiae*	a
Ploceidae	Zebra Finch	*Taeniopygia guttata*	a

Species listed under migratory bird agreements: J = JAMBA, C = CAMBA, R = ROKAMBA
Source: (a) NSW NPWS Atlas of NSW Wildlife; (b) Morris and Burton (1992); (c) J. Porter and J. Spencer (2006, pers. obs.). Nomenclature follows Simpson and Day (1999).

Bird species list for Sturt National Park

Family	Common name	Scientific name	
Dromaiidae	Emu	*Dromaius novaehollandiae*	
Phasianidae	Brown Quail	*Coturnix ypsilophora*	
	Stubble Quail	*Coturnix pectoralis*	
Turnicidae	Little Button Quail	*Turnix velox*	
Pelecanidae	Australian Pelican	*Pelecanus conspicillatus*	
Anhingidae	Darter	*Anhinga melanogaster*	
Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	
	Little Black Cormorant	*Phalacrocorax sulcirostris*	
	Little Pied Cormorant	*Phalacrocorax melanoleucos*	
	Pied Cormorant	*Phalacrocorax varius*	
Podicipedidae	Australasian Little Grebe	*Tachybaptus novaehollandiae*	
	Great Crested Grebe	*Podiceps cristatus*	
	Hoary-headed Grebe	*Poliocephalus poliocephalus*	
Anatidae	Australasian Shoveler	*Anas rhynchotis*	
	Australian Wood (Maned) Duck	*Chenonetta jubata*	
	Black Swan	*Cygnus atratus*	
	Blue-billed Duck	*Oxyura australis*	
	Chestnut Teal	*Anas castanea*	
	Grey Teal	*Anas gracilis*	
	Freckled Duck	*Stictonetta naevosa*	
	Hardhead (White-eyed Duck)	*Aythya australis*	
	Musk Duck	*Biziura lobata*	
	Pacific Black Duck	*Anas superciliosa*	
	Pink-eared Duck	*Malacorhynchus membranaceus*	
	Plumed Whistling Duck	*Dendrocygna eytoni*	
Rallidae	Australian Spotted Crake	*Porzana fluminea*	
	Black-tailed Native Hen	*Gallinula ventralis*	
	Dusky Moorhen	*Gallinula tenebrosa*	
	Eurasian Coot	*Fulica atra*	
	Purple Swamphen	*Porphyrio porphyrio*	
Ardeidae	Great Egret	*Ardea alba*	JC
	Little Egret	*Egretta (Ardea) garzetta*	
	Nankeen (Rufous) Night Heron	*Nycticorax caledonicus*	
	Pacific (White-necked) Heron	*Ardea pacifica*	
	White-faced Heron	*Egretta (Ardea) novaehollandiae*	
Threskiornidae	Australian White Ibis	*Threskiornis molucca (T. aethiopica)*	
	Glossy Ibis	*Plegadis falcinellus*	C
	Royal Spoonbill	*Platalea regia*	
	Straw necked Ibis	*Threskiornis spinicollis*	
	Yellow-billed Spoonbill	*Platalea flavipes*	
Gruidae	Brolga	*Grus rubicunda*	
Otididae	Australian Bustard	*Ardeotis australis*	
Pedionomidae	Plains-wanderer	*Pedionomus torquatus*	
Scolopacidae	Black-tailed Godwit	*Limosa limosa*	JCR
	Common Greenshank	*Tringa nebularia*	JCR
	Latham's (Japanese) Snipe	*Gallinago hardwickii*	JCR
	Marsh Sandpiper	*Tringa stagnatilis*	JCR
	Red-necked Stint	*Calidris ruficollis*	JCR
Scolopacidae	Sharp-tailed Sandpiper	*Calidris acuminata*	JCR

