A VEGETATION SURVEY

OF THE KANOWANA WETLANDS

COOPER CREEK, SOUTH AUSTRALIA

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A States Assistance Cooperative Project with ANPWS & SANPWS

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ABSTRACT

In 1987 a large area of the Cooper Creek system in north eastern South Australia was proclaimed a Wetland of International Importance under the Ramsar Convention. The Convention provides a framework for international co-operation for the conservation of wetland habitats and wildlife. Contracting parties are required to monitor the ecology of the listed wetlands and to develop management plans to ensure their biological integrity.

The Kanowana Block, containing a vast network of channels, lakes, waterholes, swamps and floodouts irrigated by floodwaters from the Cooper Creek, is included in the Ramsar listed area. In 1990, State Cabinet approved acquisition of the Block and its addition to the State's reserve system.

In 1990, a co-operative project was established between the Australian and South Australian National Parks and Wildlife Services to undertake a vegetation survey and inventory of the Kanowana wetlands. During three survey periods in April, May and August 1992, a total of 173 sites were botanically surveyed, and records were made of waterbird species and numbers on 19 wetland sites.

The project resulted in the identification of:
- 14 floristic associations;
- 157 plant species (eight naturalised) representing 108 genera belonging to 42 families; and
- 47 species of waterbirds.

The Kanowana Wetlands exhibit the characteristics of a biologically dynamic and productive floodplain system supporting a rich and diverse biota. Intermittent floodwaters and productive grey clay floodplains together with subtle variations in local relief, result in a myriad of nutrient enriched niches. Of the 47 species of waterbirds observed during the survey, eight species were found to be present in numbers exceeding 1000 at nine lakes, and over 10 000 waterbirds were recorded at two different sites.

This study has shown that the Kanowana Block contains significant wetland habitat. It is recommended that the grazing rights be purchased and the area managed principally for its conservation values. Federal assistance with the purchase of Kanowana and with the management of the Coongie Lakes Wetland of International Importance would enable the South Australian National Parks and Wildlife Service to manage for conservation objectives and expectations on a significant section of the Cooper floodplain.

This study has additionally identified the need for:
- an integrated catchment management approach to ensure the biological integrity of the Cooper Creek wetland system;
- vegetation survey and mapping of the Cooper Creek system in South Australia in order to identify the extent and nature of the communities of the floodplain; and
- development of an improved gauging system in order to clarify the dynamics of the hydrology of Cooper Creek.

ACKNOWLEDGMENTS

The Kanowana Wetlands Study was funded by the Australian National Parks and Wildlife Service (ANPWS). Following establishment of the project in 1990, consecutive years of flooding prevented access to the area and delayed the effective commencement of field work until 1993. We are grateful to the ANPWS for their understanding of the unpredictable nature of arid zone flood events and for having a dynamic and flexible administrative approach in the support of projects.

David Goodwins, Louise Mitchell and Derek Mitchell of the GIS Section, Office of Planning and Urban Development, co-ordinated the development of the vegetation and site maps. The vegetation analysis was conducted with the invaluable assistance of Keith Casperson of the Biological Conservation Branch. David Symmon of the South Australian State Herbarium reviewed and verified the plant voucher specimens.

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1 INTRODUCTION

1.1 Background

The term *Kanowana Wetlands* is derived from the Kanowana pastoral block, covering an area of some 6700km^2, and forming part of the Clifton Hills pastoral lease in far north eastern South Australia (Figure 1). Whilst much attention has been focussed on the Coongie Lakes system at the terminus of the North West Branch of the Cooper Creek (Reid & Gillen 1988, Reid & Puckridge 1990), these lakes form only part of an extensive integrated desert wetland system (Figure 2).

Within the Kanowana Block is a vast network of lakes, swamps, waterholes, channels and floodouts, irrigated by floodwaters from the South West Branch of the Cooper, referred to as the Main Channel, and from the Northern Overflow from Coongie Lakes (Figure 1). Kanowana is considered to be of high conservation value because of its extensive wetlands and remoteness, and is noted as the location where the last validated sightings of the Night Parrot occurred in South Australia. As a result of the remoteness of the area, knowledge of the wetland types and associated vegetation is scant.

In 1987, a large area of the Cooper Creek system in South Australia was proclaimed a Wetland of International Importance under the Ramsar Convention (see Section 1.2.1), and was named after the Coongie Lakes. In 1988 a major portion of this proclaimed wetland was dedicated as a reserve under the South Australian *National Parks and Wildlife Act, 1972.* This area, formerly the Innamincka Pastoral Lease, and containing the Coongie Lakes, subsequently became known as the Innamincka Regional Reserve. In 1990, Cabinet of the South Australian Government approved that the Kanowana Block which adjoins the Innamincka Regional Reserve be acquired for conservation management and dedicated as a reserve.

During 1990 a co-operative project was developed between the Australian National Parks and Wildlife Service (ANPWS) and the South Australian National Parks and Wildlife Service (SANPWS) to undertake a survey and inventory of the Kanowana area. The main aim was to adopt a site-based survey to assess, classify and map the vegetation of the area, thus creating baseline data for future monitoring and contributing to an understanding of the wetland system. Additionally, the project was to be treated as a pilot study, developing approaches and techniques for vegetation survey and mapping in other desert wetland systems within the Lake Eyre Basin.

1.2 International Agreements

The conservation and management of wetlands and waterbirds is provided for in Australia through State and National legislation, and by international agreements including the Convention on Wetlands of International Importance (Ramsar) and Migratory Bird Agreements.

1.2.1 Wetlands Of International Importance

The 1971 Convention on Wetlands of International Importance, known as the Ramsar Convention from its place of adoption in Iran, is an inter-governmental treaty which provides the framework for international cooperation for the conservation of wetland habitats. The broad objectives of the Convention are to stem the loss of wetlands and to ensure their conservation. Contracting parties have agreed to designate wetlands for inclusion in a "List of Wetlands of International Importance" and undertake specific management duties to ensure the conservation of these sites. Criteria for identifying Wetlands of International Importance have been adopted by the contracting parties (Appendix A).

Under the Convention there is a general obligation for the contracting parties to include wetland conservation considerations within their national land-use planning and to promote wise use of wetlands. Significantly, contracting parties have defined wise use to mean the maintenance of the ecological character of wetlands. Contracting parties are required to inform the Convention Bureau of any changes or likely changes in the ecological character of any listed site, and are encouraged to develop management plans and undertake monitoring of listed wetlands.

Coongie Lakes, one of four Wetlands of International Importance listed in South Australia, was designated in 1987. The Coongie Lakes Wetland, encompassing some 19 800km^2, includes a significant portion of the Cooper Creek floodplain and extends from the Queensland border downstream to an area below Lake Hope. Much of the area is now included in the Innamincka Regional Reserve. The remaining areas are contained within the Pastoral Leases of Gidgealpa, Clifton Hills, Kanowana, Waukatana and the Lake Hope Block of Mulka (Figure 1).

It is important to realise that the stated area of 19 800km^2 does not represent the actual area of wetlands contained within the designated wetland as the listed site includes significant areas of the Strzelecki desert dunefields. Mapping of the floodplain system will provide accurate data both on the extent and on the types of habitats contained within this wetland system.

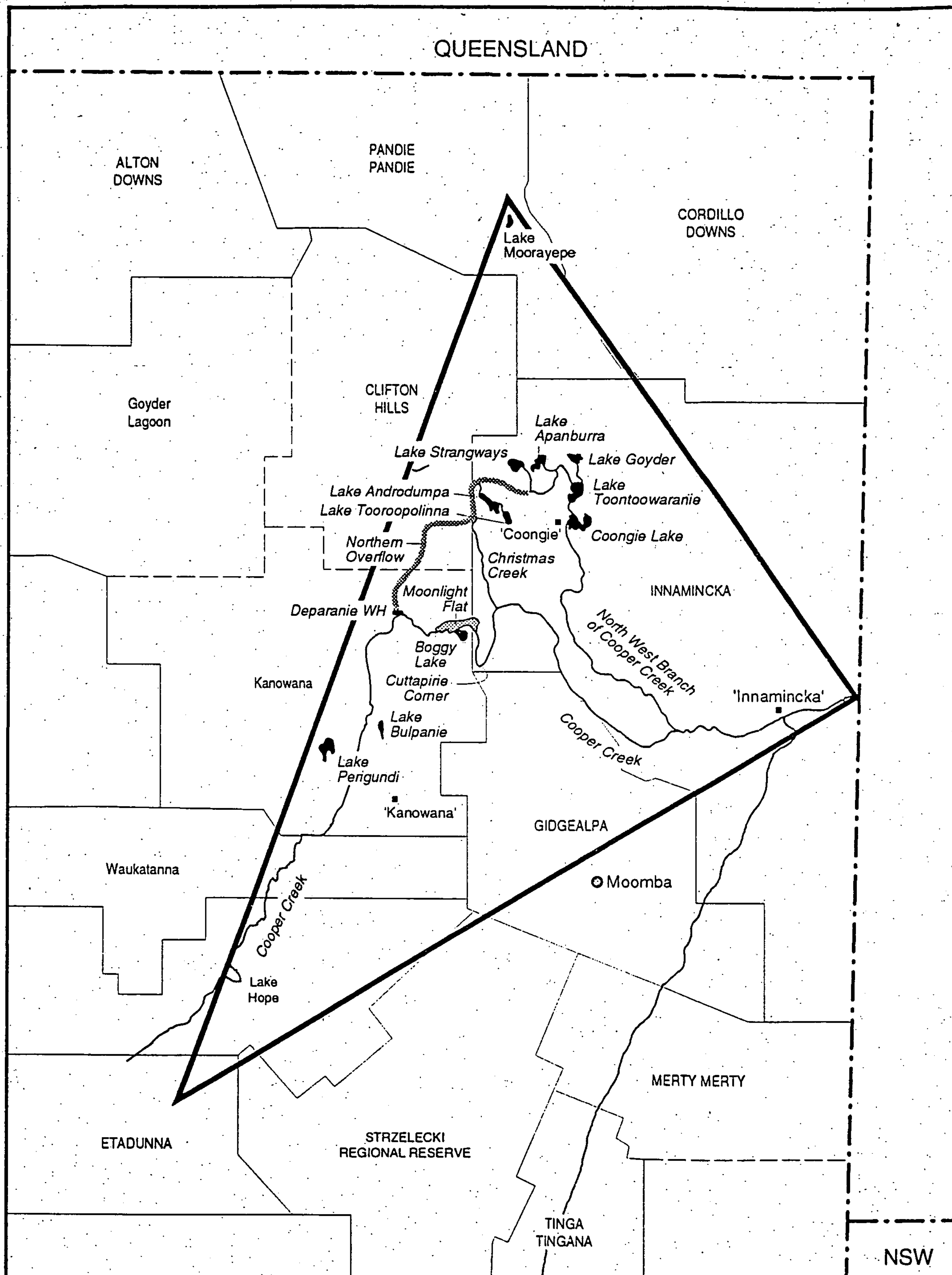


FIGURE 1
COOPER CREEK WETLANDS:
COONGIE LAKES WETLAND OF
INTERNATIONAL IMPORTANCE

0 50km
SCALE

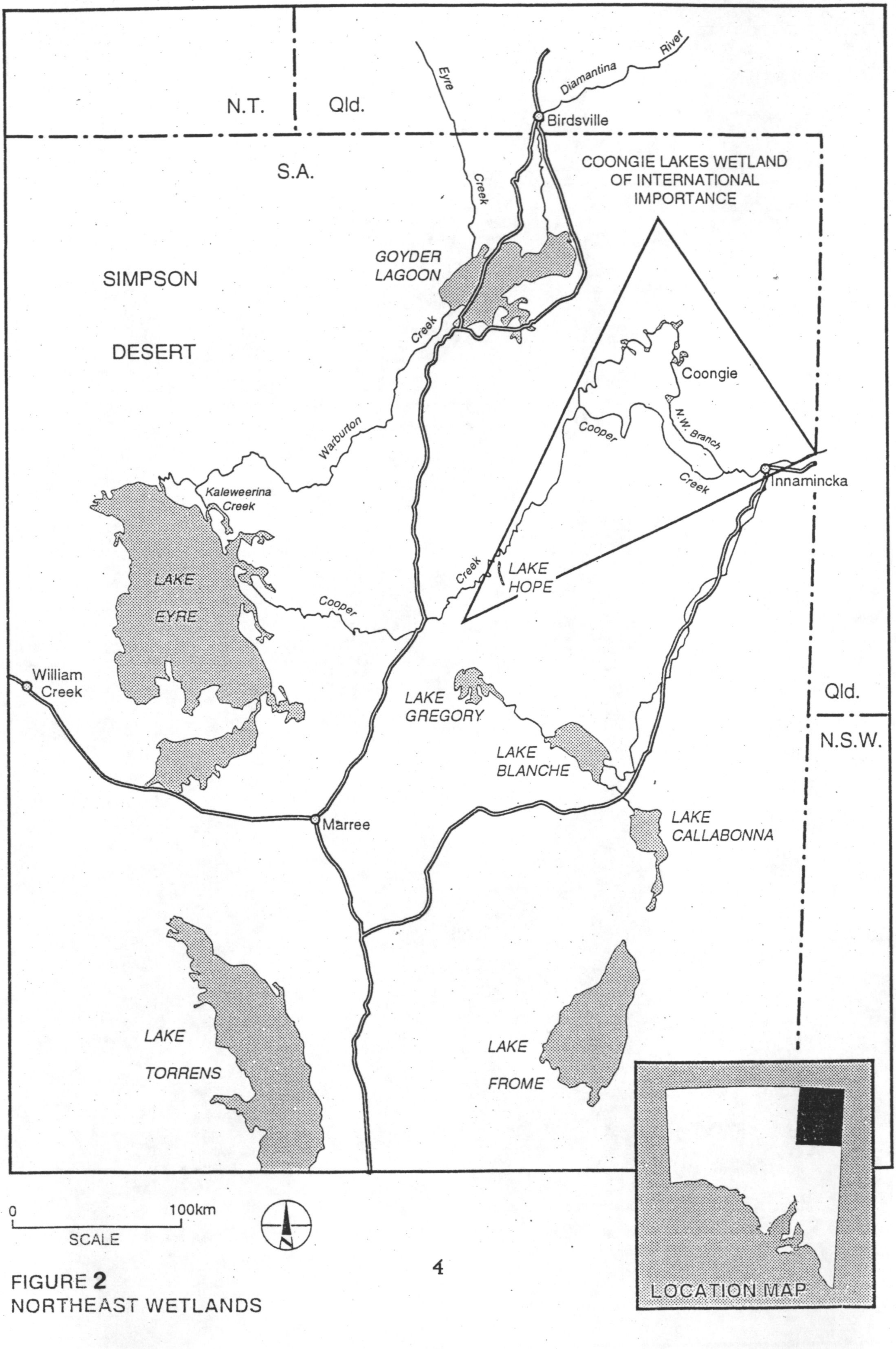


FIGURE **2**
NORTHEAST WETLANDS

1.2.2 Migratory Bird Agreements

Migratory birds comprise a significant component of Australian avifauna, and the need to ensure for their conservation is recognised by the establishment of Agreements between the Australian Government and the Governments of Japan and China.

In February 1974, an Agreement was signed between Australia and Japan providing for the protection of Migratory Birds and Birds in Danger of Extinction and their Environment (Appendix B). The Agreement, referred to as *Jamba* (Japan-Australian Migratory Bird Agreement), currently lists some 76 migratory species, as well as birds considered as endangered.

A similar Agreement was formalised in 1988 between the Government of the People's Republic of China and Australia, for the Protection of Migratory Birds and their Environment (CAMBA). In addition, Agreements to provide for the conservation of migratory birds and their habitat are currently under negotiation between Australia and the Governments of Papua New Guinea and the Republic of Indonesia.

The Agreements are designed to promote cooperative measures between the countries and include:

- controls on the taking, trade or exchange of migratory birds and their eggs;
- establishment of sanctuaries and other facilities for the management and protection of migratory birds and their habitat; and
- joint research and the exchange of information on migratory birds.

To date a total of 27 bird species listed in the JAMBA and CAMBA Agreements have been identified within the Coongie Lakes Wetland of International Importance (Appendix B).

1.2.3 Management and Administration

The responsibility for nature conservation in Australia, including legislation, management of wetlands, and conservation of waterfowl and migratory birds, is vested with the Commonwealth, State and Territory Governments in their respective areas of jurisdiction. ANPWS is the principal adviser to the Commonwealth Government on national nature conservation and wildlife policies, and has an overall coordinating role in the implementation of International Agreements and Conventions.

Activities of the various authorities are coordinated through ANZECC (Australian New Zealand Environment and Conservation Council), which provides a national forum for discussion and formulation of programs. Working Groups under ANZECC review and advise on Wetlands of International Importance and Migratory Bird Agreements. ANPWS provides the Convener for the Working Groups, and coordinates the preparation of national and international reports.

ANZECC has agreed that it is the responsibility of individual States and Territories to nominate and manage Wetlands of International Importance and to implement Migratory Bird Agreements. Within South Australia, this responsibility is vested with the Minister for the Department of Environment and Land Management. In South Australia, protection of birds listed in the Migratory Agreements is provided through the *National Parks and Wildlife Act, 1972*. It is noteworthy that the four Wetlands of International Importance within this State are wholly or partially designated as reserves under this *Act*.

1.3 Climate

Located in the arid core of the continent, the Kanowana Wetlands Study Area receives a median annual rainfall of 100-150mm (Figure 3a) (Allan 1990), whilst mean annual evaporation exceeds 3600mm (Figure 3b) (Kotwicki 1986, 1987). The rainfall is the most variable, both spatially and temporally, in Australia (Figure 3c, Allan 1990, Mollenmans et al. 1984). There is a seasonal tendency for rains to occur in late summer resulting from incursions of moist tropical air masses, rain and monsoon depressions, and thunderstorms (Allan 1990). However, unseasonal rains, although usually highly localised, may be significant. Such localised falls of rain can cause the usual distributary channel system of the Cooper floodplain to perform the function of tributaries; draining into rather than out of the floodplain channels.

Beyond the seasonal time scale, and of great significance to the major flood events of the Cooper, are the effects of the El Nino Southern Oscillation (ENSO) phenomenon; involving the interactions of ocean and atmosphere across the Indo-Pacific region (Allan 1985, 1988c). The major rainfall events, and in particular major flooding of the Lake Eyre Basin with subsequent filling of Lake Eyre, are linked to the Anti-ENSO phase (positive oscillation phase) of the phenomenon. This phase results in above average rainfall during the winter-spring period, which may extend into summer, particularly in the eastern half of the continent - the main catchment area for the Lake Eyre Basin (Allan 1990). In comparing available rainfall data, Allan has noted an extremely significant increase in summer rainfall during this century (of the order of 70-80%), which he equates with the greater influence and intensity of the anti-ENSO episodes during more recent decades.

Maximum temperatures average 36-39°C in summer, and 18-24°C in winter. The coldest month is usually July, with occasional sub-zero conditions and mean minimum temperatures of around 5°C. Winds are usually from the south south-east, particularly in spring and autumn, with contrasting desiccating northerly winds during summer. Winds are more variable in winter, with an increased number of calmer days.

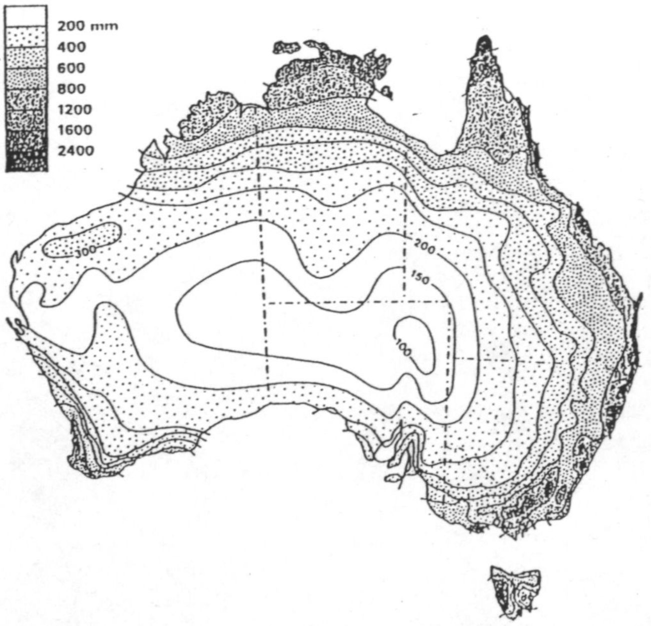


FIGURE 3a: RAINFALL

Median annual rainfall in mm (Source: AWRC 1976 in Paijmans et al. 1975)

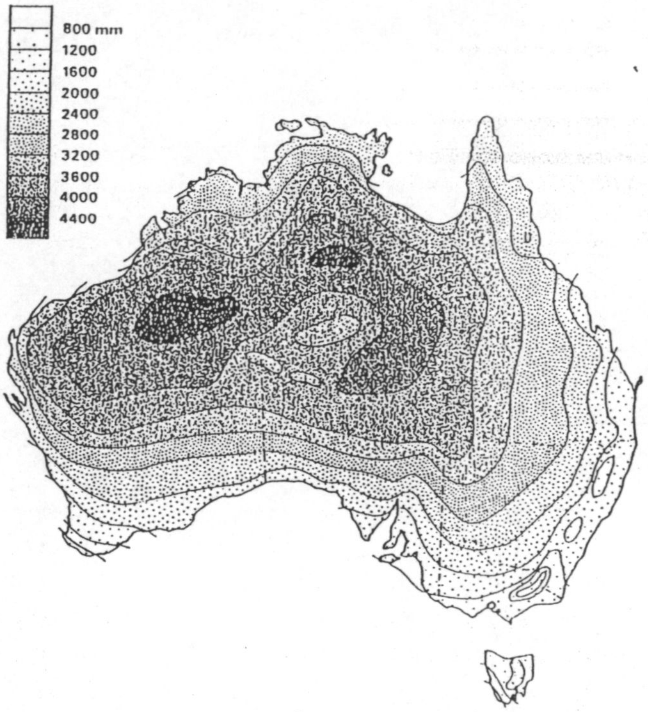


FIGURE 3b: EVAPORATION

Total evaporation in mm from a USWB Class A pan for the whole year (Source: AWRC 1976 in Paijmans et al. 1975)

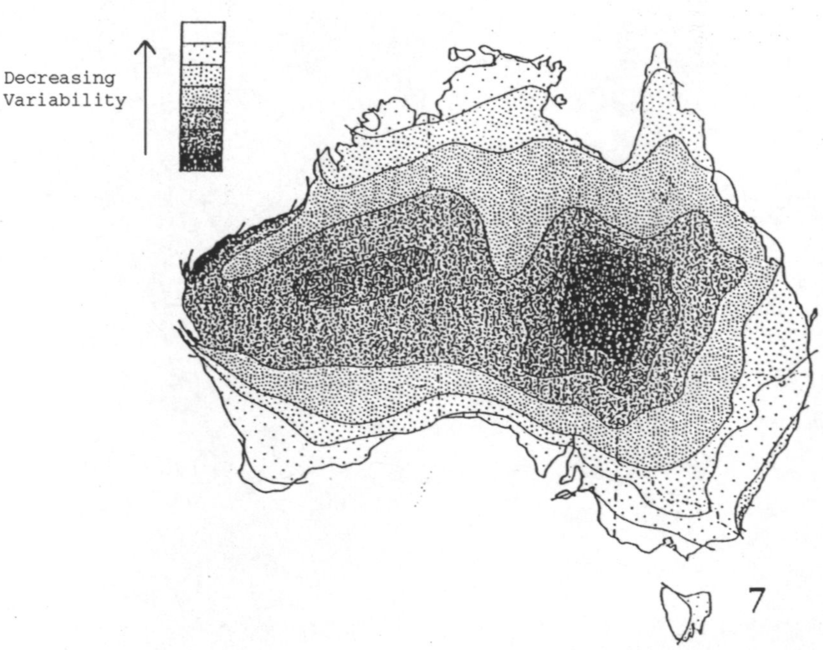


FIGURE 3c: RAINFALL VARIABILITY

Annual rainfall variability (Source: Gaffney 1975 in Paijmans et al. 1975)

1.4 Hydrology

The Study Area consists of the floodplain system of the Cooper Creek, originating as the Barcoo and Thomson Rivers in the catchment area of the Great Divide in central Queensland. This combined river system has a drainage area of 296 000km^2; the largest of the seven river systems which drain into Lake Eyre. In total, the desert rivers drain an area of approximately 1 170 000km^2, constituting one of the largest internal drainage systems in the world (Figure 4) (Mollenmans et al. 1984, Paijmans et al. 1985, Armstrong 1990). Kotwicki (1986), modelling the drainage of the Lake Eyre Basin, found that 17% of the floodwaters entering Lake Eyre North came from the Cooper catchment, 64% from the Warburton-Diamantina-Georgina catchment, and 19% from other sources. The significance of the Queensland catchment in sustaining the dynamics of the extensive desert wetlands in South Australia is clearly emphasised by Kotwicki's analysis.