Family	Common name	Scientific name
	Wood Sandpiper	*Tringa glareola* JCR
Glareolidae	Australian Pratincole	*Stiltia Isabella*
Rostratulidae	Painted Snipe	*Rostratula benghalensis* C
Charadriidae	Banded Lapwing	*Vanellus tricolor*
	Black-fronted Dotterel	*Elseyornis (Charadrius) melanops*
	Inland (Australian) Dotterel	*Charadrius (Peltohyas) australis*
	Masked Lapwing	*Vanellus miles*
	Red-capped Plover	*Charadrius ruficapillus*
	Red-kneed Dotterel	*Erythrogonys cinctus*
Recurvirostridae	Banded Stilt	*Cladorhynchus leucocephalus*
	Black-winged Stilt	*Himantopus himantopus*
	Red-necked Avocet	*Recurvirostra novaehollandiae*
Laridae	Silver Gull	*Larus novaehollandiae*
	Caspian Tern	*Sterna caspia* C
	Gull-billed Tern	*Sterna nilotica*
	Whiskered (Marsh) Tern	*Chlidonias hybridus*
Accipitridae	Black-breasted Buzzard	*Hamirostra melanosternon*
	Black Kite	*Milvus migrans*
	Black-shouldered Kite	*Elanus axillaris*
	Brown Goshawk	*Accipter fasciatus*
	Collared Sparrowhawk	*Accipter cirrhocephalus*
	Little Eagle	*Hieraaetus morphnoides*
	Spotted Harrier	*Circus assimilis*
	Square-tailed Kite	*Lophoictinia isura*
	Swamp Harrier	*Circus approximans*
	Wedge-tailed Eagle	*Aquila audax*
	Whistling Kite	*Haliastur (Milvus) sphenurus*
Falconidae	Australian Hobby	*Falco longipennis*
	Black Falcon	*Falco subniger*
	Brown Falcon	*Falco berigora*
	Grey Falcon	*Falco hypoleucos*
	Nankeen (Australian) Kestrel	*Falco cenchroides*
	Peregrine Falcon	*Falco peregrinus*
Columbidae	Common Bronzewing	*Phaps chalcoptera*
	Crested Pigeon	*Ocyphas (Geophaps) lophotes*
	Diamond Dove	*Geopelia cuneata*
	Flock Bronzewing	*Phaps histrionica*
	Peaceful Dove	*Geopelia placida*
Cacatuidae	Red-tailed Black Cockatoo	*Calyptorhynchus banksii*
Psittacidae	Galah	*Eolophus (Cacatua) roseicapillus*
	Little Corella	*Cacatua sanguinea*
	Major Mitchell's (Pink) Cockatoo	*Cacatua leadbeateri*
Polytelitinae	Red-winged Parrot	*Aprosmictus erythropterus*
Playtcercinae	Budgerigar	*Melopsittacus undulatus*
	Blue Bonnet	*Northiella haematogaster*
	Blue-winged Parrot	*Neophema chrysostoma*
	Bourke's Parrot	*Neopsephotus bourkii*
	Cockatiel	*Nymphicus hollandicus*
Playtcercinae	Mallee Ringneck	*Barnardius zonarius*
	Mulga Parrot	*Psephotus varius*
	Red-rumped Parrot	*Psephotus haematonotus*

Family	Common name	Scientific name
Cuculidae	Black-eared Cuckoo	*Chalcites (Chrysococcyx) osculans*
	Pallid Cuckoo	*Cuculus pallidus*
	Horsfield's Bronze-Cuckoo	*Chalcites (Chrysococcyx) basalis*
Strigidae	Southern Boobook	*Ninox novaeseelandiae*
	Barking Owl	*Ninox connivens*
Tytonidae	Barn Owl	*Tyto alba*
	Masked Owl	*Tyto novaehollandiae*
Podargidae	Tawny Frogmouth	*Podargus strigoides*
Aegothelidae	Australian Owlet-nightjar	*Aegotheles cristatus*
Caprimulgidae	Spotted Nightjar	*Eurostopodus argus*
Apodidae	Forked-tailed Swift	*Apus pacificus* JCR
Halcyonidae	Red-backed Kingfisher	*Todiramphus pyrrhopygia*
Meropidae	Rainbow Bee-eater	*Merops ornatus*
	Sacred Kingfisher	*Todiramphus sanctus*
Coraciidae	Dollarbird	*Eurystomus orientalis*
Neosittidae	Variegated Sittella	*Daphoenositta chrysoptera*
Climacteridae	Brown Treecreeper	*Climacteris picumnus*
Maluridae	Splendid Fairy-wren	*Malurus splendens*
	Variegated (Purple-backed) Fairy-wren	*Malurus lamberti*
	White-winged Fairy-wren	*Malurus leucopterus*
Pardalotidae	Banded Whiteface	*Aphelocephala nigricincta*
	Chestnut-rumped Thornbill	*Acanthiza uropygialis*
	Inland (Broad-tailed) Thornbill	*Acanthiza apicalis (albiventris)*
	Little Grassbird	*Megalurus gramineus*
	Red-browed Pardalote	*Pardalotus rubricatus*
	Redthroat	*Pyrrholaemus (Sericornis) brunneus*
	Southern Whiteface	*Aphelocephala leucopsis*
	Striated Pardalote	*Pardalotus striatus*
	Weebill	*Smicrornis brevirostris*
	Yellow (Little) Thornbill	*Acanthiza nana*
	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Meliphagidae	Black Honeyeater	*Certhionyx niger*
	Brown Honeyeater	*Lichmera indistincta*
	Crimson Chat	*Epthianura tricolor*
	Gibberbird	*Ashbyia lovensis*
	Little Friarbird	*Philemon citreogularis*
	Orange Chat	*Epthianura aurifrons*
	Painted Honeyeater	*Grantiella picta*
	Pied Honeyeater	*Certhionyx variegatus*
	Singing Honeyeater	*Lichenostomus virescens*
	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*
	White-fronted Chat	*Epthianura albifrons*
	White-plumed Honeyeater	*Lichenostomus penicillatus*
	White-fronted Honeyeater	*Phylidonyris albifrons*
	Yellow Chat	*Epthianura crocea*
	Yellow-plumed Honeyeater	*Lichenostomus ornatus*
Meliphagidae	Yellow-throated Miner	*Manorina flavigula*
Cinclosomatidae	Chirruping Wedgebill	*Psophodes cristatus*
	Chestnut-breasted Quail-thrush	*Cinclosoma castaneothorax*
	Cinnamon Quail-thrush	*Cinclosoma cinnamomeum*

Family	Common name	Scientific name
Pomatostomidae	Chestnut-crowned Babbler	*Pomatostomus ruficeps*
	Grey-crowned Babbler	*Pomatostomus temporalis*
	Hall's Babbler	*Pomatostomus halli*
	White-browed Babbler	*Pomatostomus superciliosus*
Petroicidae	Mistletoebird	*Dicaeum hirundinaceum*
	Hooded Robin	*Melanodyras cucullata*
	Jacky Winter	*Microeca fascinans (leucophaea)*
	Red-capped Robin	*Petroica goodenovii*
Pachycephalidae	Crested Bellbird	*Oreoica gutturalis*
	Grey Shrike-Thrush	*Colluricincla harmonica*
	Rufous Whistler	*Pachycephala rufiventris*
Dicruridae	Magpie-lark	*Grallina cyanoleuca*
	Grey Fantail	*Rhipidura fuliginosa*
	Restless Flycatcher	*Myiagra inquieta*
	Willie Wagtail	*Rhipidura leucophrys*
Oriolidae	Olive-backed Oriole	*Oriolus sagittatus*
Campephagidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
	Ground Cuckoo-shrike	*Coracina maxima*
	White-bellied Cuckoo-shrike	*Coracina papuensis*
	White-winged Triller	*Lalage sueurii*
Artamidae	Australian Magpie	*Gymnorhina tibicen*
	Black-faced Woodswallow	*Artamus cinereus*
	Dusky Woodswallow	*Artamus cyanopterus*
	Grey Butcherbird	*Cracticus torquatus*
	Masked Woodswallow	*Artamus personatus*
	Pied Butcherbird	*Cracticus nigrogularis*
	White-breasted Woodswallow	*Artamus leucorynchus*
	White-browed Woodswallow	*Artamus superciliosus*
Corvidae	Australian Raven	*Corvus coronoides*
	Little Crow	*Corvus bennetti*
Corcoracidae	Apostlebird	*Struthidea cinerea*
Hirundinidae	Fairy Martin	*Hirundo ariel*
	Tree Martin	*Hirundo nigricans*
	Welcome Swallow	*Hirundo neoxena*
	White-backed Swallow	*Cheramoeca leucosternus*
Motacillidae	Richard's (Australian) Pipit	*Anthus novaesseelandiae*
Alaudiadae	Brown Song Lark	*Cincloramphus cruralis*
	Rufous Songlark	*Cincloramphus mathewsi*
	Singing Bushlark	*Mirafra javanica*
Sylviidae	Clamorous Reed-warbler	*Acrocephalus stentoreus*
Passeridae	House Sparrow	*Passer domesticus* *
Ploceidae	Painted Finch	*Emblema pictum*
	Zebra Finch	*Taeniopygia guttata*
Zosteropidae	Silvereye	*Zosterops lateralis*
Sturnidae	Common Starling	*Sturnus vulgaris* *