Within South Australia, approximately 45km downstream from the Queensland border, the Cooper Creek splits into two major channels. The North West Branch (Channel) terminates in the Coongie Lakes system, whilst the Main (South West) Channel, wends its way through the dunefields and wetlands of the Kanowana Wetlands Study Area to Lake Eyre (Figure 1).

The gradient of the Cooper is subtle, averaging three to four centimetres per kilometre in Queensland, and decreasing to the west of Innamincka to less than 0.5cm/km (Wopfner 1970). The subtleness of the gradient has a significant influence upon the dynamics of the wetland system. Small increases or variations in flood events can result in the inundation of vast areas of the floodplain because of low local relief and hydrological variability of the system (Reid & Puckridge 1990). This variability also tends to blur distinctions between terrestrial and aquatic habitats under varying flooding regimes. A consequence of the hydrological subtlety is that slight and seemingly insignificant disturbances to local relief, such as those created by grading a track, can present effective barriers to the natural irrigation of large areas of the floodplain.

Mollenmans et al. (1984) have proposed a useful model describing four classes of flood within the Cooper system, based on the determination of the nature of rainfall in the catchment area (Appendix C). Mollenmans' model requires verification, and could be further refined by the establishment of additional flood gauging stations. Currently, the only gauging station on the Cooper in South Australia is located at Cullyamurra Waterhole, east of Innamincka (Figure 4). Allan (1988), in a hydrological examination of the Coongie Lakes system, proposed the positioning of an additional gauging station on the North West Branch near Coongie Lake.

Less costly flow measuring devices, such as regular current metering points and/or gauging boards, were recommended for location downstream of Tirrawarra Swamp on the North West Channel, on the Main Channel near Embarka Waterhole and Cuttapirie Corner, and on Browne and Ellor Creeks in the Coongie Lakes district.

Mollenmans et al. (1984) have estimated that only 5% of the water recorded at Currareva gauging station in Queensland (Figure 4) reaches the Cullyamurra station in South Australia. Most of the floodwaters are absorbed within the myriad channels comprising the Cooper in the aptly named channel country of south west Queensland. During periods of greater than average rainfall, the amount reaching Cullyamurra apparently increases to 20% of that recorded at Currareva.

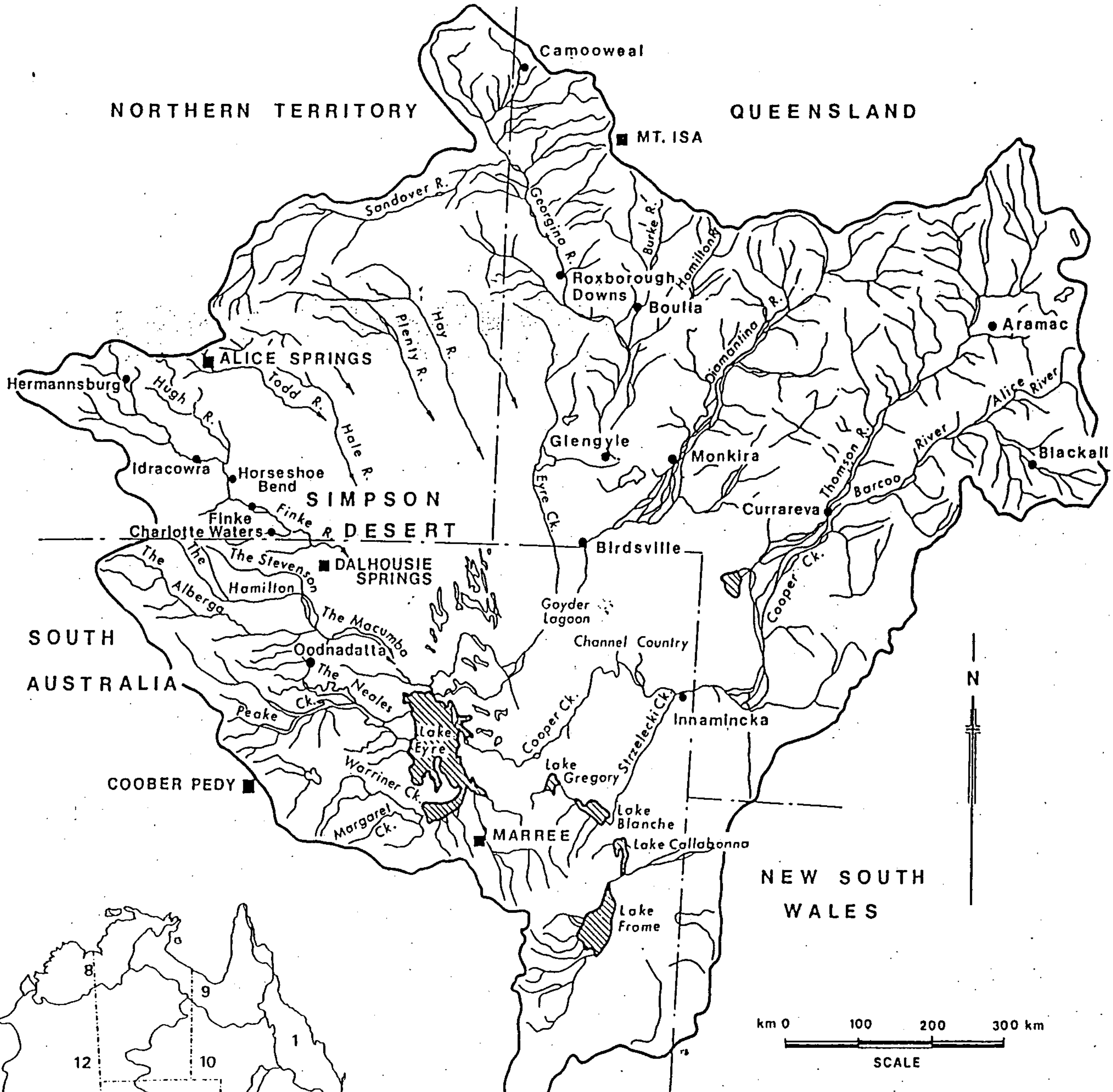
Bonython (1963) provides a useful account of a Cooper Creek flood event, with particular reference to the Kanowana Wetlands Study Area. Following heavy rains in the catchment area in March 1963, floodwaters reached Innamincka by April 19th. After reaching the junction of the Main and North West Channels, the flood progressed to Kanowana and Coongie Lakes, arriving at Kanowana by May 9th. Here the flood was retarded for a period of ten days, presumably inundating the extensive floodplain and filling peripheral lakes. The flood eventually reached Lake Eyre by August 8th, being held up several times en route whilst local floodplain systems were inundated.

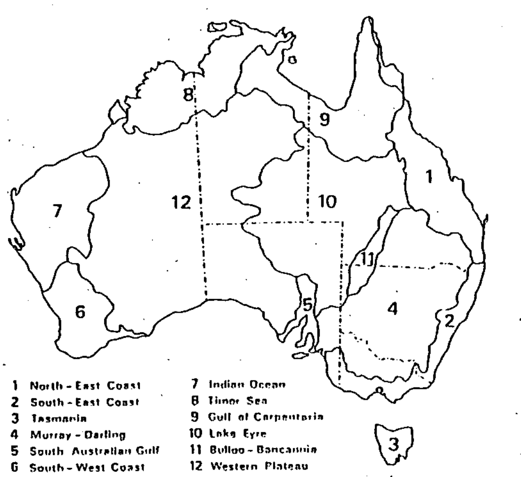
1.5 Wetlands

1.5.1 Introduction

The typical definitions of wetlands as used by Ramsar (Appendix A), do not adequately describe the spatial and temporal variability of wetlands encountered in arid Australia. The descriptions of wetland types present in the Kanowana Study Area follow those of Paijmans et al. (1985) (Appendix D). The inclusion of the category "land subject to inundation" is crucial in comprehending the dynamic nature of the Cooper Creek floodplain, particularly in terms of the temporal and spatial variability of flood events.

Much of the Kanowana Study Area may be defined as "land subject to inundation" to a varying extent, depending on the frequency, duration, and depth of flooding events. In extreme conditions, such as those of the dramatic 1974 floods (Appendix E), the entire floodplain may be inundated, resembling a vast interconnected, braided channel system. More typically, however, the floodplain contains a discontinuous collection of lakes, channels, swamps, and waterholes, all subject to differing flood regimes, and thus presenting a system of great complexity and variability.





Drainage Divisions adopted by the Australian Water Resources Council (Source: Paijmans et al. 1985)

FIGURE 4: LAKE EYRE DRAINAGE BASIN

• indicates river guaging station location (Source: E&WS Water Resources Branch)

Appendix D reveals the potential range of wetland types to be encountered in the Study Area. It must be emphasised that this is a provisional description derived from field observation and the previously cited flood classes of Mollenmans et al. (1984) (Appendix C). Further clarification of the structure and function of the wetlands awaits detailed hydrological studies. However, as the distribution of vegetation associations within the floodplain reflects the frequency and duration of inundation, a model of wetland types could possibly be derived from the vegetation map developed during this Study.

A general description of the wetland types in the Study Area is based on four main categories: lakes, swamps, land subject to inundation, and river and creek channels.

1.5.2 Lakes

Lakes are defined as areas of open water, generally over one metre deep, with little or no persistent emergent vegetation. Waterholes are to be found predominantly in the Main Channel, whereas the occasional billabong, such as Chillimookoo Waterhole, is to be found in anabranches or flood channels. As indicated by Mollenmans et al. (1984), yearly flows are purported to extend as far as Cuttapirie Corner, regularly flushing and filling waterholes en route. Other waterholes in the area, such as those along the Northern Overflow, Christmas Creek, or further down the Main Channel, although not permanent, may retain water for extended periods following major floods. However, permanence is a nebulous term to apply to a desert wetland system, for in extreme drought even apparently permanent waterholes are known to dry out completely.

Whilst none of the lakes in the Study Area could be classified as permanent, many of the intermittent lakes, whether on the floodplain or in terminal drainage basins, may retain water for several years after a flood event, providing an extensive network of waterbird habitat. Additionally, none of these lakes could be classified consistently as seasonal, that is alternatively wet and dry each year according to seasons. However, the well-above average flows between 1989 and 1991 resulted in intermittent lakes retaining water over several seasons. These lakes are depicted as those full of water in the accompanying vegetation map (Appendix F1). The map reveals that most of these lakes are in terminal drainage basins or depressions extruding into the surrounding dunefields of the Strzelecki Desert.

When dry, the lakebeds exhibit the typical deep grey clays associated with the Cooper floodplain system, displaying a self-mulching characteristic at the surface. From the centre of each lake to the shoreline, the clays gradually give way to sands associated with the deflation of desiccated lake bed alluvia.

Lakes found closer to or directly irrigated by the major channels are more likely to flood, and are prone to dry out more rapidly as a result of back flow drainage. This is in contrast to peripheral lakes in terminal drainage basins, where floodwaters of a particular volume may be required to break sills. However, once breached, there is little chance of backflow into the channel from whence the floodwaters issue. Consequently, these terminal drainage lakes retain water for extended periods. Such lakes include many of those found on the Northern Overflow, such as Lakes Apanburra, Strangways, Androdumpa, Tooroopolinna, Moolionburrinna, and McKinlay. These lakes of the Northern Overflow, compared with those associated with the Main Channel, require well above average flows to fill (Appendix C), and this is associated with the inundation of vast areas of surrounding floodplain.

Lake Talinnie, a terminally draining salt lake fed by the floodwaters of the Northern Overflow, appears to be one of the few *episodic* lakes of the system. The lake appears to be rarely filled, and displays the physical characteristics defined by Paijmans et al. (1985) for this subclass, namely a salt crust over saturated slimy black mud (unless inundated).

1.5.3 Swamps

Swamps are typically vegetated areas, and where water is present it is usually less than one metre deep, with persistent emergent vegetation. The vegetation is predominantly a perennial shrubland comprising stands of *Muehlenbeckia cunninghamii*, *Chenopodium auricomum*, *C. nitrariaceum*, and *Atriplex nummularia* (*Eucalyptus microtheca* overstorey may be present). These stands may be monospecific, or a mixture of two or more species, depending on the flooding regime, and edaphic characteristics. Following the annual flows to Cuttapirie Corner, local floodout areas immediately adjacent to the Main Channel may be seasonally inundated, producing thick stands of *M. cunninghamii* closer to the channel, backed by a band of *C. auricomum*.

Intermittent floodplain swamps are more prevalent throughout the area. The most extensive swamps are associated with the Main Channel and the Kanowana Channel, particularly in those areas where the channels become discontinuous, flooding a wide expanse before contracting once again. Associated soils are typically deep cracking grey clays, with a tendency to gilgai formation in areas, producing a local micro-relief of many small depressions. The most outstanding example of this type of wetland is provided by an unnamed lake in the south east of the Study Area which forms a terminal drainage depression dominated by *Eragrostis australasica* (Appendix F3). Such expanses of *E. australasica* are rare, with occurrences usually restricted to small patches on clay pans on the periphery of the floodplain.

1.5.4 Land Subject to Inundation

Land subject to inundation represents much of the floodplain not occupied by the other categories of wetland. Although most flows down the Cooper Creek system do not result in total inundation of the floodplain, in rare flood conditions inundation is almost complete (Appendix C).

Land subject to inundation displays a biologically transient quality; influenced by the frequency, duration and depth of flooding events. The inundation of vast areas of the floodplain extends the availability of the range of biologically productive niches utilised by a wide variety of birds. With the subsequent exploitation of these ephemeral wetlands and their decline in biological productivity, there is a subsequent contraction to more reliable sources of water such as the Coongie Lakes system, a highly significant refuge in drier conditions. Hence the significance of this category of wetland is directly related to its biological productivity following flooding of land that is usually dry (Reid & Puckeridge 1990).

It has also been suggested that the filling of previously dry wetlands can be a trigger for the breeding of waterfowl, thus the extensive ephemeral inundations of the floodplain would represent a highly significant opportunity for a major breeding event (Crome 1986).

Floodouts immediately adjacent to major channels and lakes are inundated more regularly than the peripheral areas of the floodplain and this is reflected in the vegetation found in these areas. Depending on the soil type and local relief, the vegetation ranges from extensive floodouts of *Sporobolus mitchelli* grassland or mixed herbs and forbs, to less regularly inundated *Halosarcia indica* shrublands, to the least inundated ephemeral zone at the periphery of the floodplain.

1.5.5 Rivers and Creek Channels

The channel system within the Kanowana Wetlands is dominated by the Main Channel of Cooper Creek, the Kanowana Channel (an anabranch of the Main Channel), and the Northern Overflow complex via the Hamilton Creek from the Coongie Lakes system (Figure 1 and Appendix F). The Main Channel apparently flows more regularly than the Northern Overflow, which is inundated after the Coongie lakes system has been flooded. However, flow patterns in such a hydrologically subtle landscape are complex and require further research for clarification.

This system of channels supplies water and distributes nutrients; driving the biological productivity of the wetland system. According to the nature of each flood event, the channels irrigate adjacent floodplains and associated wetlands to varying degrees. Associated with the channels are distributaries feeding the terminally draining lakes and floodouts in the surrounding dunefield (Appendix F).

Continuous channels are clearly defined by a *Eucalyptus microtheca* woodland with associated trees and shrubs, indicative of the increased moisture regime related to more regular or sustained inundation. However, the Northern Overflow, whilst preserving a clearly defined channel and associated woodland along Hamilton Creek, gradually loses definition, broadening to create a vast extended floodout system; a mosaic of vegetation types, according to soil and local relief.

The Main Channel is mostly confined between sandy loam banks with a fringing woodland of *E. microtheca*. In places the Channel becomes discontinuous, creating either a braided (anastomosing) system of swampy conditions, usually dominated by *M. cunninghamii* shrubland, or broadens and shallows to a vast floodout of *S. mitchelli* grassland or a meadow of herbs and forbs, before reconsolidating downstream into a clearly defined channel.

In the south west of the Study Area, both the Kanowana and Main Channels lose definition and resemble an elongated *E. microtheca* woodland floodout with a dense *M. cunninghamii* understorey confined by adjacent dunefields.

For the most part, the channels are intermittent. When flooded they flush and fill the major semi-permanent waterholes en route, creating a network of refuges during drier conditions.

1.6 History

1.6.1 Aboriginal Occupation

Cooper Creek was the lifeblood of a rich and complex Aboriginal culture. Aboriginal presence along the lower Cooper has been established as dating from the late Pleistocene, or approximately 12 000 BP (Veth et al. 1990). Along the length of this desert river system the presence of water and the concomitant high biological productivity of the associated floodplain sustained a significant Aboriginal population.

Four language groups were present within the Study Area: Ngamini, Yawarawarrka, Diyari, and Yandruwantha (Figure 5). However, the apparent certainty of the boundaries depicted in Figure 5 is a cartographic construct providing a general model of group distribution. The actual situation was more culturally and spatially flexible resulting from a complexity of social and cultural links between groups (Kimber 1981, Jacobs 1986, Hercus 1990).

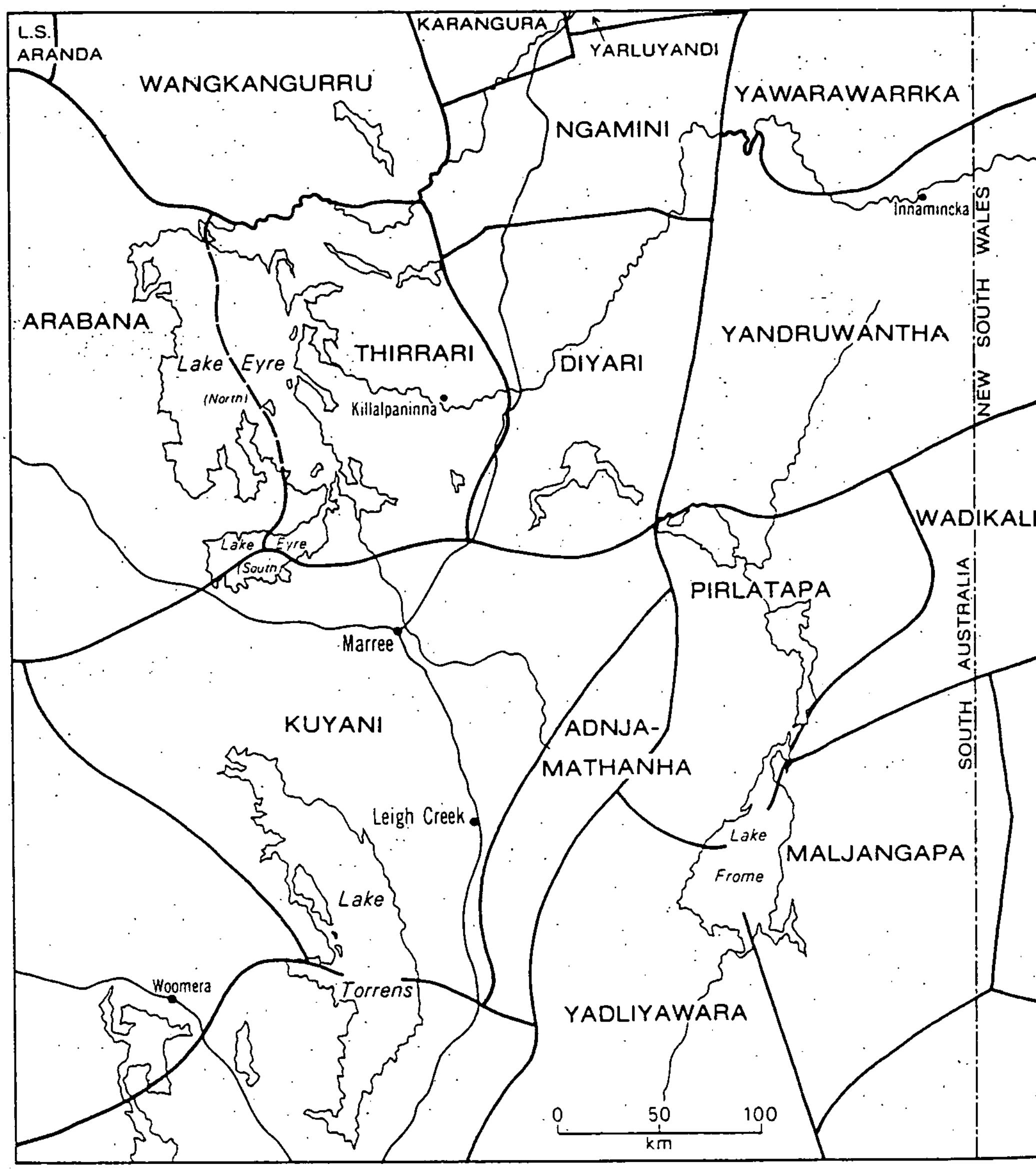


FIGURE 5: TRIBAL BOUNDARIES IN THE NORTH EAST DESERT REGION
(Source: Hercus 1985)

An example is provided by Reuther, a Lutheran missionary in the region, who observed that:

> "tribes come to each other's assistance. The tribal boundary may not be crossed over without permission. But if conditions become dry within one tribal area it is customary to offer one's tribal neighbours a section of country for hunting or a lake on which to fish. Since the Salt Creek is flooded oftener than the Cooper, the [neighbours] ie the Wongkgurus often invite [the Diyaris] to visit them" (Reuther in Kimber 1981).