* introduced species

Species listed under migratory bird agreements: J = JAMBA, C = CAMBA, R = ROKAMBA
Sources for Sturt National Park bird species list: A preliminary checklist of birds of Sturt National Park (1990) and NSW NPWS Atlas of NSW Wildlife. Nomenclature follows Simpson and Day (1999).

Mammal species list for Sturt National Park

Order	Family	Common name	Scientific name
Montremata	Tachyglossidae	Short-beaked Echnida	*Tachyglossidae aculeatus*
Polyprotodonta	Dasyuroidea	Kultarr (Jerboa Marsupial Mouse)	*Antechinomys laniger*
Diprotodonta		Fat-tailed Dunnart	*Sminthopsis crassicaudata*
		Stripe-faced Dunnart	*Sminthopsis macroura*
		Paucident Planigale (Giles' Planigale)	*Planigale gilesi*
		Narrow-nosed Planigale	*Planigale tenuirostris*
		Wangai Ningaui	*Ningaui ridei*
	Macropodidae	Western Grey Kangaroo	*Macropus fuliginosus*
		Eastern Grey Kangaroo	*Macropus giganteus*
		Euro (Wallaroo)	*Macropus robustus*
		Red Kangaroo	*Macropus rufus*
Chiroptera	Molossidae	White-striped Mastiff bat	*Tadarida australis*
		Southern Freetail Bat	*Mormopterus planiceps*
		White-striped Free-tailed Bat	*Nyctophilus australis*
	Emballonuridae	Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*
	Vespertilionidae	Little Cave (Little) Bat	*Eptesicus pumilus*
		Gould's Wattled Bat	*Chalinolobus gouldii*
		Little Pied Bat	*Chalinolobus picatus*
		Lesser Long-eared Bat	*Nyctophilus geoffroyi*
		Greater Long-eared Bat	*Nyctophilus timoriensis*
		Inland Broad-nosed Bat	*Scotorepens balstoni*
		Little Broad-nosed Bat	*Scotorepens greyii*
		Inland Forest Bat	*Vespadelus baverstocki*
Rodentia	Muridae	Forrest's Mouse	*Leggadina forresti*
		Dusky Hopping Mouse	*Notomys fuscus*
		Fawn Hopping Mouse	*Notomys cervinus*
		Sandy Island Mouse	*Pseudomys hermannsburgensis*
		Water Rat	*Hydromys chrysogaster*
		House Mouse	*Mus musculus* *
		Long-haired Rat	*Rattus villosissimus*
Carnivora	Permaelidae	Pig-footed Bandicoot	*Chaeropus ecaudatus*
	Canidae	Dingo	*Canis lupis dingo*
		Red Fox	*Vulpes vulpes* *
	Felidae	Cat	*Felis catus* *
Lagomorphora	Leporidae	European Rabbit	*Oryctolagus cuniculus* *
Artiodactyla	Suidae	Pig	*Sus scrofa* *
	Bovidae	Goat	*Capra hircus* *

* introduced species

Source: A preliminary checklist of mammals of Sturt National Park, 17th January 1988, and NSW NPWS Atlas of NSW Wildlife

Reptile species recorded at Lake Pinaroo and surrounds

Location	Family	Common name	Scientific name	No.	Date collected
Lake Pinaroo	Gekkonidae	Bearded Gecko	*Diplodactylus damaeum*	2	Sep-98
		Tree Dtella	*Gehyra variegata*	2	Sep-98
		Becked Gecko	*Rhynchoedura ornata*	1	Sep-98
	Typhlopidae	Interior Blind Snake	*Ramphotyphlops endoterus*	1	Sep-98
Lake Pinaroo (Eastern Dune)	Scincidae	Pale-rumped Ctenotus	*Ctenotus regius*	1	Nov-99
	Varanidae	Gould's Goanna	*Varanus gouldii*	3	Nov-99
Fromes Swamp	Varanidae	Gould's Goanna	*Varanus gouldii*	1	Dec-96
Fort Grey	Scincidae	Carnaby's Wall Skink	*Cryptoblepharus carnabyi*	3	Nov-99
	Agamidae	Mallee Dragon	*Ctenophorus fordii*	1	Apr-97, Nov-97
		Central Netted Dragon	*Ctenophorus nuchalis*	3	Apr-97
		Central Bearded Dragon	*Pogona vitticeps*	1	Nov-79
	Gekkonidae	Grey's skink	*Menetia greyi*	3	Oct-87, Nov-99
		Bearded Gecko	*Diplodactylus damaeum*	4	Nov-97, Nov-99
		Crowned Gecko	*Diplodactylus stenodactylus*	4	May-78,Oct-87, Nov-97, Nov-99
		Tessellated Gecko	*Diplodactylus tesselatus*	2	May-78
		Tree Dtella	*Gehyra variegata*	14	Oct-87, Nov-99
		Bynoe's Gecko	*Heteronotia binoei*	9	Apr-97, Nov-99
		Smooth Knob-tailed Gecko	*Nephrurus levis*	1	Nov-97
		Becked Gecko	*Rhynchoedura ornata*	2	Nov-97, Nov-99
	Scincidae	Wedge-snout Ctenotus	*Ctenotus brooksi*	1	Nov-99
		Pale-rumped Ctenotus	*Ctenotus regius*	1	Nov-99
		Barred Wedgesnout Ctenotus	*Ctenotus schomburgkii*	12	Apr-97, Nov-99
		Narrow-banded Sand Swimmer	*Eremiascincus fasciolatus*	2	Apr-97, Nov-99
		Southern Sand-slider	*Lerista labialis*	11	Dec-76, Oct-87: Apr-97, Nov-99
		Yellow-tailed Plain-slider	*Lerista xanthura*	3	Apr-97, Nov-99
		Centralian Blue-tongued Lizard	*Tiliqua multifasciata*	1	Sep-88
		Shingleback	*Tiliqua rugosa*	1	Apr-97
	Varanidae	Gould's Goanna	*Varanus gouldii*	1	Nov-99
Water tanks	Varanidae	Gould's Goanna	*Varanus gouldii*	1	Nov-99
	Gekkonidae	Bynoe's Gecko	*Heteronotia binoei*	2	Nov-99

Source: Collections details supplied by R. Sadlier (2006) (April 1978 – November 1999). No. = number of individuals captured. Fort Grey records include the homestead, airstrip and campsite. Water tank collections were from the lignum and quartpot water tanks