Reciprocal obligations also apparently existed during times of seasonal abundance to avoid wasting surplus (Kimber 1981).

The people of the Cooper were inextricably entwined within the dynamic ebb and flow of biological conditions induced by flooding events. After floods, groups dispersed to peripheral lakes and floodplain areas inundated by main channels. There they exploited the explosion of life which follows the influx of nutrient-rich floodwaters. McKinlay (1862) must have viewed the Kanowana Study Area following such an event, for he continually encountered groups camped in lakes, particularly in the Ngamini and Yawarawarrka territories: "Go where you will, you will find them in groups of fifty and hundreds, and often many more ..." (McKinley 1862 p 36). He was most impressed with the appearance of the people, stating that they were: "Upon the whole about the finest race I have seen in the colonies" (ibid p34).

Davis, a member of McKinlay's group, was also suitably impressed with the obvious biological productivity that sustained such a population, stating that "they seem to revel in plenty of food with nets of their own fabrication they dragged the creeks for fish, procuring large quantities" (Davis 1863).

Nets were also used to catch waterfowl, supplementing the abundant catches of callop and bony bream. Seasonal surplus was not wasted, and various means were adopted to preserve and store foodstuffs (Kimber 1981, Hercus 1989). Favourable seasons also enabled the gathering of large groups from various language groups at particular locations to fulfil ritual obligations or to trade.

As the Cooper was a fairly reliable source of water it was part of one of the major Aboriginal trading routes across Australia. Kopperamanna, on the lower Cooper, was one of the great trading centres with large groups gathering to exchange items such as pitcherie from the north, ochre and sandstone slabs (for grinding stones) from the south, and softwood shields, axeheads and boomerangs from the north east (Tolcher 1986).

Following inundation, the productive grey clay soils of the floodplains yielded a wide range of plant material including edible seeds, tubers, fruit, and other vegetable matter used for a great variety of purposes (Johnston & Cleland 1943). Further afield, the dunefield system of the Strzelecki Desert extended the range of plant and animal foods after suitable local rains filled interdune claypans, enabling foraging sorties from the permanent waters of the Cooper.

Following the eventual subsidence of the waters and the resources of the peripheral lakes and floodplain, groups would retreat to reliable waterholes. At particular waterholes, semipermanent "villages" were encountered by early European explorers, comprising substantial huts of timber and mud structure that were: "wind and rain proof, and often large enough to hold several people. Large numbers of the huts are sometimes met with near the permanent waters" (Howitt 1878, p302). Apparently these structures were built for winter habitation. Their construction was a specialised activity with good builders being in great demand and borrowed from camp to camp (Horne & Aiston 1924).

Gason, a police officer stationed in the Diyari territory for nine years, made an estimate of the population of the area:

> "The Dieyerie [Diyari] tribe numbers about 230, the four neighbouring tribes the Yandrawontha [Yandruwantha], Yarrawaurka [Yawarawarrka], Auminie [Ngamini] and Wongkaooroo [Wangkangurru] about 800 ... in all about 1030" (Gason 1879, p257).

However, Gason also indicates that the population may have previously been significantly higher, providing evidence of an epidemic that the Diyari referred to as "mooramoora". Gason states this disease was:

> "unquestionably small-pox to which the natives were subject evidently before coming into contact with Europeans, as many old men and women are pockmarked in the face and body. They state that a great number have been carried off by this disease and I have been shown on the top of a sandhill, seventy four graves which are said to be those of men women and children carried off by this fell disorder" (Gason 1879 p293).

To both the explorer and pastoralist and to the detriment of the original population, the Cooper system, with its water and biological abundance, represented the key to the northern exploration route and the economic development of the region. Close on the heels of pastoral occupation came a police presence and the establishment of Lutheran missions. The combined effect of European contact decimated the population. Epidemics of influenza swept through in the summer of 1891-92, and during World War I.

Pastoral usurpation of tribal land lead to conflict and displacement. Several massacres are said to have taken place in the region (Hercus 1990). Hercus (ibid) describes a massacre of people from several tribal groups at Cooncherie (Koonchera) waterhole on the western edge of Yawarawarrka territory, when almost an entire group of men, women and children who had gathered to enact the Mindiri emu ritual were shot to avenge the theft of a young bullock.

Of the four language groups found in the Study Area, the Ngamini and Yandruwantha languages have become extinct, Yawarawarrka virtually so, and only two speakers of Diyari remain (Hercus 1990). Today, the area is bereft of its traditional peoples, and the few descendants have contracted to regional centres such as Birdsville, Quilpie, Port Augusta and Maree.

1.6.2 Pastoral Occupation

The area within the Kanowana Block was initially taken up for pastoral use during the period of 1874-80. A major station was established at Perricherrie Waterhole (Parachirrinna) and later at Kanowana (Round Waterhole). By the late 1800s virtually the entire region of the north east of the State was under pastoral occupation. This period also saw the development, through the amalgamation of the original numerous small pastoral leases, of large blocks that were capable of surviving the economic and seasonal changes associated with the region.

In 1914 Kanowana was sold to Clifton Hills Station and in 1930 the Block was amalgamated with Clifton Hills who still hold the lease. A record of the Kanowana Lease along with notes on early stocking records is provided by Tolcher (1986). Vickery's (1986) description of pastoral development on Innamincka provides background on the grazing use of the Cooper Creek and surrounding environs in South Australia.

Essentially, the history of livestock use for the region followed a pattern of rapid settlement accompanied by large increases in stock numbers (both sheep and cattle) only to be followed by major declines due to a combination of seasonal fluctuations and degradation of the resource base. As an example typical for the district, Tolcher (1986) reported that "on Kanowana the cattle population had fallen from 20 000 head in 1896 to between 5-6000 in 1898, and in 1903 only 1600 head remained".

It is interesting to note that in 1885 a surveyor described Kanowana as

> "beautifully grassed country, the grass in some instances being as high the camels. The party saw several fine waterholes almost black with duck, and shallow lakes where pelicans floated on the glassy surface. Kanowana was then carrying 6600 cattle" (Tolcher 1986).

This pattern of land use where livestock numbers were largely unregulated except by seasons and carrying capacity has slowly changed and in recent years the region has been fenced and livestock use, now by cattle, is subject to more control. Corresponding with the development of fencing, most of the feral horses were removed from the district and the area no longer supports large numbers of these animals.

The Kanowana Block was managed for years from the station located at Round Waterhole but following World War II this site was abandoned and grazing use of the Block declined. For decades the area only supported a few hundred cattle. However, following the most recent flood events, the Block was used for cattle agistment by several operators. As permanent water developments are currently lacking for much of Kanowana, the Cooper floodout is only useable for livestock grazing on an opportunistic basis following flood events.

1.6.3 Oil and Gas Production

The Cooper Basin over the past several decades has become the largest onshore hydrocarbon production province in Australia. The Basin contains significant amounts of oil and gas resources and is also known to contain large coal deposits and has future potential as a source of geothermal energy. Currently the Cooper Basin is a major supplier of energy resources both on a State and National level (DME 1986).

The Kanowana Block is located within the Cooper Basin oil and gas fields and the area has proven to be prospective for hydrocarbon production. To date, exploration activities have resulted in some 5000km of seismic and 12 wells - not in production - on the Block. Environmental management of oil and gas exploration and production is through the Petroleum Act and via the use of Codes of Practice and an audit system for exploration activities. This management approach has been developed jointly in South Australia between the Department of Mines and Energy, the Department of Environment and Land Management and the commercial producers and applies to all lands in the district subject to hydrocarbon development including activities on the adjoining Innamincka Regional Reserve.

Details on petroleum exploration and development methods along with a history of exploration and production, known reserves, future energy potential and environmental protection procedures have been summarised for the Innamincka area in a report by the Department of Mines and Energy, South Australia (DME 1986).

1.7 Previous Botanical Work

Previous botanical work relating to the Kanowana Wetland Study Area has been of an incidental nature. The first botanical forays that happened to transect the area were really subordinate to the main intentions of early European exploration. These expeditions combined the advancement of geographical knowledge and an evaluation of natural resources with a view to their possible exploitation.

The first botanical collections within the Study Area were made during Charles Sturt's explorations in 1844-46, and were subsequently examined by plant taxonomist Robert Brown (1849). Sturt also made cursory reference to the nature of vegetation and landforms which he encountered. To the east of the Study Area, A.C. Gregory, searching for the missing explorer Leichardt, followed Cooper Creek into South Australia, collecting specimens en route. These specimens were later reported on by Mueller (Black 1917).

The tragic litany of explorers in pursuit of fellow disorientated explorers was continued by A.W. Howitt in search of Bourke and Wills, both of whom died on the Cooper in 1861 after traversing the Kanowana Wetlands area following the advance and withdrawal phases of their transcontinental expedition. Howitt, like Gregory, also returned with a plant collection made during the relief expedition. Howitt's botanical collectors were Drs. Wheeler and Murray, whose specimens were also reported on by Mueller (Black 1917).

John McKinlay, also in search of Bourke and Wills, spent an extended period of time within the Kanowana Wetlands area during 1861. His journal (McKinlay 1862), provides an illuminating account of the floodplain system, with reference to recent flood events and subsequent vegetation responses. Upon his arrival and encampment at Lake Coogiecooginna (written Cudye-Cudyena in his journal) he elatedly describes the scene as being "quite a treat, abundance of good water and any quantity of grass of various kinds and plenty of clover" (ibid p8). His journal thereinafter, in descriptions of lakes and floodplains, abounds with such phrases as "plenty of clover and grasses", "plenty of luxuriant feed" and in more detail "a large flooded flat, recently under water with a great abundance of clover and grasses reaching as far as the eye can trace" (ibid p15).

McKinlay also clearly reveals the differences and contrasts he found within this system. His accounts range from the luxuriance of grassy flats and clover covered lake beds to contrasting samphire encircled salt lakes and desiccated dunefields which had not "had any rain for many months; the grasses and herbage generally on the hilly ground being like tinder" (ibid p15). There is no doubt that McKinlay was impressed with this land of stark contrasts, and with the significance of this floodplain system, arriving at the conclusion that "many lakes and creeks in this part are permanent" (ibid p15).

Stimulated by McKinlay's glowing reports, pastoralists were soon attracted to the area. As a consequence of this activity, the surveyor J.W. Lewis, was directed by the South Australian Government to examine the Cooper System as part of a wider brief to explore the Lake Eyre region during 1874-75. The naturalist on this expedition, F.W. Andrews, according to Lewis' report (Lewis 1875) only collected grasses during the survey. An examination of the appendix to the report reveals an extensive list of mammals, birds and reptiles encountered, but no reference to botanical specimens.

Following this period of exploration and cursory botanical collections, Tate (1889) compiled a synthesis of collections for the Lake Eyre Basin. A more deliberate examination of vegetation was ancillary to the biological survey of the South Australian Museum which traversed sections of the Study Area during a 1916 expedition (SAM 1917). Once again the emphasis was on plant collection, identification and subsequent listing, a task completed by Black (1917) who also provided brief descriptive notes on life forms and habitats of some of the listed species.

Following these early collections, as Lange & Fatchen (1990) indicate in their detailed summary of botanical literature for the broader north east region, there was a shift in emphasis in botanical research. The emphasis changed from the earlier purely taxonomic approach to broader ecological concepts combining taxonomy with the identification of plant communities and their relationships with their physical environments.

Investigations of this form produced some excellent subjective interpretations in defining plant associations whether at the broader regional level, or more locally examining aspects of the Cooper Creek system. Regional studies providing incidental insights into the vegetation of the Cooper floodplain include the vegetation maps and vegetation association descriptions of Specht (1972), the South Australian Pastoral Board (1973), Lewis (1982) and the land systems approach adopted by Laut et al. (1977). Local studies relating to parts of the Cooper system include the work of the Environmental Research and Planning Group (1980) and Social and Ecological Assessment (1982).

During the last decade, 1982-1992, there has been a gradual focussing in on the floodplain system, with accounts from Mollenmans et al. (1984) and the Lands Assessment Branch (LAB) of the South Australian Department of Lands (1986).

Using and expanding the lands system approach of the LAB, a mapping program, jointly funded by the South Australian Department of Environment and Planning, the South Australian Department of Mines and Energy, and SANTOS Pty Ltd, later progressed to the detail of land units within the floodplain, defining and describing terrain and vegetation land units (DEP 1988). These units were used to produce a land unit map of the Coongie Lakes area for the purpose of delineating a conservation zone within the recently proclaimed Innamincka Regional Reserve.

The Coongie Lakes Biological Study (Reid & Gillen 1988), of which a botanical survey was a component, marked a shift from the subjective classification of plant communities to the use of multivariate analytical techniques. From this pattern analysis 16 floodplain and 11 dunefield plant or vegetation associations were defined (Gillen & Reid 1988).

2 METHODOLOGY

2.1 Vegetation Survey

2.1.1 Introduction

The 1990 Montreux Conference of Ramsar determined that in designating Wetlands of International Importance, contracting parties should provide a description and map of the designated wetland area. The aim of the Kanowana Wetlands Study was to achieve this objective by determining the extent and nature of the floodplain system within the proposed study area, and the vegetation associations to be found within this system. These intentions dictated the methodology adopted for determining an appropriate vegetation sampling strategy, subsequent analysis and mapping.

2.1.2 Survey Periods

The project was initiated in 1991 and the first field trip undertaken during April-May of that year. As a result of extensive flooding of the Study Area during three consecutive years of inundation, access to most of the floodplain was severely restricted. Consequently, only 18 sites were sampled during this period and 15 land units identified (Appendix G).

The project recommenced in 1992 when floodwaters had subsided to a level that enabled wider access. This new period of work was accompanied by a change in consultant and a subsequent shift in approach to the study. Previously the study had been restricted to that area of the designated wetlands within the Kanowana Pastoral Block (Figure 1). It was decided that as the Coongie Lakes System had, some years previously, been subject to an intensive biological survey (Reid & Gillen 1988) and land unit mapping (DEP 1988), the current study area should be juxtaposed with the previous area of work. Consequently the Study Area was increased to include wetlands of the Christmas Creek mapsheet (1:100 000) immediately north of the Kanowana mapsheet (1:100 000) and contiguous with the Coongie Lakes system (Figure 1).

Three phases of field work were required to adequately survey the wider geographical area. The first phase, during April 1992, combined a reconnaissance with sampling, aiming to locate sites sparsely across the whole of the Study Area. This wide geographical scattering of sites provided an overview of the vegetation and floodplain characteristics, and assisted the determination of vehicular access.

Along with existing pastoral station tracks and mining rig roads, seismic tracks in the area were identified as potential access routes. The network of seismic tracks provided a series of transects across the floodplain vegetation, and junctions of these lines created readily relocatable points for the establishment of sites for monitoring vegetation changes over time, and the vegetative recovery of seismic tracks. During this first phase of field work 60 sites were surveyed.

The second phase, in May 1992, concentrated in the south west of the Study Area, and resulted in 72 sites being located and surveyed.

The final phase, during July-August 1992, was intended as a period of clarification. The density of sites was increased across the whole of the study area to provide additional data and thus a clearer analysis to help clarify the vegetation associations of the floodplain system. In addition, areas that had not been surveyed during the preceding phases, particularly peripheral lakes and internally draining areas running into the surrounding dunefield, were identified and sampled. A total of 41 sites were surveyed during this period.

2.1.3 Design and Strategy

A systematic approach to biological field work has been established in South Australia by the Survey and Research Section of the South Australia National Parks and Wildlife Service (Robinson et al. 1991). The methodology has evolved over several regional flora and vertebrate fauna surveys. Relevant aspects of this methodology were adopted for the Kanowana Wetlands Study to enable the collection of data in a manner consistent with established standards and to provide the groundwork for a possible future faunal survey of the floodplain system.

A site-based survey system was adopted; identifying a minimum data set that would enable the analysis, subsequent identification and mapping of vegetation associations as efficiently as possible, within a limited timeframe. A stratified approach to site selection was used; aimed at deliberately locating sites in identified homogeneous stands of vegetation, and avoiding ecotones, edge effects and local gradients in relief. This explanation is somewhat of a simplification, for in some instances the floodplain vegetation communities represent a continuum or subtle grading of one type into another, rather than exhibiting discrete boundaries.

Each site established and surveyed consisted of a 100m x 100m quadrat, consistent with arid land surveys by SANPWS. All sites were photographed (depicting site vegetation and landform), and located by marking the relevant aerial photograph with a pin-prick. Coordinates (latitudes and longitudes) were determined in the field using a Global Positioning System (GPS). Physical features and soil texture were recorded, and voucher specimens of all plant species encountered were collected and lodged with the South Australian State Herbarium for positive identification. The occurrence of all plant species within each quadrat was recorded along with details of life forms, relative abundance, and life cycle stage. The relative abundance was estimated using an adapted form of Braun-Blanquet semi-quantitative measure. Additionally, a more quantitative measure for overall cover was determined using a step-point approach for herb, grass or forbland, and a belt transect (with a two metre ranging rod) for woodland and shrubland.

2.1.4 Analysis

The main aim in analysing the floristic data was to use an objective repeatable procedure that would reveal the range of floristic patterns extant on the floodplain of the study area. Pattern analysis broadly refers to the use of numerical techniques to facilitate the investigation and manipulation of a large data set. This process provides an insight into the range of floristic associations and possible environmental variables influencing their composition and distribution. The PATN software package compiled by CSIRO (Belbin 1987), is used by the SANPWS for analysis of data from regional surveys and was used to analyse the floristic data of the Kanowana Wetlands Study.

Based on previous experience in the determination of floristic associations in the nearby Coongie Lakes District (Gillen and Reid 1988), a series of stages were identified for the analysis of the Kanowana Wetlands data. During the first stage of the analysis, all annual species were masked from the data, placing the emphasis on perennial and biennial species in describing floristic associations (species used for the analysis are identified in Appendix H).

Biennials were retained principally to enable an insight into the vegetative response associated with inundation of many of the lakes in the area that would otherwise be bare of vegetative cover in drier conditions. This initial analysis, based purely on the incidence of species, inadequately represented the situation observed in the field.

The next stage of the analysis was performed using both incidence of species, and their associated abundance values. The resulting clustering of sites based on the similarity of their species composition and abundance, far more adequately reflected field experience. Further clarification was provided by the masking of plant species that occurred only once during the survey, and removal of five sites that exerted a distorting influence on the outcome of the analysis.

From the association matrix of similarity measures resulting from the analysis, a dendrogram was generated (Appendix I), revealing the variety of floristic associations to be encountered at any chosen level of similarity. Following the selection of floristic associations/groups that made most sense from field experience, the centroids of each of the groups were ordinated to help reveal possible environmental influences determining their geographical range and distribution, and relationships to other groups (Appendix I).

2.1.5 Mapping

The mapping aspect of the study involved two main components. These comprised the delineation of the floodplain system, and the subsequent overlaying of vegetation units upon this system.

The first component, extent of floodplain, was simply based on the outer limits of land subject to inundation as revealed on relevant topographic maps. Inspection of satellite imagery depicting flood events, and aerial photography provided support for the location of this boundary. Using the Coongie, Kanowana and Christmas Creek mapsheets of the 1:100 000 topographic series (South Australia Department of Lands 1987) the boundary was digitised using the ARCINFO GIS (Geographic Information System) software package. Other geomorphological details, such as channels, creeks, drainage lines and lakes, as well as station tracks, mining rig roads and oil and gas wells, were also digitised.

The second component of mapping, the depiction of floodplain vegetation associations, involved several stages. Each of the topographic sheets (1:100 000) were photographically enlarged and reproduced on transparent film by the Department of Lands to match the scale of relevant aerial photographs for these sheets (1:50 000 Coongie and Christmas Creek and 1:40 000 for the Kanowana sheets). Overlapping aerial photography with these transparent sheets, allowed direct transcription of photo-interpreted boundaries. This technique was also used to locate and copy all sites pin-pricked on aerial photography directly unto the transparent sheet from which they were subsequently digitised. Concomitant with the digitising of sites was the generation of coordinates for later comparison with those determined in the field using the GPS unit.

To gain an overview of the distribution of floristic groups across the study area a map was produced replacing site codes with the floristic group to which each site had been assigned from the analysis. This map was used, in conjunction with field notes and boundaries drawn in the field onto aerial photographs, to determine and mark vegetation boundaries onto the transparent topographic sheets. Mapping units were derived from the floristic associations determined from the analysis. Whenever confidently recognisable from field experience and aerial photography, mapping units consisted of one association. However in instances where confident identification of boundaries was not possible, several associations that were known to co-exist in a particular area were combined to form a mapping complex of several floristic associations.

In addition to the 14 floristic groups used for mapping, an ephemeral vegetation unit was recognised. Whilst the map depicts one localised area of ephemeral vegetation, this is an artefact of mapping scale rather than an indication of extent. Throughout the Study Area, particularly at the periphery of the floodplain, immediately adjacent to the surrounding dunefield, is a thin zone least subject to inundation. The vegetation of this zone is largely ephemeral, dependent on local rain rather than flood events. During the survey this zone was found to be occupied principally by annual chenopods, particularly mixed *Atriplex* spp.