Reptile species list for Sturt National Park

Family	Common name	Scientific name
Gekkonidae	Gibber Gecko	*Diplodactylus byrnei*
	Northern Spiny-tailed Gecko	*Diplodactylus ciliaris*
	Fat-tailed Gecko	*Diplodactylus conspicillatus*
	Box-patterned Gecko	*Diplodactylus steindachneri*
	Crowned Gecko (Pale-snouted Ground Gecko)	*Diplodactylus stenodactylus*
	Tessellated Gecko	*Diplodactylus tesselatus*
	Tree Dtella	*Gehyra variegata*
	Bynoe's Gecko (Prickly Gecko)	*Heteronotia binoei*
	Bearded Gecko	*Lucasium damaeum*
	Smooth (Three-lined) Knob-tailed Gecko	*Nephrurus levis*
	Becked Gecko	*Rhynchoedura ornata*
	Eastern Spiny-tailed Gecko	*Strophurus intermedius*
	Thick-tailed Gecko	*Underwoodisaurus milii*
Pygopodidae	Exictable Delma	*Delma tincta*
	Burtons Snake Lizard	*Lialis burtonis*
	Hooded Scaly-foot	*Pygopus nigriceps*
	Eastern Hooded Scaly foot	*Pygopus schraderi*
Agamidae	Mallee Dragon	*Ctenophorus fordii*
	Central Netted Dragon	*Ctenophorus nuchalis*
	Painted-ground Dragon	*Ctenophorus pictus*
	Central Bearded Dragon	*Pogona vitticeps*
	Gibber Earless Dragon	*Tympanocryptis intima*
	Lined Earless Dragon	*Tympanocryptis lineata*
	Long-tailed Earless Dragon	*Tympanocryptis tetraporophora*
Varanidae	Gould's Goanna	*Varanus gouldii*
Scincidae		*Cryptoblepharus boutonii*
	Carnaby's Wall Skink	*Cryptoblepharus carnabyi*
		Cryptoblepharus plagiocephalus
	Wedge-snout Ctenotus	*Ctenotus brooksi*
	Leonhardi's Ctenotus	*Ctenotus leonhardii*
	Pale-rumped Ctenotus	*Ctenotus regius*
	Barred Wedgesnout Ctenotus	*Ctenotus schomburgkii*
	Eastern Wedgesnout Ctenotus	*Ctenotus strauchii*
	Spotted Ctenotus	*Ctenotus uber*
	Slender Blue-tongue	*Cyclodomorphus venustus*
	Gunther's Skink	*Cyclodomorphus branchialis*
	Desert Skink	*Egernia inornata*
	Gidgee Skink	*Egernia stokesii*
	Narrow-banded Sand Swimmer	*Eremiascincus fasciolatus*
	Broad-banded Sand Swimmer	*Eremiascincus richardsonii*
	Southern Sand-slider	*Lerista labialis*
	Wood Mulch-slider	*Lerista muelleri*
	Eastern Robust Slider	*Lerista punctatovittata*
	Yellow-tailed Plain-slider	*Lerista xanthura*
	Grey's skink	*Menetia greyi*
	Saltbush Morethia	*Morethia adelaidensis*

Family	Common name	Scientific name
Scincidae	Bouelenger's Skink	*Morethia boulengeri*
	Red-tailed Soil-crevice Skink	*Proablepharus kinghorni*
	Centralian Blue-tongued Lizard	*Tiliqua multifasciata*
	Shingleback	*Trachydosaurus rugosus*
Typhlopidae	Blind Snake	*Ramphotyphlops australis*
	Prong-snouted Blind Snake	*Ramphotyphlops bituberculatus*
	Interior Blind Snake	*Ramphotyphlops endoterus*
Boidae	Woma	*Aspidites ramsayi*
	Children's Pyton	*Liasis childreni*
	Stimson's Pyton	*Liasis stimsoni*
	Carpet Pyton	*Morelia spilota* ssp. *Variegata*
Elapidae	Yellow-faced Whip Snake	*Demansia psammophis*
	Collared Whip Snake	*Demansia torquata*
	Red-napped Snake	*Furina diadema*
	Grey Snake	*Hemiaspis damelii*
	King Brown Snake (Mulga)	*Pseudechis australis*
	Ringed Brown Snake	*Pseudonaja modesta*
	Western Brown Snake (Bwardar)	*Pseudonaja nuchalis*
	Eastern Brown Snake	*Pseudonaja textilis*
	Narrow-banded Snake	*Simoselaps fasciolatus*
	Myall (Curl) Snake	*Suta suta*

Source: A preliminary checklist of reptiles and amphibians of Sturt National Park, 28th January 1988, and NSW NPWS Atlas of NSW wildife

Amphibian species recorded at Lake Pinaroo and surrounds

Location	Family	Common name	Scientific name	No.*	Date collected
Lake Pinaroo	Hylidae	Short-footed or Blotched Waterholding Frog	*Cyclorana breviceps*	2	Sep-98
		Water Holding Frog	*Cyclorana platycephala*	3	Sep-98
		Desert Tree Frog	*Litoria rubella*	2	Sep-98
	Myobatrachidae (Leptodactylidae)	Common Spadefoot Toad or Painted Burrowing Frog	*Neobatrachus sudelli*	5	Sep-98
Fort Grey (campsite)	Myobatrachidae (Leptodactylidae)		*Neobatrachus* sp.	1	Nov-99
Water tanks	Myobatrachidae (Leptodactylidae)		*Neobatrachus* sp.	9	Nov-99

* number of individuals captured; water tank collections were from the lignum and quartpot water tanks.
Source: R. Sadlier (2006, pers. comm.)