Finally all transcribed vegetation boundaries were directly digitised, checked, corrected or adjusted where necessary, and the final vegetation map produced.

2.2 Bird Survey

2.2.1 Introduction

The Cooper Creek wetland system in South Australia is recognised for providing habitats that support a diversity of bird life and the high productivity associated with these ephemeral wetlands is reflected by the large numbers of waterbirds that the system supports on occasions. The relationship between waterbirds, principally waterfowl, and wetlands is implicit in the designation of a Wetland of International Importance. In order to contribute to knowledge of this relationship in the Kanowana Wetlands Study Area, opportunistic observations of waterbirds were recorded as an adjunct to the main intent of vegetation classification and mapping.

The types of birds found in the area have been documented in reports by Foale (1975), Mollenmans et al. (1984), May (1986), Reid and Gillen (1988), Badman (1989) and Reid et al.(1990). Recently a major survey of waterbird numbers was undertaken on selected areas of the region by Kingsford and Porter (1992) and Holmes (1992) did a detailed survey of birds present on an area of the Kanowana floodplain during the 1991 flood event.

2.2.2 Survey Periods and Methods

Between April 1991 and August 1992 a total of five visits were made to the survey area of the Kanowana and adjoining Innamincka floodplain. Records were noted of all birds observed in the floodplain habitat and counts were taken of waterbirds present on the lakes and on several floodplain sites. Waterbird observations and counts were made using a spotting scope and binoculars.

Because of flooding, access to much of the study area was limited during 1991 with the result that most count data were obtained in 1992. Counts and observations of birds were opportunistic and not based on established sites or transects and most of the sites were not re-visited. As a result, waterbird numbers are based on estimates of birds present at a site during a single observation period and do not represent cumulative or regional counts. Bird nomenclature and taxonomy follows Blakers et al. 1984.

3 RESULTS

3.1 Vegetation

3.1.1 Floristics

A total of 328 voucher specimens were collected over the three phases of field work, and were subsequently lodged with the South Australian Herbarium. From these specimens 163 taxa were identified, 157 to species level (the remaining six to genus level), adopting the nomenclature of Flora of South Australia (Jessop & Toelken 1986). These represent 108 genera belonging to 42 families (Appendix J). Table 1 lists the four most commonly encountered families, accounting for 51% of the species collected during the survey.

Table 1 Most Common Floristic Families

	Genera	Species
Chenopodiaceae	11	30
Compositae	15	18
Leguminosae	11	17
Graminae	10	16

The predominance of these four main families in the composition of the flora is consistent with other collections made within the broader region (Boyland 1984, Purdie 1984, Gillen & Reid 1988). Of the total of 157 species, eight (5%) are naturalised species (Appendix I).

Frankenia cupularis was the only species collected during the survey included in the list of rare and threatened plants of Australia (Briggs & Leigh 1988). This species has been accorded such status because of its apparent lack of field distribution information. The species was recorded at 36 sites across the Study Area, and was revealed by pattern analysis to be sufficiently abundant to contribute to a distinctive floristic group (Appendix F3). This finding reinforces the need for continued standardised surveys in order to contribute to the clarification of the range and distribution of plant species in remote areas.

3.1.2 Analysis

The floristic pattern analysis was performed using 84 of the 157 positively identified species, and included 168 of the 173 sites surveyed.

Examination of the dendrogram generated from the analysis shows an initial division into two floristic complexes (I & II in Appendix I). Complex I, comprising Groups 1-6, contains almost all the sites located on dry lake beds or lake margins. Complex II, Groups 7-14, contains sites located along channels, associated floodouts, and the floodplain.

Cutting the dendrogram at the level shown in Appendix I resulted in 14 floristic groups which were considered intuitively to represent the range of vegetation types encountered in the field.

3.1.3 Floristic Associations

This section examines each of the floristic associations. For each Group (association) the following information is provided:

- a brief description of the group;
- a table displaying associated sites, with soil texture and landforms encountered at each site;
- a photograph depicting one of the sites, providing an indication of the structure of the vegetation, and nature of the landscape;
- a list of perennial and biennial species composition, indicating the major and minor contributing species of each floristic group, ranked according to cover/abundance values;
- frequency values of those species occurring at greater than 40% of all sites in the group; and
- a map showing the distribution of all sites in the group across the Study Area.

GROUP 1

SITE	SOIL	LANDFORM
LK1001	CLS	FLOODPLAIN
BP1001	CLS	LAKE
MA1004	HC	FLOODOUT
RO1001	HC	FLOODOUT
TL1004	HC	FLOODOUT
DE1005	HC	FLOODPLAIN
KW1002	HC	FLOODPLAIN
KW1006	HC	FLOODPLAIN
LS1003	HC	FLOODPLAIN
LW1004	HC	FLOODPLAIN
MO1004	HC	FLOODPLAIN
NF1002	HC	FLOODPLAIN
AL1001	HC	LAKE
CH1006	HC	LAKE
CL1001	HC	LAKE
DE1002	HC	LAKE
FL1001	HC	LAKE
PL1002	HC	LAKE
BL1006	MHC	FLOODPLAIN
BL1002	MHC	LAKE
KC1005	MHC	LAKE
LA1001	SCL	ALLUVIAL FAN
LT1003	SCL	FLOODPLAIN
TL1002	SCL	FLOODPLAIN

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Group 1 Floristic Association and Structural Formation Range: *Sporobolus mitchellii* (rat's-tail couch) low open to low sparse tussock grassland

Associated Perennials (at ≥ 40% of sites in group)
Forbs: *Psoralea cinerea, Cressa cretica*

Associated Annuals
Grasses: *Dactyloctenium radulans*
Forbs: *Morgania floribunda, Portulaca oleracea, Trianthema triquetra, Atriplex crassipes, A. spongiosa, Alternanthera nodiflora*

Species Richness
(indicates percentage of species included in the analysis)
30%

Incidence
(indicates percentage of sites included in the analysis)
7%

Description
Widespread throughout the floodplain system, most typically occurring as a band on the upper margins of lakes on a slight sandy veneer over heavy cracking grey clays. Also occurs as extensive monospecific grasslands in the beds of shallow peripheral lakes such as Lake Karangie on the Northern Overflow and Boggy and Andree Lakes south of the Main Channel. On some areas the *Sporobolus mitchellii* band may extend further out onto the floodplain, with a sparse overstorey of *Eucalyptus microtheca*.

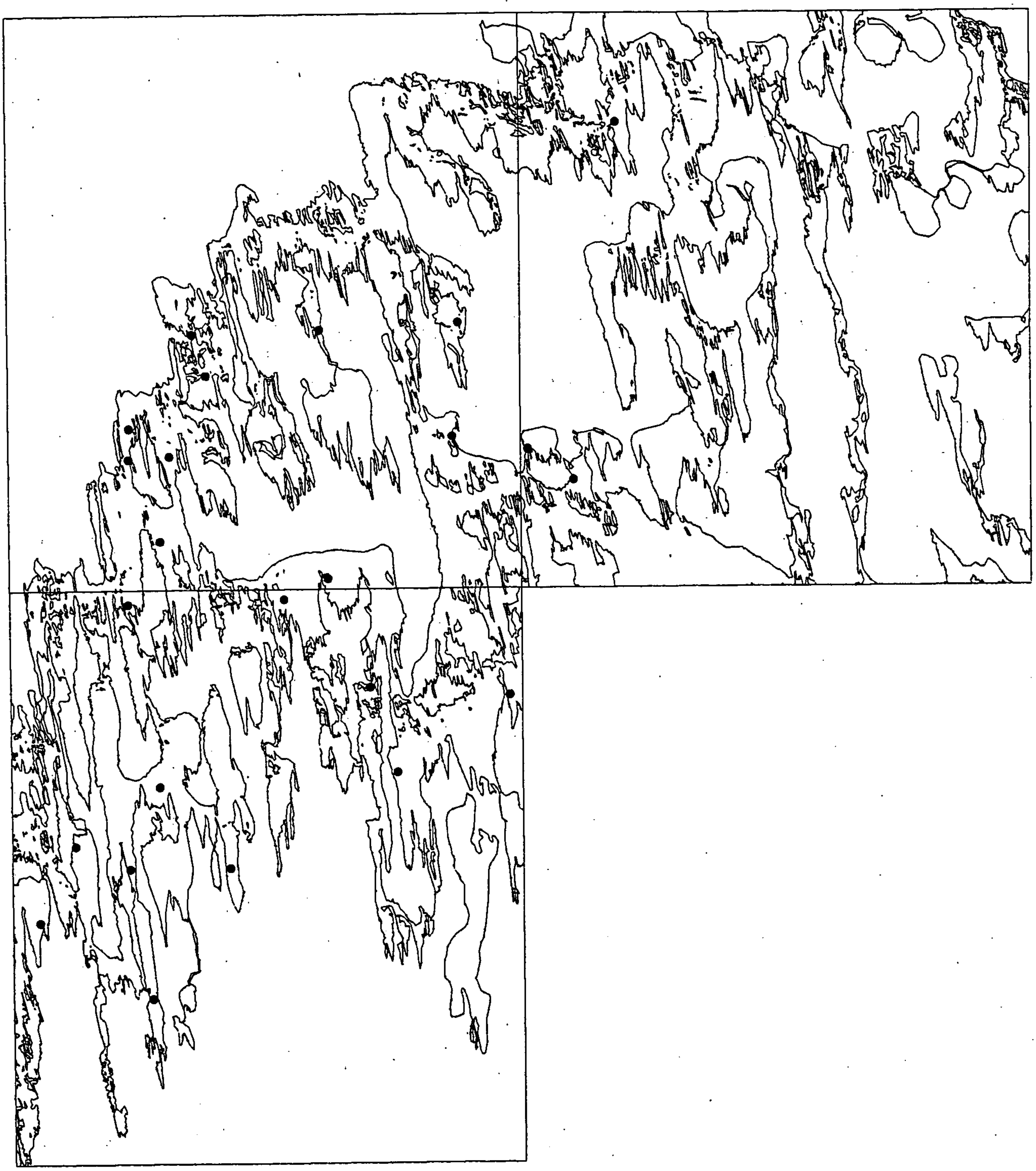
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 1 24 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Sporobolus mitchellii	3.0000	1.0000	5.8609	2.42
Cressa cretica	0.7167	0.5000	0.2869	0.54
Psoralea cinerea	0.4792	0.4583	0.1946	0.44
Euphorbia drummondii	0.2167		0.3538	0.59
Marsilea drummondii	0.1792		0.0861	-0.29
Solanum esuriale	0.1250		0.3813	0.62
Eucalyptus microtheca	0.1250		0.3033	-0.55
Muehlenbeckia cunninghamii	0.0879		0.6306	-0.79
Glinus lotoides	0.0667		0.0455	-0.21
Eragrostis dielsii var. diel	0.0458		0.0151	-0.12
Eragrostis parviflora	0.0417		0.0080	0.09
Solanum oligacanthum	0.0375		0.1315	-0.36
Morgania floribunda	0.0208		0.3329	-0.58
Halosarcia indica ssp. leios	0.0167		0.2674	-0.52
Mukia micrantha	0.0083		0.0033	-0.06
Heliotropium curassavicum	0.0083		0.0971	-0.31
Teucrium racemosum	0.0083		0.2546	-0.50
Epaltes cunninghamii	0.0083		0.2415	-0.49
Sclerolaena calcarata	0.0083		0.0039	-0.06
Verbena officinalis	0.0042		0.0625	-0.25
Senecio cunninghamii var. se	0.0042		0.1649	-0.41
Convolvulus erubescens	0.0042		0.0073	-0.09
Zaleya galericulata	0.0042		0.0003	0.02
Frankenia cupularis	0.0042		0.2027	-0.45
Sclerolaena intricata	0.0042		0.2014	-0.45

STUDY AREA

GROUP DISTRIBUTION



• GROUP 1

GROUP 2

SITE	SOIL	LANDFORM
NO1002	CLS	FLOODPLAIN
MC1003	LS	FLOODPLAIN
MO1002	S	FLOODPLAIN
LT1001	S	LAKE
MC1001	S	LAKE
MO1003	S	LAKE
NO1006	S	LAKE
OF1005	S	LAKE
ST1003	S	LAKE
LT1002	SCL	FLOODPLAIN
YL1001	SL	LAKE
NO1001	ZCL	FLOODPLAIN

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Group 2 Floristic Association and Structural Formation Range: *Sporobolus mitchellii* (rat's-tail couch)/ *Halosarcia indica* (samphire)/ *Cyperus gymnocaulus* (spiny sedge) low open mixed grass/shrub/sedgeland

Associated Perennials (at ≥ 40% of sites in group)
Shrubs: *Muehlenbeckia cunninghamii*
Subshubs: *Sclerolaena intricata, Atriplex velutinella, Solanum oligicanthum, Osteocarpum acropterum*
Forbs: *Psoralea cinerea, Cressa cretica, Heliotropium curassavicum*
Grasses: *Eragrostis dielsii*

Associated Annuals
Grasses: *Dactyloctenium radulans*
Forbs: *Morgania floribunda, Trigonella suavissima, Trianthema triquetra, Bergia ammanoides, B. trimera, Atriplex spongiosa, A. intermedia, Portulaca oleracea*

Species Richness
(indicates percentage of species included in the analysis)
48%

Incidence
(indicates percentage of sites included in the analysis)
7%

Description
Most typically occurs on pale low sandy dunes fringing the margins of minor lakes. *Halosarcia indica* indicates saline conditions which may be associated with deflation from dry lake beds which are less frequently flooded. This irregularity in flooding is also probably revealed in the absence of an overstorey of *Eucalyptus microtheca* (usually found around lakes subject to more regular inundation). Drier, more saline conditions are encountered to the north, particularly the Hamilton Creek to Northern Overflow section. Lake Talinnie provides an example of an internally draining salt lake surrounded by halophytic vegetation. Alfred Creek, a distributory from the Northern Overflow draining into Lake Strangways, is also a good example showing fringing halophytic vegetation along saline channels.

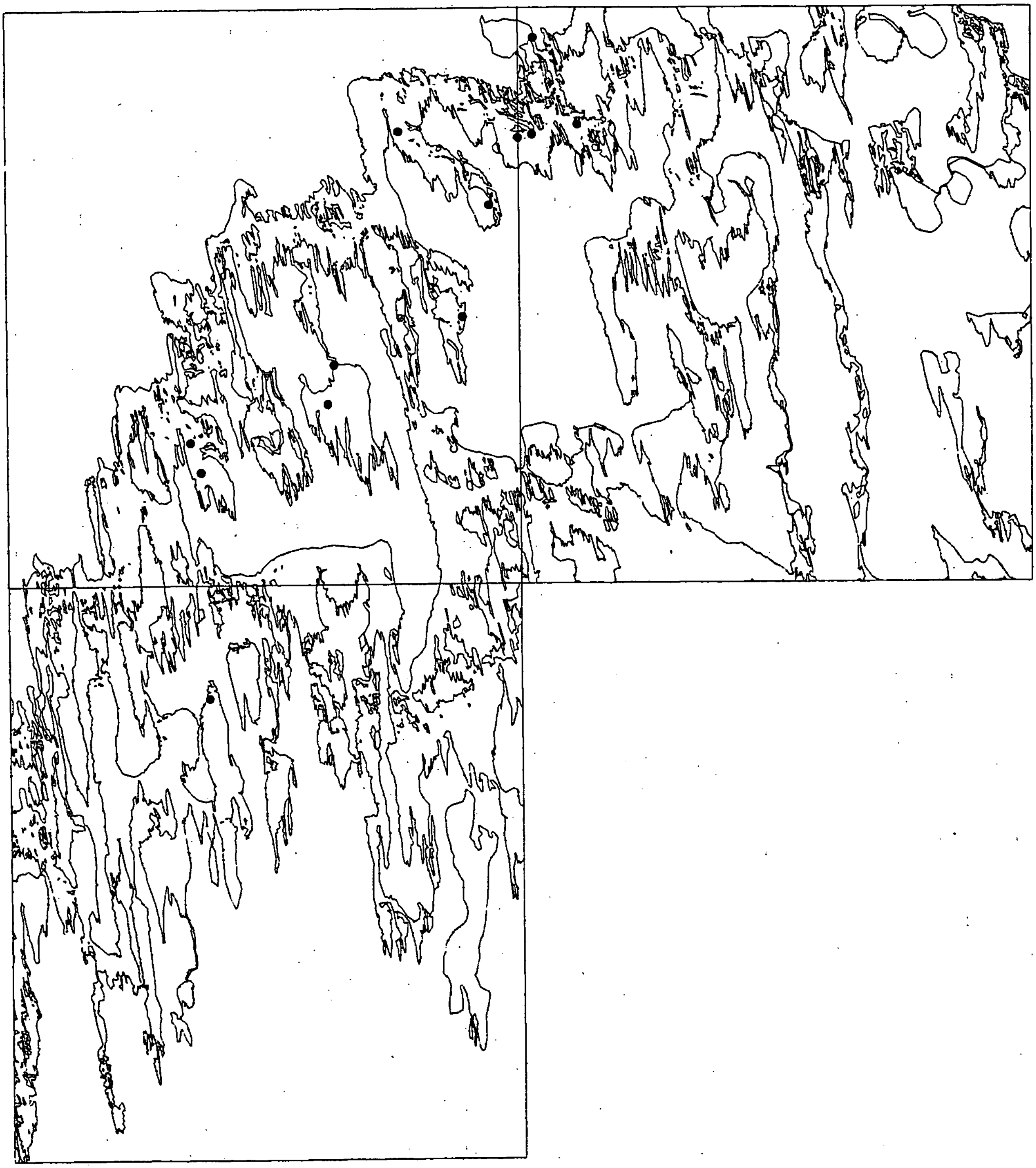
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 2 12 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Sporobolus mitchellii	2.3330	1.0000	2.8291	1.68
Halosarcia indica ssp. leios	1.1170	0.9167	2.2270	1.49
Cyperus gymnocaulos	1.0080	0.6667	4.6867	2.16
Heliotropium curassavicum	0.7583	0.7500	3.6776	1.92
Sclerolaena intricata	0.6333	0.8333	0.8558	0.93
Morgania floribunda	0.5333	0.7500	0.0685	0.26
Cressa cretica	0.4333	0.5833	0.0062	0.08
Eragrostis dielsii var. diel	0.3750	0.6667	1.0711	1.03
Atriplex velutinella	0.2833	0.5000	1.1493	1.07
Muehlenbeckia cunninghamii	0.2667	0.4167	0.3526	-0.59
Psoralea cinerea	0.2667	0.4167	0.0004	0.02
Swainsona oroboides	0.2583		2.8090	1.68
Mimulus repens	0.2500		1.9423	1.39
Lotus cruentus	0.1833		1.1348	1.07
Teucrium racemosum	0.1667		0.0401	-0.20
Eragrostis setifolia	0.1667		0.8516	0.92
Scaevola collaris	0.1667		2.0123	1.42
Solanum oligacanthum	0.1333	0.5833	0.0219	-0.15
Osteocarpum acropterum var.	0.1167	0.4167	0.1240	0.35
Atriplex limbata	0.1000		0.7860	0.89
Epaltes cunninghamii	0.0917		0.1072	-0.33
Sida ammophila	0.0917		1.1066	1.05
Eucalyptus microtheca	0.0842		0.3686	-0.61
Marsilea drummondii	0.0833		0.2066	-0.45
Verbena officinalis	0.0250		0.0295	-0.17
Minuria rigida	0.0250		0.0006	0.02
Convolvulus erubescens	0.0250		0.0077	0.09
Psoralea pallida	0.0250		0.3018	0.55
Enchylaena tomentosa var. gl	0.0250		0.0197	-0.14
Chenopodium auricomum	0.0167		0.2090	-0.46
Haloragis aspera	0.0167		0.1503	-0.39
Frankenia cupularis	0.0167		0.1790	-0.42
Eragrostis parviflora	0.0167		0.0040	-0.06
Dentella pulvinata	0.0167		0.0073	-0.09
Lawrencia glomerata	0.0083		0.0882	0.30
Wahlenbergia tumidifructa	0.0083		0.0147	-0.12
Sclerolaena bicornis	0.0083		0.0226	-0.15
Sclerolaena calcarata	0.0083		0.0039	-0.06
Sauropus trachyspermus	0.0083		0.0302	0.17
Boerhavia schomburgkiana	0.0083		0.0173	-0.13

STUDY AREA

GROUP DISTRIBUTION



• GROUP 2

GROUP 3

SITE	SOIL	LANDFORM
PL1001	CLS	LAKE
HC1001	LS	CHANNEL
AP1002	S	LAKE
BP1002	S	LAKE
CG1001	S	LAKE
LM1002	SCL	LAKE
TW1003	SL	FLOODOUT

7

Group 3 Floristic Association and Structural Formation Range: *Eucalyptus microtheca* (coolibah) low open sparse woodland

Associated Perennials (at ≥ 40% of sites in group)
Shrubs: *Muehlenbeckia cunninghamii*
Subshrubs: *Solanum oligicanthum*
Forbs: *Glinus lotiodes, Verbena officinalis, Haloragis aspera, Wahlenbergia tumidifructa, Marsilea drummondii*
Grasses: *Sporobolus mitchelli, Eragrostis dielsii*
Sedges: *Cyperus gymnocaulus*

Associated Annuals
Grasses: *Dactyloctenium radulans*
Forbs: *Trianthema triquetra, Phyllanthus lacunarius, Epaltes australis, Trigonella suavissima, Alternanthera nodiflora, Portulaca oleracea, Calotis porphyroglossa, Morgania floribunda, Bergia ammanoides, Senecio gregorii, Atriplex spongiosa, A. intermedia*

Species Richness
(indicates percentage of species included in the analysis)
44%

Incidence
(indicates percentage of sites included in the analysis)
4%

Description
Principally found on pale low sandy rises or lunettes fringing intermittent floodplain lakes which receive regular inundation. These sands, overlying heavier clays, provide suitable conditions for a mixed understorey of forbs, sedges and grasses, and occasionally a sparse layer of *Muehlenbeckia cunninghamii*. *Eucalyptus microtheca* is a useful indicator of the frequency of flooding as it is usually found in areas that are subject to more regular inundation (Jessop 1981).

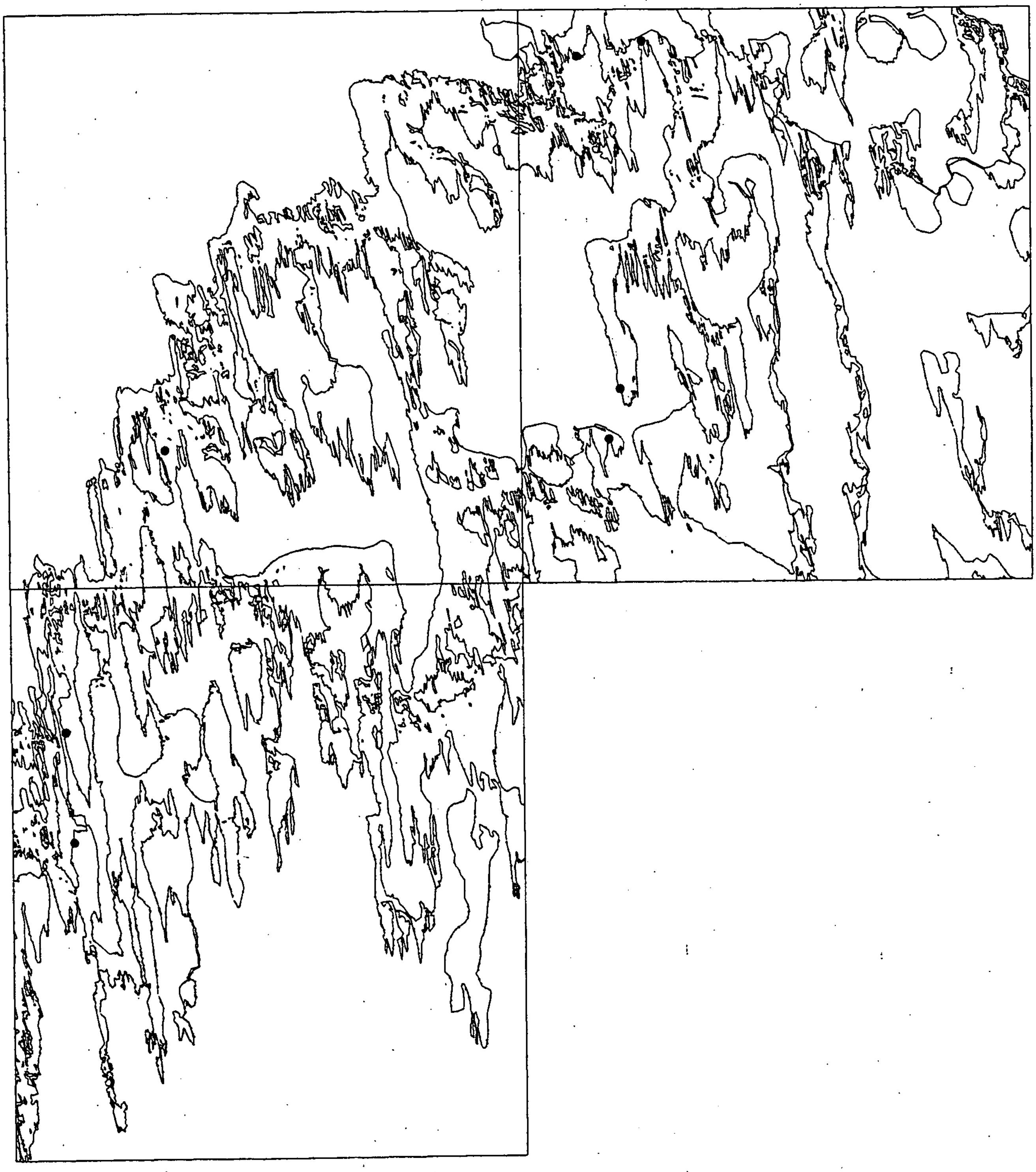
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 3 7 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Morgania floribunda	2.1430	1.0000	8.3862	2.90
Sporobolus mitchellii	1.7290	1.0000	1.0258	1.01
Eucalyptus microtheca	1.5860	1.0000	2.1570	1.47
Cyperus gymnocaulos	1.0000	0.5714	4.5991	2.14
Glinus lotoides	0.8714	1.0000	3.5016	1.87
Verbena officinalis	0.7443	0.8571	6.4288	2.54
Haloragis aspera	0.3000	0.4286	0.0763	0.28
Euphorbia drummondii	0.2857		0.7489	0.87
Eragrostis dielsii var. diel	0.1714	0.4286	0.1016	0.32
Wahlenbergia tumidifructa	0.1714	0.4286	0.7012	0.84
Marsilea drummondii	0.1714	0.4286	0.0939	-0.31
Psoralea cinerea	0.1429		0.0500	-0.22
Convolvulus erubescens	0.1429		1.1398	1.07
Eragrostis parviflora	0.1429		0.4972	0.71
Solanum oligacanthum	0.0571	0.5714	0.1016	-0.32
Muehlenbeckia cunninghamii	0.0429	0.4286	0.7133	-0.84
Cyperus exaltatus	0.0286		0.3449	0.59
Solanum esuriale	0.0286		0.0003	0.02
Senecio cunninghamii var. se	0.0286		0.1207	-0.35
Enchylaena tomentosa var. gl	0.0286		0.0158	-0.13
Teucrium racemosum	0.0143		0.2432	-0.49
Abutilon malvaefolium	0.0143		0.1654	0.41
Sida fibulifera	0.0143		0.0909	0.30
Epaltes cunninghamii	0.0143		0.2301	-0.48
Sclerolaena diacantha	0.0143		0.0000	0.00
Pterocaulon sphacelatum	0.0143		0.0842	0.29
Acacia salicina	0.0143		0.0246	-0.16
Cressa cretica	0.0143		0.3565	-0.60
Tephrosia sphaerospora	0.0143		0.1615	0.40
Sclerolaena intricata	0.0143		0.1821	-0.43
Atriplex velutinella	0.0143		0.0238	-0.15
Swainsona oroboides	0.0143		0.0017	-0.04
Osteocarpum acropterum var.	0.0143		0.0195	-0.14
Sclerolaena calcarata	0.0143		0.0003	-0.02
Lotus cruentus	0.0143		0.0031	-0.06
Acacia stenophylla	0.0143		0.0453	-0.21
Myriophyllum verrucosum	0.0143		0.1725	0.42

STUDY AREA

GROUP DISTRIBUTION

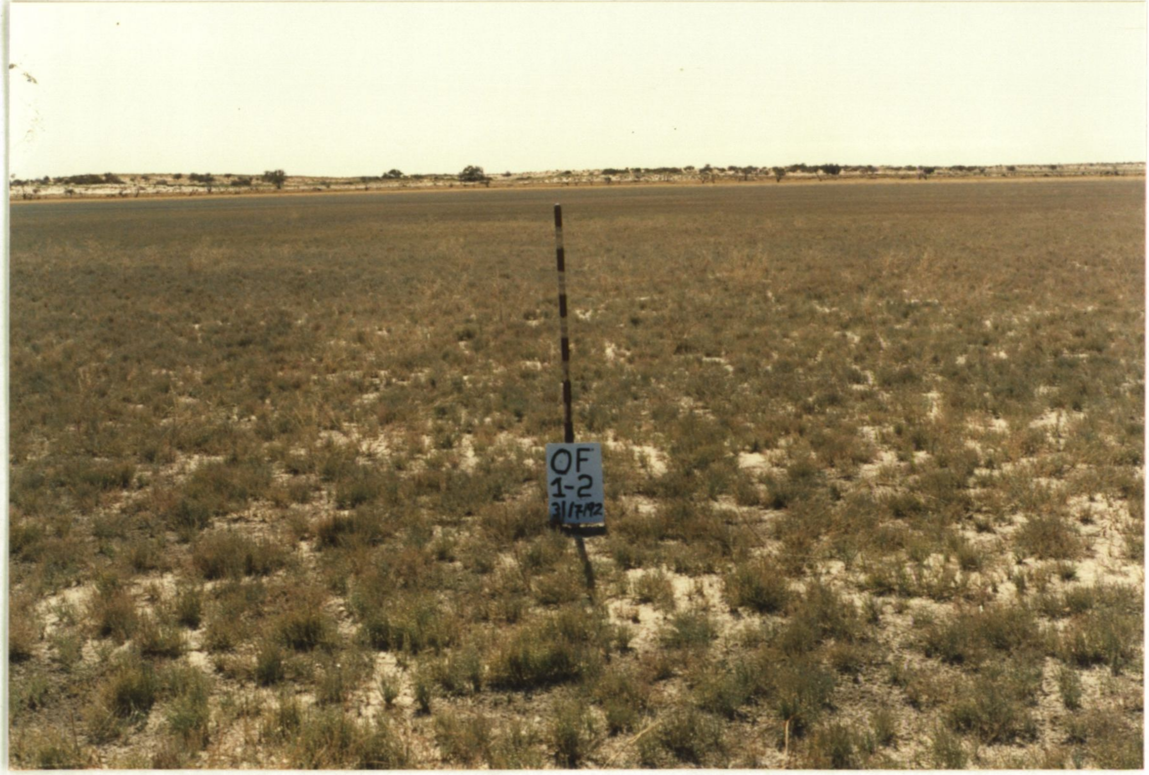


• GROUP 3

GROUP 4

SITE	SOIL	LANDFORM
LS1005	CLS	FLOODPLAIN
CO1003	HC	FLOODPLAIN
BW1001	HC	LAKE
RO1002	HC	LAKE
TL1001	HC	LAKE
YL1002	HC	LAKE
OF1002	MHC	FLOODPLAIN

7



Group 4 Floristic Association and Structural Formation Range: *Cressa cretica* (rosinweed) low open to sparse forbland

Associated Perennials (at ≥ 40% of sites in group)
-

Associated Annuals
Grasses: *Dactyloctenium radulans*
Forbs: *Trianthema triquetra, Atriplex spongiosa, Trigonella suavissma, A. intermedia, Sesbania cannabina*

Species Richness
(indicates percentage of species included in the analysis)
11%

Incidence
(indicates percentage of sites included in the analysis)
4%

Description
Most commonly encountered as monospecific assemblages of the cosmopolitan, convolvulaceous *Cressa cretica* in shallow local depressions of self-mulching grey clay at outer limits of the floodplain. Occasional stands of *Eragrostis australasica* are encountered, usually small patches in local impervious clay depressions more likely to be inundated by local rainfall events than floods. One notable exception in scale was an expanse of almost pure *E. australasica* found in the bed of an unnamed lake in the south east of the Study Area. The affinity of *C. cretica* with *E. australasica* has been observed by Specht (1972). Specht describes *E. australasica* occurring as monospecific communities in swamp centres with a zone of *C. cretica* immediately surrounding the canegrass. Both species are apparently suited to slightly saline soils. Further surveys and subsequent analysis may separate the complex into different associations.

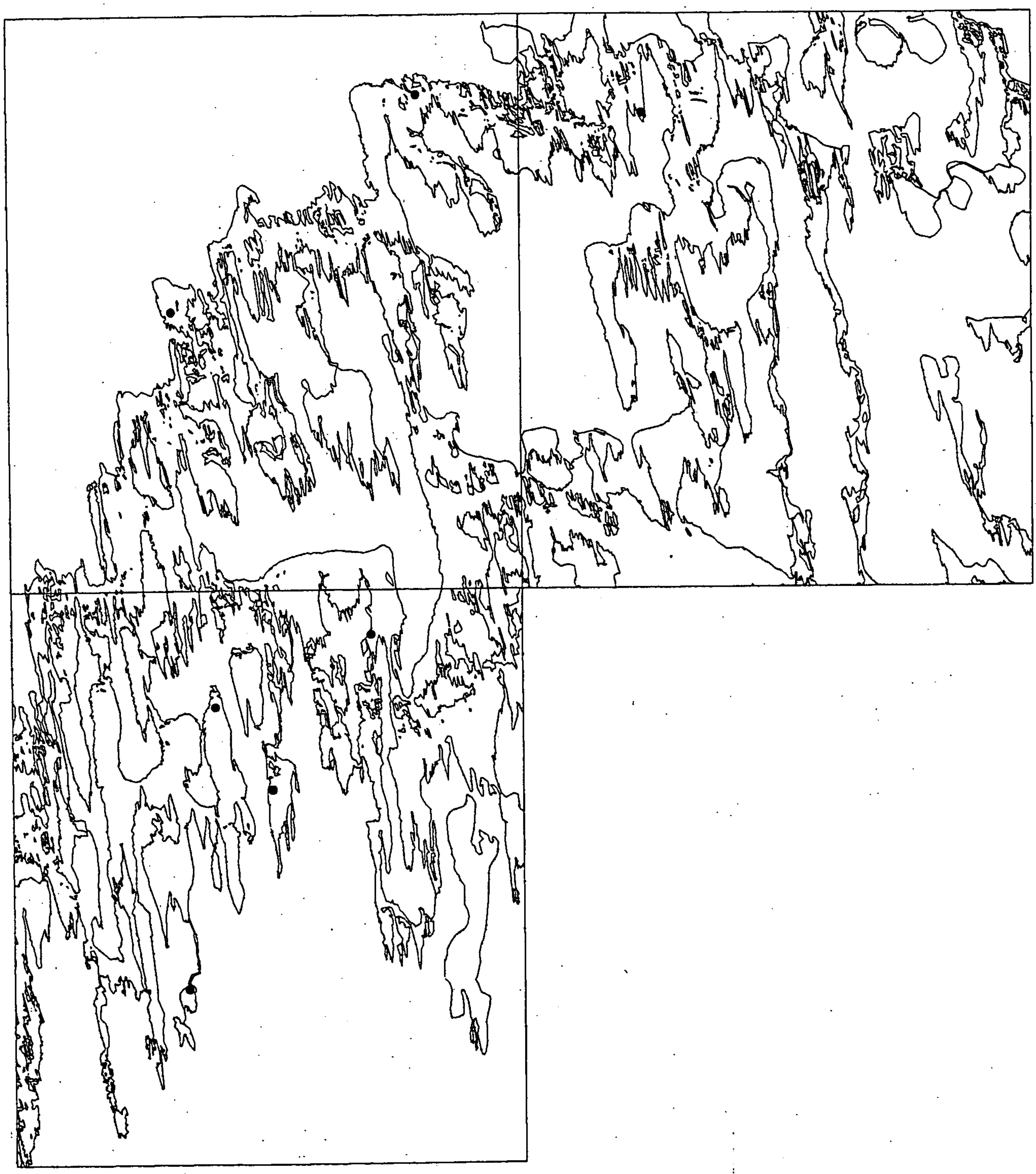
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 4 7 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Cressa cretica	2.2860	1.0000	9.4022	3.07
Eragrostis australasica	0.5714		4.8379	2.20
Sporobolus mitchellii	0.4429		0.1697	-0.41
Halosarcia indica ssp. leios	0.1429		0.0821	-0.29
Psoralea cinerea	0.1429		0.0500	-0.22
Maireana coronata	0.0143		0.0549	0.23
Marsilea drummondii	0.0143		0.3257	-0.57
Solanum oligacanthum	0.0143		0.1719	-0.41
Mukia micrantha	0.0143		0.0001	-0.01
Sclerolaena intricata	0.0143		0.1821	-0.43

STUDY AREA

GROUP DISTRIBUTION



• GROUP 4

GROUP 5

SITE	SOIL	LANDFORM
SK1001	HC	FLOODPLAIN
SK1002	HC	FLOODPLAIN
JL1001	HC	LAKE
LS1001	HC	LAKE
LW1005	HC	LAKE
MC1005	HC	LAKE
TS1002	HC	SWAMP
ML1001	MHC	LAKE
MC1004	S	LAKE
RO1003	SL	LAKE

10

Group 5 Floristic Association and Structural Formation Range: *Solanum oligicanthum* (desert nightshade) low very open to sparse shrubland

Associated Perennials (at ≥ 40% of sites in group)
Shrubs: *Halosarcia indica ssp. leiostachya*
Forbs: *Cressa cretica, Heliotropium curassivicum, Mukia micrantha*
Grasses: *Sporobolus mitchellii*

Associated Annuals
Forbs: *Atriplex spongiosa, Trianthema triquetra, Trigonella suavissima, Epaltes australis, Portulaca olearacea*
Grasses: *Panicum decompositum, Dactyloctenium radulans*

Species Richness
(indicates percentage of species included in the analysis)
30%

Incidence
(indicates percentage of sites included in the analysis)
6%

Description
Most often found on grey self-mulching clays, on lake beds of peripheral lakes. Presence of *Halosarcia indica* and *Cressa cretica* indicate saline conditions and less regular flushing by flooding events.

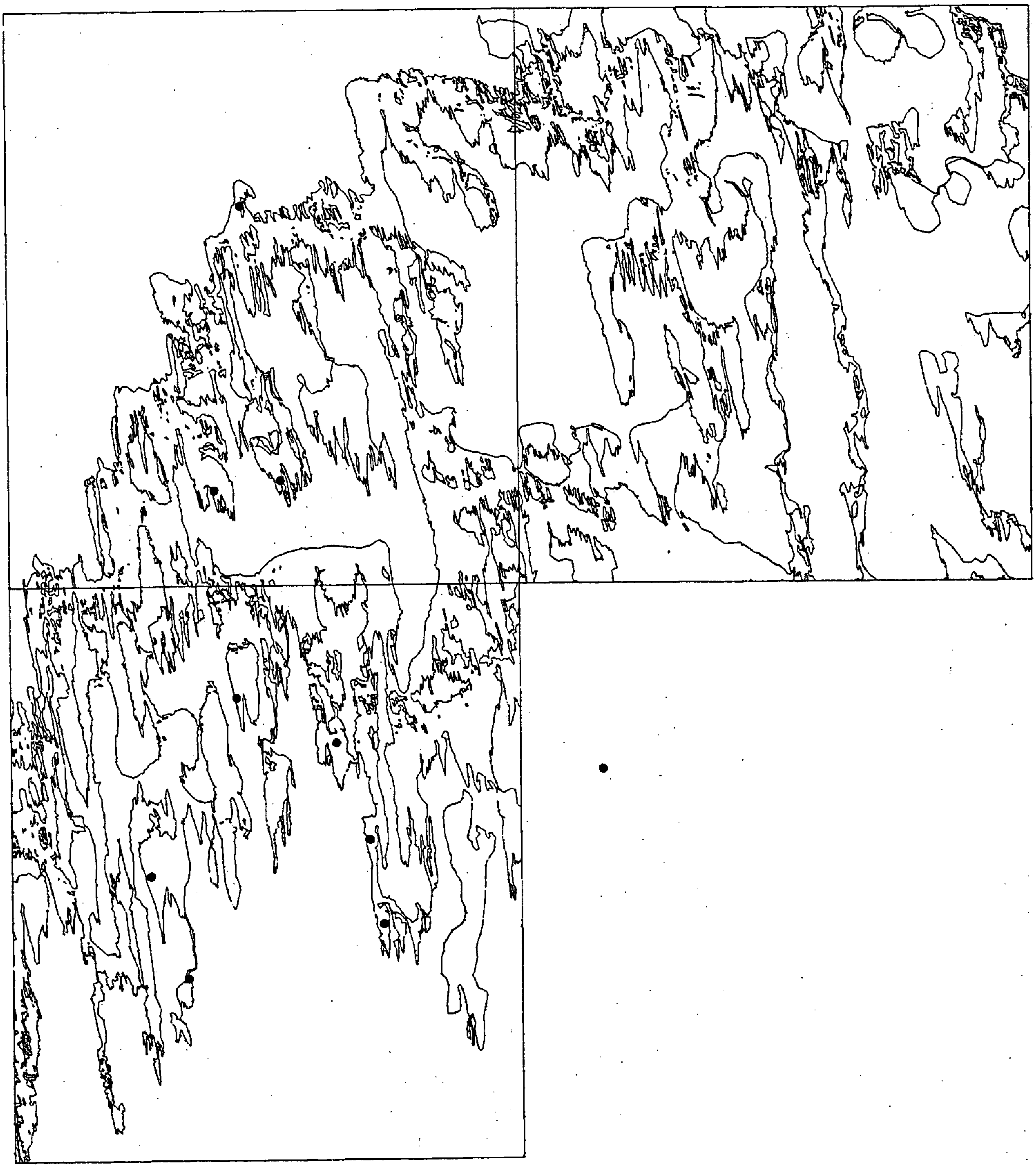
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 5 10 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Solanum oligacanthum	1.4100	1.0000	7.3464	2.71
Heliotropium curassavicum	0.7000	0.6000	3.0429	1.74
Cressa cretica	0.6000	0.5000	0.1207	0.35
Glinus lotoides	0.5100		0.8744	0.94
Halosarcia indica ssp. leios	0.4000	0.4000	0.0335	0.18
Sporobolus mitchellii	0.3600	0.8000	0.2538	-0.50
Eragrostis dielsii var. diel	0.2100		0.2066	0.45
Eragrostis australasica	0.2000		0.3811	0.62
Chenopodium nitrariaceum	0.2000		0.0191	0.14
Mukia micrantha	0.1310	0.5000	0.8665	0.93
Enchylaena tomentosa var. gl	0.1100		0.0437	0.21
Lotus cruentus	0.1100		0.3352	0.58
Mimulus repens	0.1010		0.2183	0.47
Sclerolaena intricata	0.1000		0.0574	-0.24
Atriplex velutinella	0.0200		0.0164	-0.13
Convolvulus erubescens	0.0200		0.0021	0.05
Psoralea cinerea	0.0200		0.2176	-0.47
Sida fibulifera	0.0100		0.0394	0.20
Cyperus gymnocaulos	0.0100		0.1358	-0.37
Eragrostis setifolia	0.0100		0.0081	-0.09
Muehlenbeckia cunninghamii	0.0100		0.7769	-0.88
Einadia nutans ssp. eremaea	0.0100		0.0005	0.02
Osteocarpum acropterum var.	0.0100		0.0257	-0.16
Swainsona oroboides	0.0100		0.0051	-0.07
Lawrencia glomerata	0.0010		0.0002	0.01

STUDY AREA

GROUP DISTRIBUTION



GROUP 6

SITE	SOIL	LANDFORM
PW1005	CL	FLOODPLAIN
TS1001	CLS	SWAMP
CA1001	HC	FLOODPLAIN
CH1005	HC	LAKE
LA1002	HC	LAKE
LM1001	HC	LAKE
LW1002	HC	LAKE
OF1003	HC	LAKE
YL1003	HC	LAKE
TW1001	MHC	FLOODOUT
MO1001	MHC	FLOODPLAIN
NO1003	MHC	FLOODPLAIN
TW1004	MHC	FLOODPLAIN
TW1006	MHC	LAKE
CA1004	SCL	FLOODPLAIN
KW1003	SCL	FLOODPLAIN
PW1004	SCL	FLOODPLAIN
KM1001	SL	LAKE
LA1003	SL	LAKE

19

Group 6 Floristic Association and Structural Formation Range: *Psoralea cinerea* (annual verbine) mid-height to low, open to sparse forbland

Associated Perennials (at ≥ 40% of sites in group)
Subshrubs: *Solanum oligicanthum*
Forbs: *Cressa cretica, Glinus lotiodes*
Grasses: *Sporobolus mitchellii*
(Note: *Eucalyptus microtheca* found at 36% of sites)

Associated Annuals
Trigonella sauvissima, Portulaca oleracea, Bergia trimera, Epaltes australis, Morgania floribunda

Species Richness
(indicates percentage of species included in the analysis)
40%

Incidence
(indicates percentage of sites included in the analysis)
11%

Description
Occurs widely across the study area, often on lake beds of self-mulching grey clays that have been recently inundated (6a). Also extends onto surrounding lake floodouts with a slight veneer of loamy sand over clay, and an overstorey of *Eucalyptus microtheca* (6b). A major seasonal component of this association is *Trigonella sauvissima*, heavily grazed by cattle along the Cooper.