Amphibian species list for Sturt National Park

Family	Common name	Scientific name
Myobatrachidae (Leptodactylidae)	Long-thumbed Frog or Barking Marsh Frog	*Lymnodynastes flectcheri*
	Spotted Grass Frog or Spotted Marsh	*Lymnodynastes tasmaniensis*
	Trilling Frog	*Neobatrachus centralis*
	Common Spadefoot Toad or Painted Burrowing Frog	*Neobatrachus sudelli*
Hylidae	Short-footed or Blotched Waterholding Frog	*Cyclorana breviceps*
	Water Holding Frog	*Cyclorana platycephala*
	Rough Frog or Warty Waterholding Frog	*Cyclorana verrucosa*
	Green Tree Frog	*Litoria caerulea*
	Desert Tree Frog	*Litoria rubella*

Source: A preliminary checklist of reptiles and amphibians of Sturt National Park, 28th January 1988, and NSW NPWS Atlas of NSW wildife

Appendix 5: Habitat types

Lake Pinaroo in dry conditions in May 2006

Sparse vegetation (*Glycyrrhiza acanthocarpa* and *Solanum oligocanthum*) and remains of large *Eucalyptus coolabah* ssp. *arida* at Lake Pinaroo in dry condition in 2006.
Photo: J. Porter, May 2006

Vegetation on Lake Pinaroo's eastern dune

Dune vegetation was dominated by *Eucalyptus coolabah* ssp. *arida* and the shrubs *Acacia ligulata* and *Dodonea attenuata*. Photo: J. Porter, May 2006

Large Coolibah trees and islands in the lake providing waterbird breeding habitat

Aerial photograph of Lake Pinaroo in flood in March 1976. Photo: DECC, March 1976

Large Coolibah trees providing nesting habitat for bird species

Photo: J. Porter, May 2006

Fromes Creek inflow at the southern end of Lake Pinaroo

Photo: J. Porter, May 2006

Fromes Swamp

Canegrass (*Eragrostis australasicus*) and Golden goosefoot (*Chenopodium auricomum*) in Fromes Swamp. Photo: J. Porter, May 2006

Glossary

Acceptable change is the variation that is considered 'acceptable' in a particular measure or feature of the ecological character of a wetland; acceptable variation is that variation that will sustain the component or process to which it refers (Phillips et al. 2005).

Assessment as defined by Resolution VIII.6 of the 8th Conference of Parties to the Ramsar Convention (2002) is:

> the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.

Attributes as defined by the 6th Conference of Parties to the Ramsar Convention include:

> biological diversity and unique cultural and heritage features. These lead to uses or derivations of products, but they may also have intrinsic, unquantifiable importance (Annex A to Resolution VI.1) (Ramsar Convention 1996).

Baseline is defined as ecological condition of the wetland at a starting point, usually the time of listing.

Benefits as they relate to Ramsar wetlands and to ecological character and change in that character are defined by Ramsar (9th Conference of Parties, Resolution IX.1) as 'the benefits that people receive from ecosystems' (Ramsar Convention 2005a).

Biodiversity is the variability among living organisms. It includes diversity within and among species and diversity within and among ecosystems. Biodiversity is the source of many ecosystem goods, such as food and genetic resources, and changes in biodiversity can influence the supply of ecosystem services (Millennium Ecosystem Assessment 2003).

Biogeographic region a scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover (Ramsar Convention 2005b).

Change in ecological character as redefined by Resolution IX.1 of the 9th Conference of Parties to the Ramsar Convention (2005a): 'the human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service'.

Character is a descriptive snapshot which lists the constituents present at a site and their relationships. It is a 'value free' statement. (Contrast with condition).

Components are the physical, chemical and biological parts (from large scale, for example habitat, to very small scale, for example genes).

Condition (ecological condition) refers to the health or quality of a site. It involves analysis, assessment and value-based judgment. The assessment is made comparative to other sites.