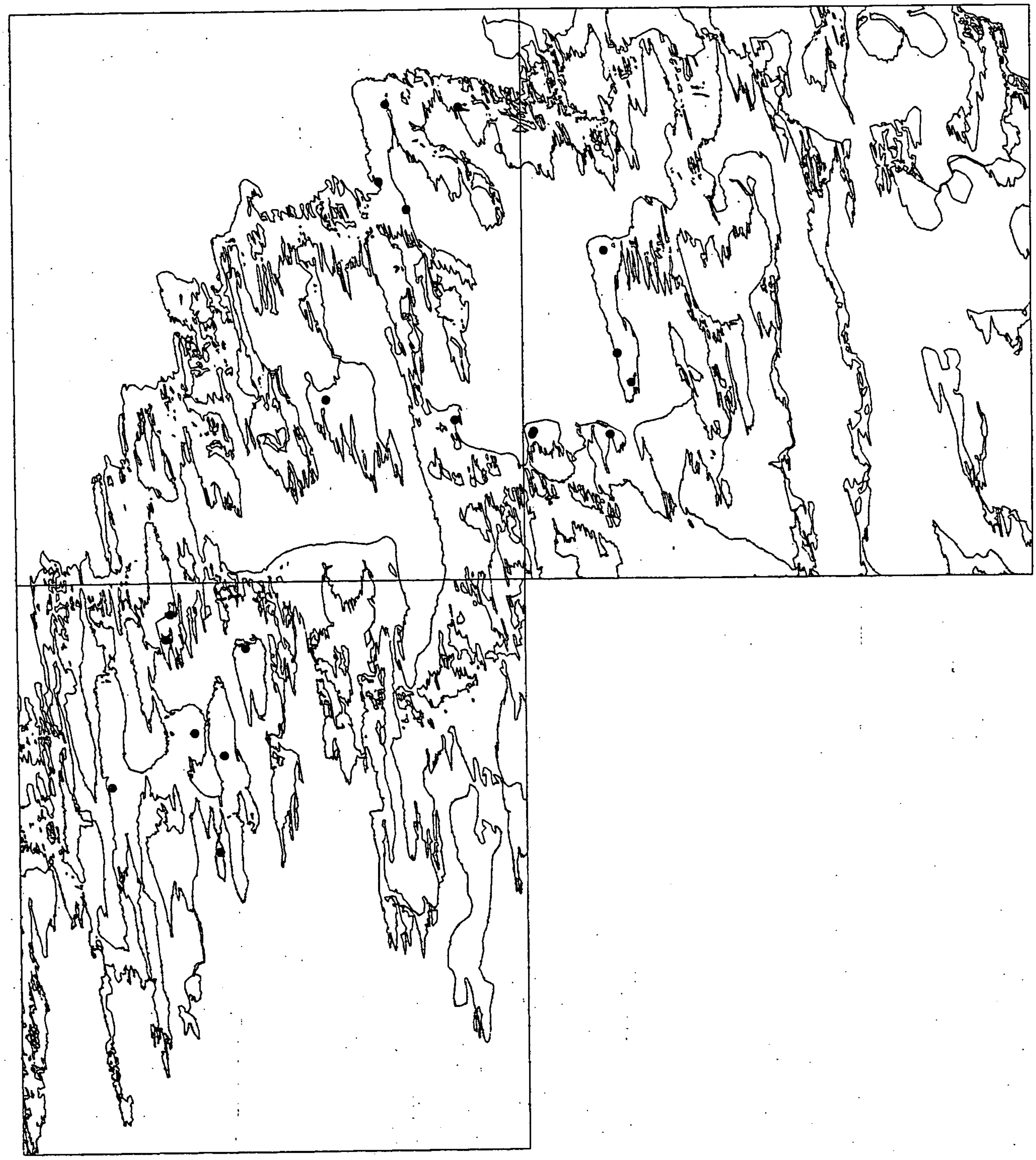
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 6 19 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Psoralea cinerea	2.3680	1.0000	17.4243	4.17
Sporobolus mitchellii	1.0790	0.9474	0.0857	0.29
Eucalyptus microtheca	0.6847		0.0497	0.22
Solanum oligacanthum	0.5526	0.5789	0.6252	0.79
Cressa cretica	0.5368	0.4211	0.0603	0.25
Glinus lotoides	0.3053	0.5789	0.1639	0.40
Morgania floribunda	0.2632		0.0325	-0.18
Solanum esuriale	0.1684		0.7880	0.89
Teucrium racemosum	0.1632		0.0429	-0.21
Euphorbia drummondii	0.1263		0.0577	0.24
Halosarcia indica ssp. leios	0.1216		0.1060	-0.33
Muehlenbeckia cunninghamii	0.1105		0.5911	-0.77
Sclerolaena intricata	0.0737		0.0882	-0.30
Heliotropium curassavicum	0.0632		0.0221	-0.15
Dentella pulvinata	0.0632		0.0307	0.18
Eragrostis parviflora	0.0579		0.0353	0.19
Zaleya galericulata	0.0163		0.0526	0.23
Sclerolaena bicornis	0.0105		0.0193	-0.14
Convolvulus erubescens	0.0105		0.0011	-0.03
Eragrostis dielsii var. diel	0.0105		0.0611	-0.25
Lotus cruentus	0.0105		0.0065	-0.08
Pluchea rubelliflora	0.0058		0.0699	0.26
Mukia micrantha	0.0053		0.0067	-0.08
Diplatia grandibractea	0.0053		0.0036	-0.06
Haloragis aspera	0.0053		0.1717	-0.41
Sauropus trachyspermus	0.0053		0.0091	0.10
Epaltes cunninghamii	0.0053		0.2475	-0.50
Wahlenbergia tumidifructa	0.0053		0.0194	-0.14
Sclerolaena calcarata	0.0053		0.0075	-0.09
Chenopodium nitrariaceum	0.0053		0.1367	-0.37
Abutilon malvaefolium	0.0005		0.0003	-0.02

STUDY AREA

GROUP DISTRIBUTION



• GROUP 6

GROUP 7

SITE	SOIL	LANDFORM
KC1002	CL	FLOODPLAIN
PW1001	CL	FLOODPLAIN
AP1003	CLS	CHANNEL
BL1005	CLS	CHANNEL
CA1002	HC	FLOODPLAIN
MW1001	HC	FLOODPLAIN
TO1003	HC	SWAMP
CA1005	LS	CHANNEL
KC1004	LS	CHANNEL
MA1002	LS	CHANNEL
MM1003	LS	CHANNEL
PA1001	LS	CHANNEL
SK1004	LS	CHANNEL
MD1002	LS	LAKE
CH1001	SCL	CHANNEL
DE1004	SCL	CHANNEL
TW1002	SCL	FLOODPLAIN
CC1001	SL	CHANNEL
CW1001	SL	CHANNEL
DP1002	SL	CHANNEL
NA1002	SL	CHANNEL
RG1001	SL	CHANNEL
TO1002	ZL	CHANNEL

23

Group 7 Floristic Association and Structural Formation Range: *Eucalyptus microtheca* (coolibah) mid-height moderately open to open woodland

Associated Perennials (at ≥ 40% of sites in group)
Trees: *Acacia stenophylla, A. salicina*
Shrubs: *Muehlenbeckia cunninghamii*
Subshrubs: *Senecio cunninghamii, Enchylaena tomentosa*

Associated Annuals
Forbs: *Morgania floribunda, Alternanthera nodiflora, Cucumis melo, Trianthema triquetra, Portulaca oleracea, Epaltes australis*

Species Richness
(indicates percentage of species included in the analysis)
67%

Incidence
(indicates percentage of sites included in the analysis)
14%

Description
Predominantly riverine association found in regularly inundated floodplain areas, typically on channel banks or levees, on texture contrast soils, usually a sandy loam over cracking clay. These areas tend to retain water for long periods between floods; as standing water in waterholes and billabongs, or as a subsurface source in sandy channel beds. The most structurally diverse and vegetatively luxuriant associations in the study area. Along the North West Branch the northern form of *Eucalyptus camaldulensis var. obtusa* is a common component of the riverine community. However, within the Study Area, the last *E. camaldulensis* encountered in the main channel was in the vicinity of Coorathilie Lake, north of Cuttapirie Corner Waterhole on the Main Branch. This delineates the outer limit of Mollenmans Class I flood.

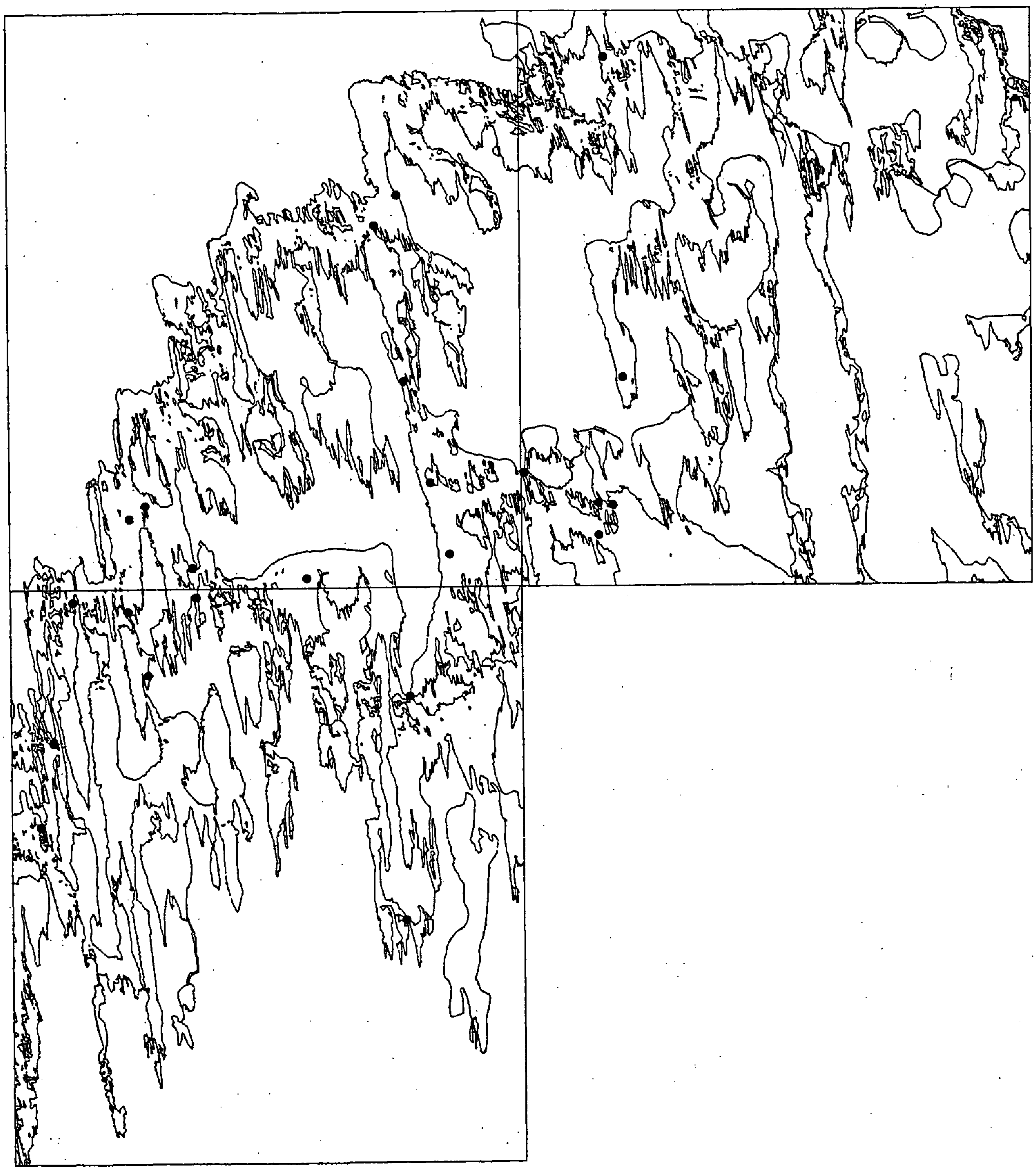
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 7 23 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Muehlenbeckia cunninghamii	2.3910	1.0000	3.1899	1.79
Eucalyptus microtheca	2.2660	1.0000	5.8012	2.41
Acacia stenophylla	0.9270	0.6957	10.3117	3.21
Senecio cunninghamii var. se	0.7565	0.7826	1.9658	1.40
Morgania floribunda	0.7217	0.8261	0.3249	0.57
Acacia salicina	0.4874	0.4348	3.9216	1.98
Epaltes cunninghamii	0.3652		0.0446	0.21
Teucrium racemosum	0.3652		0.0328	0.18
Enchylaena tomentosa var. gl	0.3261	0.5217	1.2046	1.10
Euphorbia drummondii	0.2348		0.4433	0.67
Eremophila bignoniiflora	0.1917		1.3950	1.18
Glinus lotoides	0.1913		0.0120	0.11
Sclerolaena intricata	0.1565		0.0135	-0.12
Sporobolus mitchellii	0.1565		0.5318	-0.73
Diplatia grandibractea	0.1435		1.4675	1.21
Verbena officinalis	0.1435		0.0753	0.27
Amyema preissii	0.1352		1.6321	1.28
Lysiphyllum gilvum	0.0961		1.1484	1.07
Chenopodium auricomum	0.0961		0.0873	-0.30
Atalaya hemiglauca	0.0957		1.1546	1.07
Rutidosis helichrysoides	0.0917		0.0241	-0.16
Cressa cretica	0.0870		0.2303	-0.48
Einadia nutans ssp. eremaea	0.0652		0.4050	0.64
Frankenia cupularis	0.0609		0.1068	-0.33
Mukia micrantha	0.0570		0.1119	0.33
Marsilea drummondii	0.0565		0.2497	-0.50
Haloragis aspera	0.0565		0.0866	-0.29
Atriplex nummularia ssp.	0.0526		0.1741	-0.42
Solanum nigrum	0.0526		0.6351	0.80
Lysiana exocarpi ssp. exocar	0.0522		0.6298	0.79
Mentha australis	0.0522		0.6298	0.79
Chenopodium nitrariaceum	0.0522		0.0612	-0.25
Solanum oligacanthum	0.0478		0.1153	-0.34
Cyperus gymnocaulos	0.0435		0.0804	-0.28
Atriplex velutinella	0.0435		0.0004	-0.02
Sclerolaena decurrens	0.0435		0.1158	0.34
Sclerolaena constricta	0.0435		0.4395	0.66
Eragrostis dielsii var. diel	0.0435		0.0172	-0.13
Heliotropium curassavicum	0.0435		0.0429	-0.21
Atriplex limbata	0.0435		0.1078	0.33
Boerhavia schomburgkiana	0.0174		0.0065	-0.08
Lysiana subfalcata	0.0130		0.1574	0.40
Santalum lanceolatum	0.0091		0.1102	0.33
Owenia acidula	0.0087		0.1050	0.32
Osteocarpum acropterum var.	0.0087		0.0277	-0.17
Lavatera plebeia	0.0087		0.0000	0.00
Eragrostis parviflora	0.0087		0.0124	-0.11
Wahlenbergia tumidifructa	0.0087		0.0142	-0.12
Ludwigia peploides ssp. mont	0.0043		0.0002	-0.01
Goodenia glauca	0.0043		0.0402	0.20
Sclerolaena bicornis	0.0043		0.0292	-0.17
Pterocaulon sphacelatum	0.0043		0.0034	0.06
Maireana coronata	0.0043		0.0013	0.04
Sclerolaena calcarata	0.0043		0.0088	-0.09
Dentella pulvinata	0.0004		0.0310	-0.18
Mukia maderaspatana	0.0004		0.0052	0.07

STUDY AREA

GROUP DISTRIBUTION



• GROUP 7

GROUP 8

SITE	SOIL	LANDFORM
LW1003	CL	FLOODPLAIN
AP1004	CLS	FLOODPLAIN
CG1002	CLS	FLOODPLAIN
CH1003	CLS	FLOODPLAIN
DE1001	HC	FLOODPLAIN
KC1003	HC	FLOODPLAIN
KC1006	HC	FLOODPLAIN
CO1001	LMC	CHANNEL
JL1002	LS	FLOODPLAIN
KW1001	SCL	FLOODPLAIN
MM1001	SCL	FLOODPLAIN
DE1003	SL	FLOODPLAIN
PL1003	ZCL	FLOODPLAIN
PL1004	ZCL	FLOODPLAIN

14

Group 8 Floristic Association and Structural Formation Range: *Muehlenbeckia cunninghamii* (lignum) tall, moderately open to open shrubland

Associated Perennials (at ≥ 40% of sites in group)
Trees: *Eucalyptus microtheca*
Shrubs: *Atriplex nummularia, Senecio cunninghamii*
Subshrubs: *Halosarcia indica, Solanum oligicanthum, Sclerolaena intricata*
Forbs: *Rutidosis helichrysoides, Teucrium racemosum, Epaltes cunninghamii, Haloragis aspera, Dentella pulvinata, Frankenia cupularis*

Associated Annuals
Forbs: *Alternanthera nodiflora, Trianthema triquetra, Portulaca oleracea, Morgania floribunda, Atriplex spongiosa, A. intermedia, Centaurium spicatum, Zygophyllum ammophilum, Tetragonia tetragoniodes*

Species Richness
(indicates percentage of species included in the analysis)
51%

Incidence
(indicates percentage of sites included in the analysis)
8%

Description
Encountered in more regularly inundated areas of the floodplain, most often immediately adjacent to the Main Channel. Overflow from the Channel onto grey deep cracking clays produces swampy conditions with, in places, impenetrable thickets of *Muehlenbeckia cunninghamii*. In areas where the Main Channel is discontinuous (eg Moonlight Flat), braided channels support monospecific stands of *M. cunninghamii*. More typically, *M. cunninghamii* is accompanied by scattered emergent *Eucalyptus microtheca*, and less commonly *Acacia stenophylla* (on more loamy textured soils).

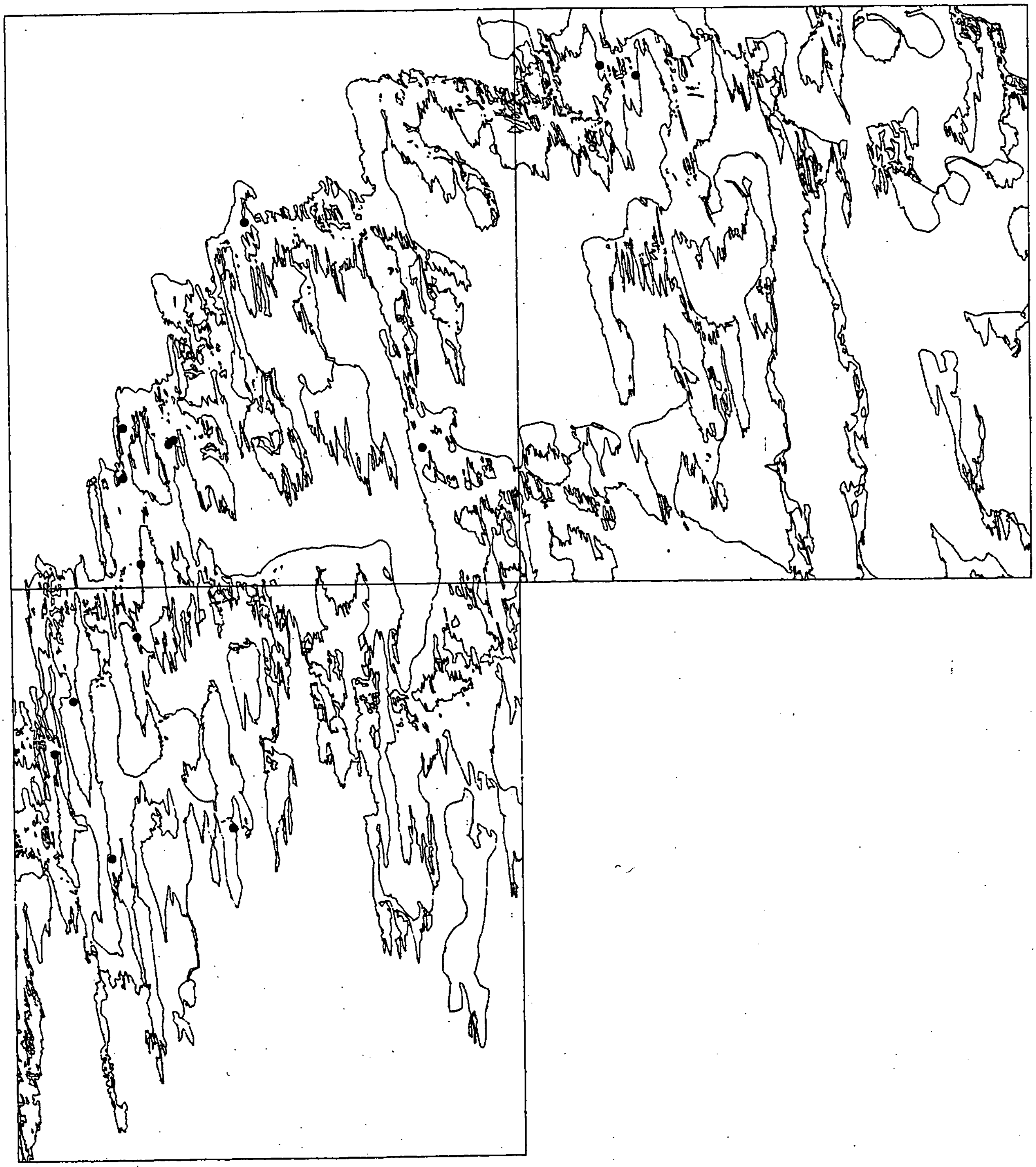
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 8 14 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Muehlenbeckia cunninghamii	2.4290	1.0000	3.3438	1.83
Rutidosis helichrysoides	1.1500	0.7143	6.5363	2.56
Teucrium racemosum	1.0860	0.8571	2.4514	1.57
Senecio cunninghamii var. se	1.0140	0.7857	4.0841	2.02
Eucalyptus microtheca	0.7457	0.9286	0.0944	0.31
Halosarcia indica ssp. leios	0.6436	0.5000	0.3941	0.63
Atriplex nummularia ssp.	0.5857	0.5000	0.3727	0.61
Morgania floribunda	0.5143	0.5714	0.0532	0.23
Sclerolaena intricata	0.3929	0.7143	0.1601	0.40
Epaltes cunninghamii	0.3000	0.4286	0.0069	0.08
Haloragis aspera	0.2429	0.5000	0.0203	0.14
Chenopodium nitrariaceum	0.1714		0.0040	0.06
Marsilea drummondii	0.1571		0.1092	-0.33
Sclerolaena calcarata	0.1500		1.0949	1.05
Dentella pulvinata	0.1214	0.5714	0.2512	0.50
Solanum oligacanthum	0.1214	0.5714	0.0306	-0.17
Frankenia cupularis	0.1071	0.4286	0.0511	-0.23
Boerhavia schomburgkiana	0.1000		0.1463	0.38
Glinus lotoides	0.1000		0.0161	-0.13
Wahlenbergia tumidifructa	0.1000		0.1744	0.42
Sporobolus mitchellii	0.0929		0.6396	-0.80
Chenopodium auricomum	0.0857		0.1002	-0.32
Ludwigia peploides ssp. mont	0.0714		0.8052	0.90
Verbena officinalis	0.0714		0.0000	0.00
Sclerolaena decurrens	0.0714		0.3878	0.62
Cressa cretica	0.0714		0.2550	-0.50
Osteocarpum acropterum var.	0.0214		0.0111	-0.11
Eragrostis parviflora	0.0214		0.0012	-0.03
Eragrostis dielsii var. diel	0.0214		0.0436	-0.21
Sclerolaena diacantha	0.0143		0.0000	0.00
Acacia stenophylla	0.0086		0.0549	-0.23
Sauropus trachyspermus	0.0079		0.0261	0.16
Crinum flaccidum	0.0079		0.0129	0.11
Euphorbia drummondii	0.0071		0.0515	-0.23
Sclerolaena constricta	0.0071		0.0034	0.06
Enchylaena tomentosa var. gl	0.0071		0.0457	-0.21
Eremophila bignoniiflora	0.0071		0.0091	-0.10
Atriplex velutinella	0.0071		0.0349	-0.19
Sclerolaena bicornis	0.0071		0.0245	-0.16
Eragrostis setifolia	0.0071		0.0118	-0.11
Pterocaulon sphacelatum	0.0071		0.0153	0.12
Psoralea cinerea	0.0071		0.2419	-0.49
Einadia nutans ssp. eremaea	0.0071		0.0001	-0.01

STUDY AREA

GROUP DISTRIBUTION



• GROUP 8

GROUP 9

SITE	SOIL	LANDFORM
LW1001	CL	FLOODPLAIN
BL1001	HC	FLOODPLAIN
LS1002	HC	FLOODPLAIN
PW1002	SCL	FLOODPLAIN
SK1003	SCL	FLOODPLAIN
CH1002	SL	FLOODOUT

6

Group 9 Floristic Association and Structural Formation Range: *Muehlenbeckia cunninghamii* (lignum)/*Chenopodium nitrariaceum* (nitre goosefoot) tall open to very open shrubland

Associated Perennials (at ≥ 40% of sites in group)
Trees: *Eucalyptus microtheca*
Shrubs: *Atriplex nummularia, Senecio cunninghamii*
Subshrubs: *Sclerolaena intricata*
Forbs: *Wahlenbergia tumidifructa, Boerhavia schomburgkiana, Teucrium racemosum, Haloragis aspera*

Associated Annuals
Forbs: *Atriplex spongiosa, A. intermedia, A. crassipes, Trianthema triquetra, Tetragonia tetragonioides, Portulaca oleracea, Tribulus terrestris, Alternanthera nodiflora, Phyllanthus lacunarius*
Grasses: *Dactyloctenium radulans, Tragus australiensis*

Species Richness
(indicates percentage of species included in the analysis)
35%

Incidence
(indicates percentage of sites included in the analysis)
4%

Description
Mainly in the southern half of the study area, on loams and open cracking clays on outer areas of the floodplain. The presence of a mix of chenopods in the association's annual component suggests a less regular flooding regime.

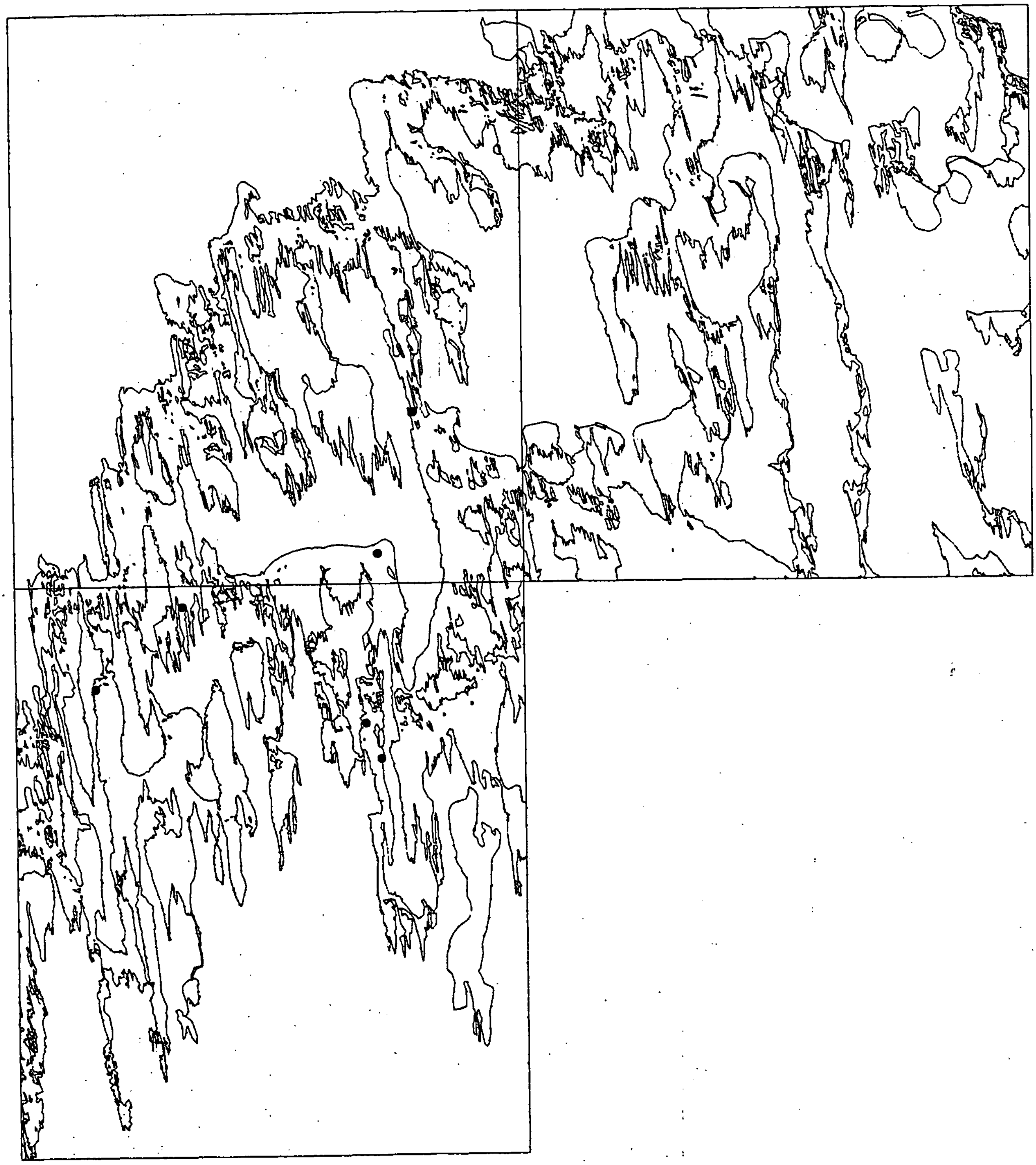
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 9 6 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Muehlenbeckia cunninghamii	1.5170	1.0000	0.6511	0.81
Chenopodium nitrariaceum	1.3330	0.5000	9.5649	3.09
Haloragis aspera	0.8500	1.0000	2.4496	1.57
Atriplex nummularia ssp.	0.7000	0.6667	0.6904	0.83
Teucrium racemosum	0.3833	0.8333	0.0466	0.22
Eucalyptus microtheca	0.3517	0.5000	0.0563	-0.24
Sclerolaena intricata	0.3500	0.5000	0.0939	0.31
Sclerolaena bicornis	0.3333		2.3432	1.53
Senecio cunninghamii var. se	0.2167	0.6667	0.0110	0.10
Boerhavia schomburgkiana	0.2167	0.6667	1.0751	1.04
Rutidosis helichrysoides	0.1833		0.0063	0.08
Acacia salicina	0.1833		0.3680	0.61
Solanum oligacanthum	0.1833		0.0013	-0.04
Minuria denticulata	0.1833		1.4166	1.19
Sclerolaena diacantha	0.1667		1.5918	1.26
Halosarcia indica ssp. leios	0.1667		0.0591	-0.24
Wahlenbergia tumidifructa	0.0667	0.6667	0.0492	0.22
Eragrostis parviflora	0.0500	0.5000	0.0196	0.14
Enchylaena tomentosa var. gl	0.0333		0.0113	-0.11
Minuria rigida	0.0333		0.0065	0.08
Maireana coronata	0.0167		0.0794	0.28
Frankenia cupularis	0.0167		0.1790	-0.42
Zaleya galericulata	0.0167		0.0554	0.24
Dentella pulvinata	0.0167		0.0073	-0.09
Marsilea drummondii	0.0167		0.3211	-0.57
Morgania floribunda	0.0167		0.3408	-0.58
Crinum flaccidum	0.0167		0.0874	0.30
Solanum esuriale	0.0167		0.0032	-0.06
Diplatia grandibractea	0.0167		0.0020	0.04

STUDY AREA

GROUP DISTRIBUTION



• GROUP 9

GROUP 10

SITE	SOIL	LANDFORM
OB1001	CLS	CHANNEL
CW1002	CLS	FLOODPLAIN
NO1004	CLS	FLOODPLAIN
OB1002	CLS	FLOODPLAIN
ST1002	LS	FLOODPLAIN
CA1003	SCL	FLOODOUT
DE1006	SCL	FLOODPLAIN
JL1003	SCL	FLOODPLAIN
OF1006	SCL	FLOODPLAIN
TL1003	SCL	FLOODPLAIN
WW1001	SCL	FLOODPLAIN
FL1002	SL	LAKE

12

Group 10 Floristic Association and Structural Formation Range: *Atriplex nummularia* (oldman saltbush) tall open to very open shrubland

Associated Perennials (at ≥ 40% of sites in group)
Trees: *Eucalyptus microtheca*
Shrubs: *Muehlenbeckia cunninghamii*
Subshrubs: *Halosarcia indica, Sclerolaena intricata, Enchylaena tomentosa*
Forbs: *Haloragis aspera, Teucrium racemosum*

Associated Annuals
Forbs: *Morgania floribunda, Portulaca oleracea, Trianthema triquetra, Tribulus terrestris, Tetragonia tetragonioides, Phyllanthus lacunarius, Calotis hispidula, C. porphyroglossa, Gnephosis arachnoidea*

Species Richness
(indicates percentage of species included in the analysis)
45%

Incidence
(indicates percentage of sites included in the analysis)
7%

Description
Widely scattered throughout the floodplain, particularly on low sandy rises at the outer extremes of the floodplain. Also found on low sandy rises adjacent to the Main Channel, often with sparse *Eucalyptus microtheca* overstorey. Boyland (1984) has observed *Atriplex nummularia* on sands covering deep grey clays.

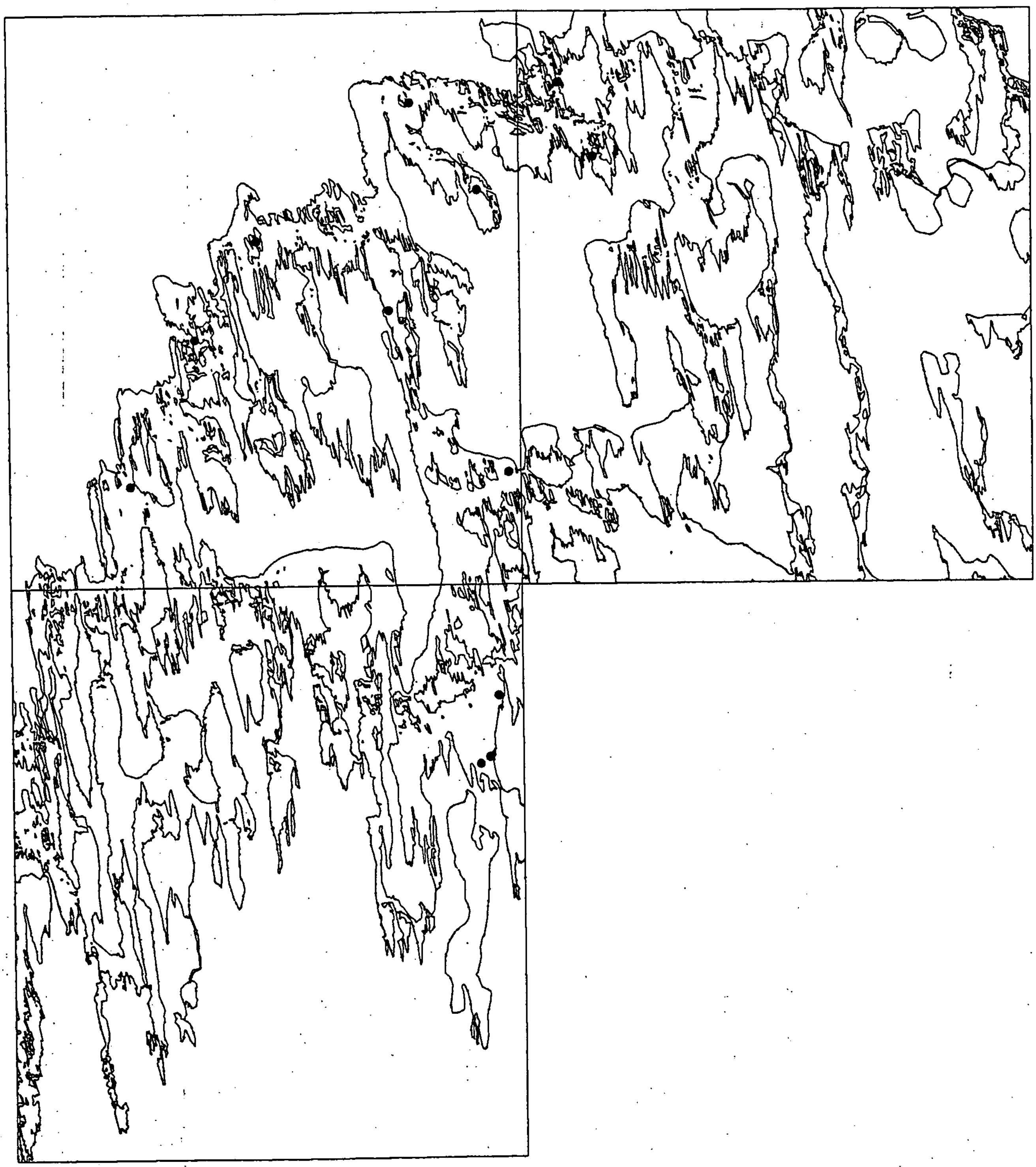
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 10 12 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Atriplex nummularia ssp.	2.4170	1.0000	17.1497	4.14
Eucalyptus microtheca	0.6758	0.5833	0.0444	0.21
Halosarcia indica ssp. leios	0.6750	0.5000	0.4694	0.69
Morgania floribunda	0.4417	0.6667	0.0125	0.11
Haloragis aspera	0.3750	0.6667	0.2043	0.45
Sclerolaena intricata	0.3600	0.7500	0.1077	0.33
Enchylaena tomentosa var. gl	0.2758	0.5833	0.7934	0.89
Muehlenbeckia cunninghamii	0.2683	0.5000	0.3505	-0.59
Senecio cunninghamii var. se	0.2583		0.0419	0.20
Solanum oligacanthum	0.1833		0.0013	-0.04
Teucrium racemosum	0.1167	0.4167	0.0878	-0.30
Eremophila bignoniiflora	0.0917		0.2395	0.49
Osteocarpum acropterum var.	0.0917		0.0538	0.23
Boerhavia schomburgkiana	0.0917		0.1127	0.34
Frankenia cupularis	0.0917		0.0675	-0.26
Dentella pulvinata	0.0917		0.1120	0.33
Rutidosis helichrysoides	0.0833		0.0312	-0.18
Atriplex velutinella	0.0833		0.0258	0.16
Epaltes cunninghamii	0.0833		0.1182	-0.34
Minuria denticulata	0.0833		0.2170	0.47
Chenopodium auricomum	0.0333		0.1791	-0.42
Acacia stenophylla	0.0183		0.0391	-0.20
Sporobolus mitchellii	0.0167		0.7818	-0.88
Eragrostis parviflora	0.0167		0.0040	-0.06
Sclerolaena bicornis	0.0167		0.0115	-0.11
Goodenia fascicularis	0.0092		0.0969	0.31
Eragrostis dielsii var. diel	0.0092		0.0635	-0.25
Sclerolaena diacantha	0.0083		0.0027	-0.05
Zaleya galericulata	0.0083		0.0080	0.09
Glinus lotoides	0.0083		0.1328	-0.36
Crinum flaccidum	0.0083		0.0153	0.12
Eragrostis setifolia	0.0083		0.0102	-0.10
Minuria rigida	0.0083		0.0081	-0.09
Solanum esuriale	0.0083		0.0118	-0.11
Wahlenbergia tumidifructa	0.0083		0.0147	-0.12
Einadia nutans ssp. eremaea	0.0083		0.0000	0.00
Tephrosia sphaerospora	0.0008		0.0001	-0.01
Lysiphyllum gilvum	0.0008		0.0054	-0.07

STUDY AREA

GROUP DISTRIBUTION



• GROUP 10

GROUP 11

SITE	SOIL	LANDFORM
MO1005	CLS	FLOODPLAIN
BL1003	HC	FLOODPLAIN
BL1004	HC	FLOODPLAIN
KW1004	HC	FLOODPLAIN
KW1005	HC	FLOODPLAIN
MO1006	HC	FLOODPLAIN
OF1004	SL	LAKE

7

Group 11 Floristic Association and Structural Formation Range: *Muehlenbeckia cunninghamii* (lignum)/ *Epaltes cunninghamii* (tall nut-heads) tall open to very open shrubland

Associated Perennials (at ≥ 40% of sites in group)
Trees: *Eucalyptus microtheca* (sparse, emergents)
Forbs: *Epaltes cunninghamii, Teucrium racemosum, Cressa cretica, Frankenia cupularis*
Grasses: *Sporobolus mitchellii*

Associated Annuals
Forbs: *Morgania floribunda, Alternanthera nodiflora, Portulaca oleracea, Atriplex spongiosa, A. crassipes, A. pumilio, Bergia trimera*

Species Richness
(indicates percentage of species included in the analysis)
29%

Incidence
(indicates percentage of sites included in the analysis)
4%

Description
Typically present in less regularly inundated areas of the floodplain, on gilgaied self-mulching grey clay supporting intermittent floodplain swamps. The presence of halophytes such as *F. cupularis* and *Atriplex* spp. indicates saline conditions and the lack of regular flushing by floodwaters.