Criteria used in its Ramsar specific context refer to the nine criteria for listing of a site as internationally significant under the provision of the Ramsar Convention (as recently amended at the 9th Conference of Parties), namely a wetland that:

1 contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region

2 supports vulnerable, endangered, or critically endangered species or threatened ecological communities

3 supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region

4 supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions

5 regularly supports 20,000 or more waterbirds

6 regularly supports 1% of the individuals in a population of one species or subspecies of waterbird

7 supports a significant proportion of indigenous fish subspecies, species or families, life history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity

8 is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend

9 regularly supports more than 1% of the population of a non-avian species of animal.

Ecological character as recently redefined by the 9th Conference of Parties to the Ramsar Convention is 'the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time. (Resolution IX.1 Annex A)' (Ramsar Convention 2005a).

Ecosystem is a dynamic complex of plant, animal, and micro-organism communities and the non-living environment interacting as a functional unit. Humans are an integral part of ecosystems. Ecosystems vary enormously in size; a temporary pond in a tree hollow and an ocean basin can both be ecosystems (Millennium Ecosystem Assessment 2003).

Ecosystem indicator can be any biological, chemical or physical characteristic of the wetland for which long term data exists.

Ecosystem service In the Millennium Ecosystem Assessment (2003), ecosystems are described as the complex of living communities (including human communities) and non-living environment (ecosystem components) interacting (through ecological processes) as a functional unit which provides inter alia a variety of benefits to people (ecosystem services). Included in ecosystem services are provisioning, regulating, and cultural services that directly affect people, and supporting services which are needed to maintain these services. Within this context, ecosystem benefits are defined as 'the benefits that people receive from ecosystems' (Resolution IX.1 Annex A, 9th Conference of Parties to the Ramsar Convention) (Ramsar Convention 2005a).

Endorheic describes an internally draining or closed drainage system.

Enhanced greenhouse effect is the direct result of human activities. The natural greenhouse effect keeps the Earth's surface much warmer than it would be if there was no atmosphere. Man-made emissions of carbon dioxide, more than any other greenhouse gas, have contributed most to the enhancement of the Earth's natural greenhouse effect.

Functions are defined by the 6th Conference of Parties to the Ramsar Convention as activities or actions, natural, a product of interactions between ecosystem structure and processes, such as flood control, sediment retention, food web support. Functions include flood water control; nutrient, sediment and contaminant retention; food web support; shoreline stabilisation and erosion controls; storm protection; and stabilisation of local climatic conditions, particularly rainfall and temperature (Annex to Resolution VI.1) (Ramsar Convention 1996).

Groundwater is water occurring below the ground surface.

Hydrology *see* water regime

Inundation is the depth and extent to which a particular location is covered by water.

Monitoring as defined by Resolution VIII.6 of the 8th Conference of Parties to the Ramsar Convention (2002) is the 'collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management'.

Processes as defined by the 6th Conference of Parties to the Ramsar Convention are 'changes or reactions which occur naturally within wetland systems. They may be physical, chemical or biological' (Annex A to Resolution VI.1). Biological processes are the dynamic biotic and abiotic interactions within an ecosystem such as primary production, decomposition, carbon and nutrient cycling, sedimentation and provision of habitats for other biota. These may or may not provide benefits or services to humans (Ramsar Convention 1996).

Rapid assessment is a synoptic assessment, which is often undertaken as a matter of urgency, in the shortest timeframe possible to produce reliable and applicable results for its defined purpose.

Turbidity is the cloudy appearance of water due to suspended material.

Values as defined by the 6th Conference of Parties to the Ramsar Convention are the perceived benefits to society, either direct or indirect, that result from wetland functions. These values include human welfare, environmental quality and wildlife support (Annex A to Resolution VI.1) (Ramsar Convention 1996).

Water quality is a general term to describe the suitability of water for a given use (such as drinking water, vegetation growth).

Water regime is the pattern of when, where and to what extent water is present in a wetland. The components of water regime are the timing, duration, frequency, extent and depth, and variability of water presence.

Wetlands 'are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth at which at low tide does not exceed six metres (Article 1.1) and may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands' (Ramsar definition Article 2.1).

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