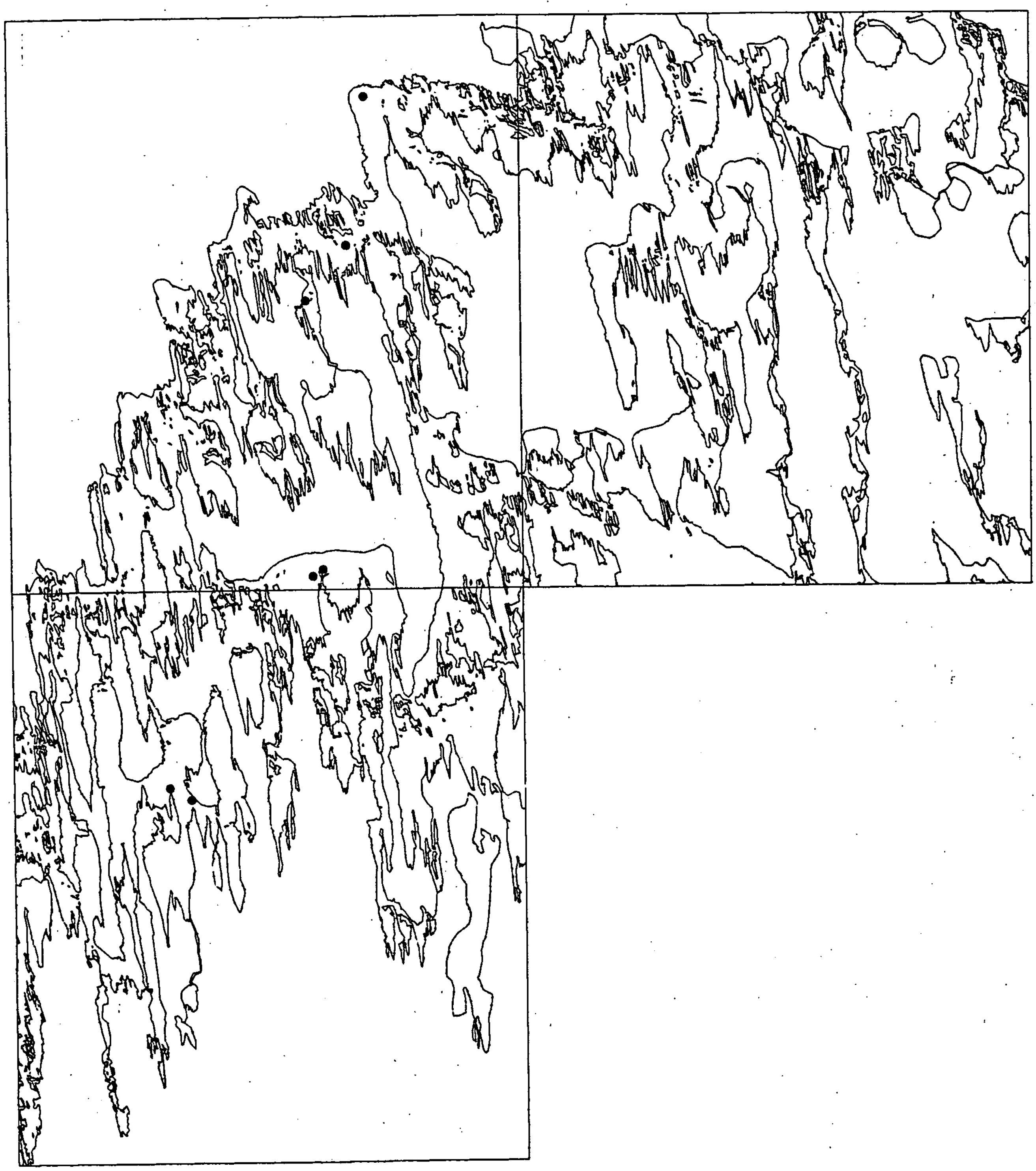
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 11 7 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Muehlenbeckia cunninghamii	2.2870	1.0000	2.7873	1.67
Epaltes cunninghamii	2.1430	1.0000	13.7765	3.71
Frankenia cupularis	1.1570	0.7143	4.2420	2.06
Teucrium racemosum	1.0000	0.7143	1.9613	1.40
Sporobolus mitchellii	0.8857	0.7143	0.0062	0.08
Marsilea drummondii	0.4286		0.0159	0.13
Morgania floribunda	0.3286	0.7143	0.0054	-0.07
Chenopodium nitrariaceum	0.2857		0.1307	0.36
Cressa cretica	0.1714	0.4286	0.1181	-0.34
Rutidosis helichrysoides	0.1571		0.0002	0.01
Psoralea cinerea	0.1571		0.0382	-0.20
Sclerolaena bicornis	0.1429		0.2980	0.55
Eragrostis setifolia	0.1429		0.5913	0.77
Euphorbia drummondii	0.0286		0.0204	-0.14
Solanum oligacanthum	0.0286		0.1464	-0.38
Sclerolaena calcarata	0.0157		0.0000	0.00
Haloragis aspera	0.0143		0.1546	-0.39
Sclerolaena intricata	0.0143		0.1821	-0.43
Wahlenbergia tumidifructa	0.0143		0.0074	-0.09
Solanum esuriale	0.0143		0.0051	-0.07
Dentella pulvinata	0.0143		0.0097	-0.10
Halosarcia indica ssp. leios	0.0143		0.2719	-0.52
Acacia stenophylla	0.0143		0.0453	-0.21
Eucalyptus microtheca	0.0057	0.5714	0.5121	-0.72

STUDY AREA

GROUP DISTRIBUTION



• GROUP 11

GROUP 12

SITE	SOIL	LANDFORM
KC1001	CL	CHANNEL
FL1003	HC	FLOODPLAIN
MM1002	HC	FLOODPLAIN
TO1004	HC	FLOODPLAIN
OF1001	LS	FLOODPLAIN
ST1001	LS	FLOODPLAIN
PA1002	MHC	FLOODPLAIN
PW1003	MHC	FLOODPLAIN
NO1005	SL	FLOODPLAIN

9

Group 12 Floristic Association and Structural Formation Range: *Frankenia cupularis* (sea-heath) low very open to sparse forbland

Associated Perennials (at ≥ 40% of sites in group)
Shrubs: *Muehlenbeckia cunninghamii* (emergent)
Subshrubs: *Sclerolaena intricata*
Forbs: *Marsilea drummondii*
Grasses: *Sporobolus mitchellii*

Associated Annuals
Forbs: *Atriplex spongiosa, A. crassipes, A. intermedia, A. sturtii, Portulaca oleracea, Trianthema triquetra*
Grasses: *Dactyloctenium radulans*

Species Richness
(indicates percentage of species included in the analysis)
37%

Incidence
(indicates percentage of sites included in the analysis)
5%

Description
Monospecific stands of *F. cupularis* occur in the south of the Study Area, on gilgaied self mulching grey clays, in areas where the Main Channel becomes discontinuous flooding out locally before reforming into a single channel. Included in this association are sites from the Northern Overflow area, found on low sandy rises and flats where *F. cupularis* becomes less obvious, and Chenopods, particularly *Halosarcia indica* predominate. A halophytic association.

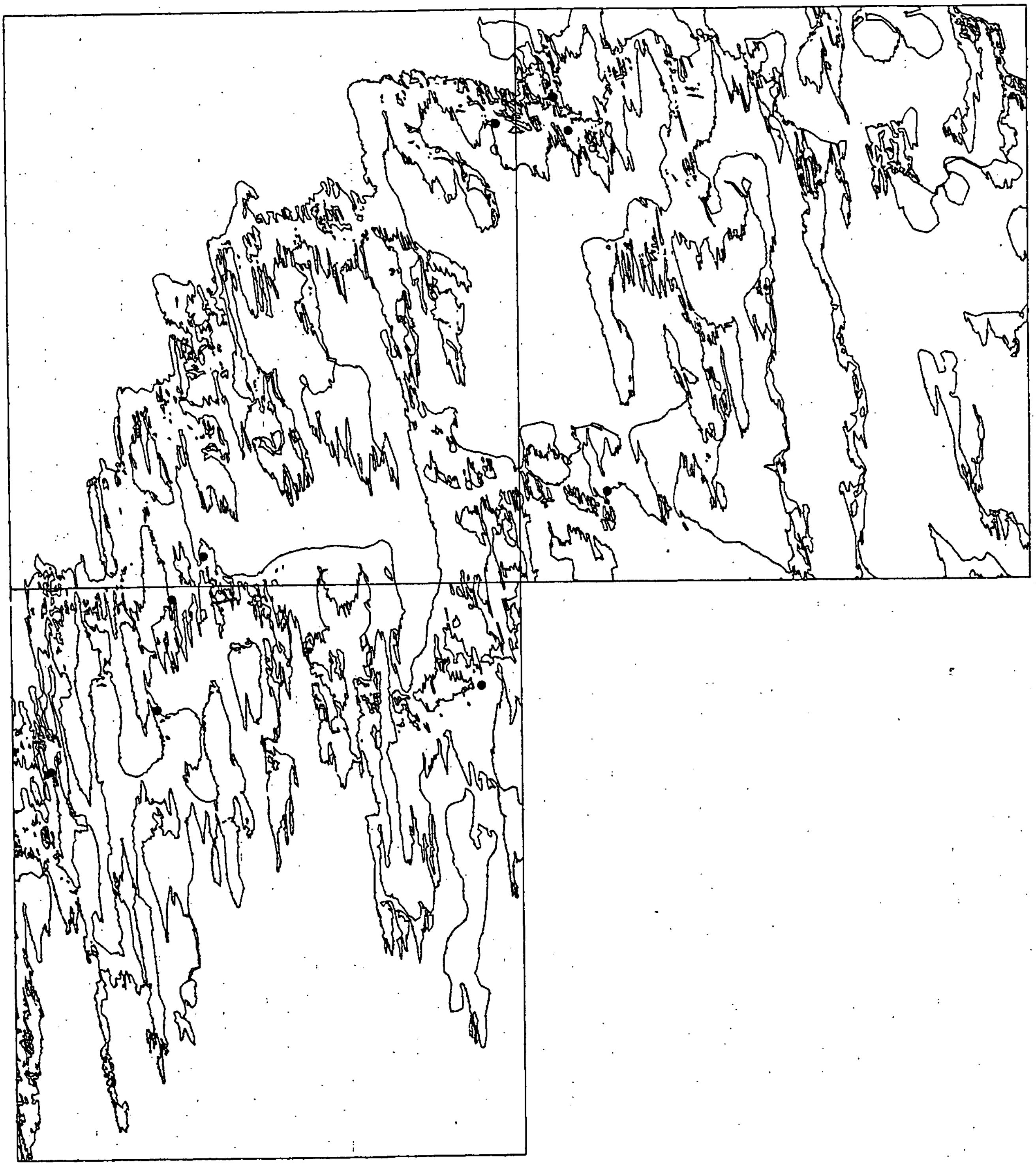
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 12 9 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Frankenia cupularis	1.3440	1.0000	6.0847	2.47
Halosarcia indica ssp. leios	0.5556		0.2182	0.47
Sporobolus mitchellii	0.4778	0.7778	0.1394	-0.37
Sclerolaena intricata	0.4667	0.6667	0.3150	0.56
Haloragis aspera	0.4444		0.3778	0.61
Teucrium racemosum	0.4444		0.1110	0.33
Osteocarpum acropterum var.	0.3333		1.9381	1.39
Marsilea drummondii	0.2667	0.6667	0.0214	-0.15
Muehlenbeckia cunninghamii	0.2556	0.4444	0.3676	-0.61
Morgania floribunda	0.2333		0.0526	-0.23
Eragrostis dielsii var. diel	0.2333		0.2878	0.54
Atriplex velutinella	0.2222		0.6297	0.79
Minuria rigida	0.2222		1.8729	1.37
Eucalyptus microtheca	0.2222		0.1734	-0.42
Rutidosis helichrysoides	0.2222		0.0321	0.18
Chenopodium auricomum	0.1333		0.0483	-0.22
Cyperus gymnocaulos	0.1111		0.0125	-0.11
Epaltes cunninghamii	0.0222		0.2154	-0.46
Solanum oligacanthum	0.0222		0.1575	-0.40
Glinus lotoides	0.0222		0.1079	-0.33
Euphorbia drummondii	0.0111		0.0447	-0.21
Dentella pulvinata	0.0111		0.0135	-0.12
Heliotropium curassavicum	0.0111		0.0920	-0.30
Sclerolaena decurrens	0.0111		0.0002	0.01
Mimulus repens	0.0111		0.0084	-0.09
Wahlenbergia tumidifructa	0.0111		0.0110	-0.10
Frankenia serpyllifolia	0.0111		0.1341	0.37
Cressa cretica	0.0111		0.3626	-0.60
Senecio cunninghamii var. se	0.0111		0.1516	-0.39
Sclerolaena calcarata	0.0111		0.0017	-0.04
Eragrostis parviflora	0.0111		0.0094	-0.10

STUDY AREA

GROUP DISTRIBUTION



• **GROUP 12**

GROUP 13

SITE	SOIL	LANDFORM
RG1002	CL	FLOODOUT
MD1001	CLS	LAKE
MA1001	HC	CHANNEL
CO1004	HC	FLOODPLAIN
DP1001	HC	FLOODPLAIN
MA1003	HC	FLOODPLAIN
MW1002	HC	FLOODPLAIN
NF1001	HC	FLOODPLAIN
CO1002	MHC	FLOODPLAIN

9

Group 13 Floristic Association and Structural Formation Range: *Marsilea drummondii* (nardoo) low closed herbland

Associated Perennials (at ≥ 40% of sites in group)
Shrubs: *Muehlenbeckia cunninghamii* (emergent or patches)
Subshrubs: *Chenopodium auricomum*
Forbs: *Cressa cretica, Epaltes cunninghamii,*
Grasses: *Sporobolus mitchellii*

Associated Annuals
Forbs: *Portulaca oleracea, Trianthema triquetra, Atriplex crassipes, A. intermedia, Alternanthera nodiflora*

Species Richness
(indicates percentage of species included in the analysis)
53%

Incidence
(indicates percentage of sites included in the analysis)
5%

Description
Local small patches in regularly inundated discontinuous sections of the Main Channel. Soils are self mulching grey cracking clays, occasionally small sandy islands of *S. mitchellii* accompany this association.

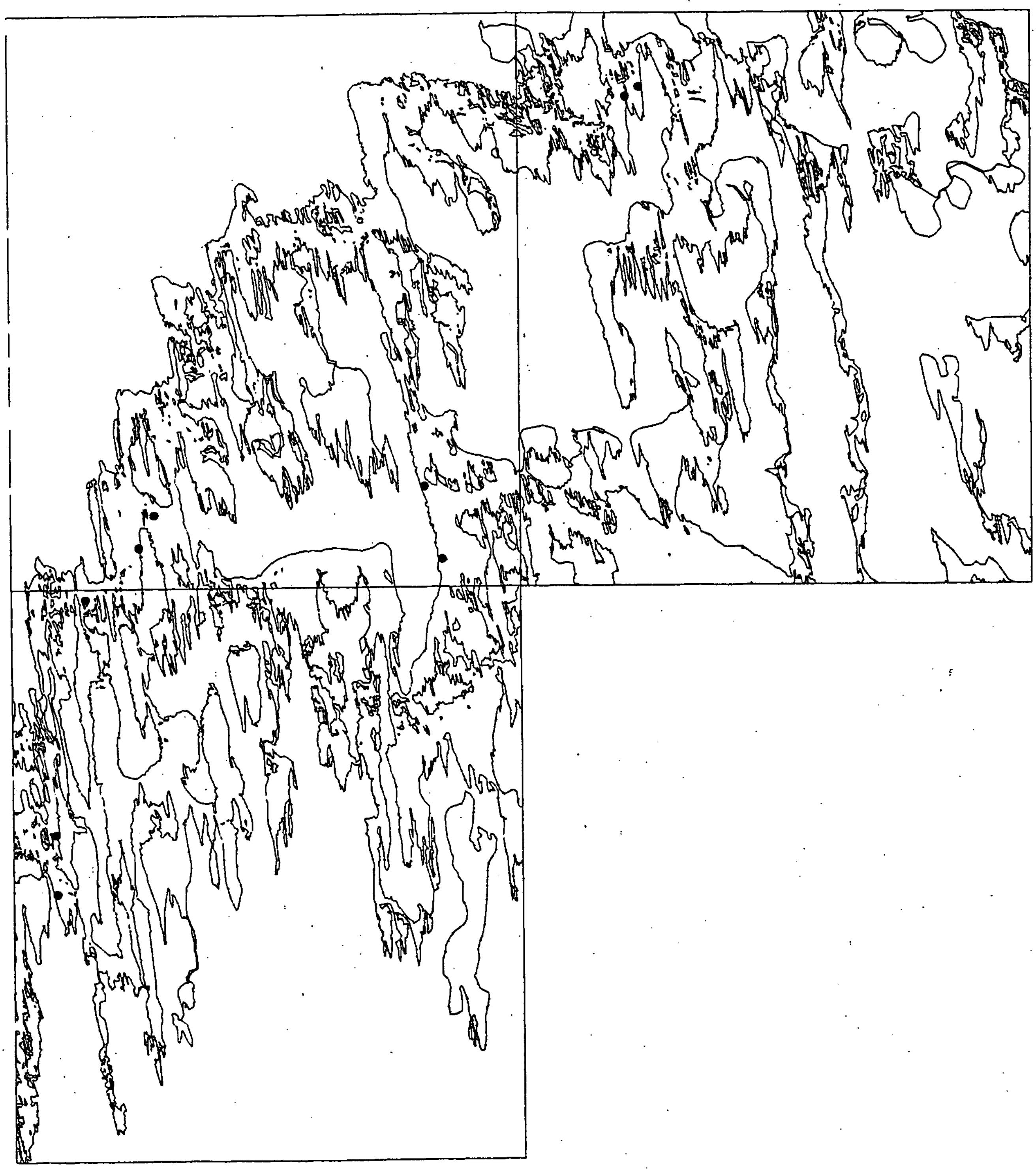
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 13 9 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Marsilea drummondii	3.3330	1.0000	25.0991	5.01
Sporobolus mitchellii	0.7111	0.7778	0.0132	-0.11
Epaltes cunninghamii	0.5778	0.4444	0.3967	0.63
Muehlenbeckia cunninghamii	0.4778	0.6667	0.1277	-0.36
Chenopodium auricomum	0.4556	0.4444	0.1906	0.44
Cressa cretica	0.4556	0.4444	0.0131	0.11
Halosarcia indica ssp. leios	0.3444		0.0066	0.08
Eucalyptus microtheca	0.1233		0.3059	-0.55
Frankenia cupularis	0.1222		0.0374	-0.19
Teucrium racemosum	0.0222		0.2284	-0.48
Senecio cunninghamii var. se	0.0111		0.1516	-0.39
Minuria rigida	0.0111		0.0050	-0.07
Haloragis aspera	0.0111		0.1606	-0.40
Sclerolaena intricata	0.0111		0.1881	-0.43
Rutidosis helichrysoides	0.0111		0.1309	-0.36
Wahlenbergia tumidifructa	0.0111		0.0110	-0.10
Morgania floribunda	0.0111		0.3515	-0.59
Acacia stenophylla	0.0111		0.0506	-0.22

STUDY AREA

GROUP DISTRIBUTION



• GROUP 13

GROUP 14

SITE	SOIL	LANDFORM
WX1001	CL	FLOODOUT
MF1001	CL	FLOODPLAIN
MF1002	CL	FLOODPLAIN
MF1003	CL	FLOODPLAIN
DW1001	HC	FLOODOUT
LS1004	HC	FLOODPLAIN
TO1001	HC	SWAMP
CH1004	MHC	FLOODPLAIN
NA1001	SL	FLOODPLAIN

9

Group 14 Floristic Association and Structural Formation Range: *Chenopodium auricomum* (Queensland bluebush) tall open to sparse shrubland

Associated Perennials (at ≥ 40% of sites in group)
Trees: *Eucalyptus microtheca* (emergent)
Shrubs: *Muehlenbeckia cunninghamii*
Subshrubs: *Sclerolaena intricata*

Associated Annuals
Forbs: *Alternanthera nodiflora, Morgania floribunda, Atriplex crassipes, A. spongiosa, Trianthema triquetra, Portulaca oleracea*
Grasses: *Dactyloctenium radulans*

Species Richness
(indicates percentage of species included in the analysis)
38%

Incidence
(indicates percentage of sites included in the analysis)
5%

Description
Occurs on grey cracking clay depressions subject to periodic waterlogging (swamps). Sites representing this association are found centrally in the Study Area, adjacent to the Main Channel, on the low lying periphery of the floodplain.

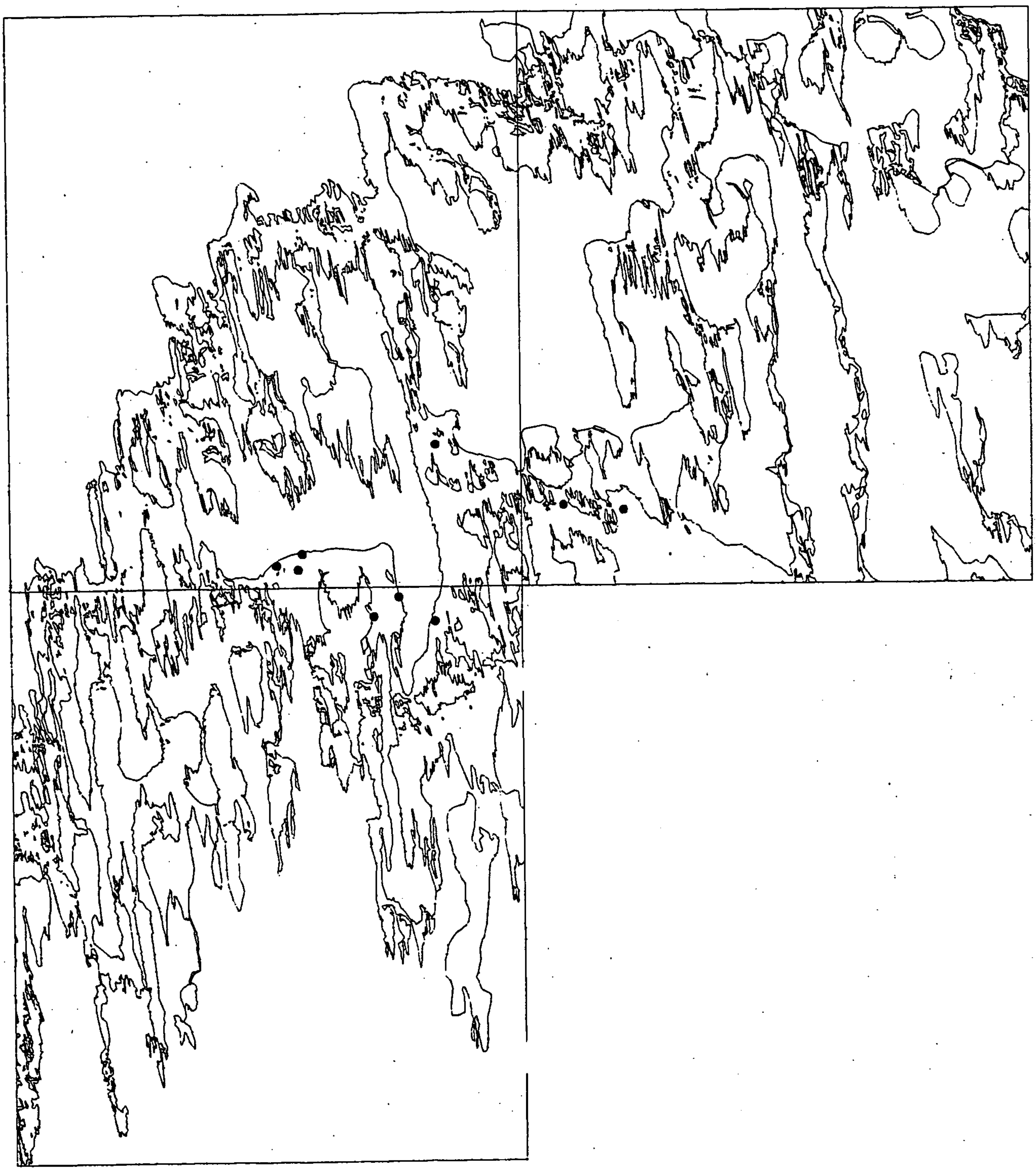
SPECIES COMPOSTION OF THE 14 GROUPS DEFINED FROM PATN
USING COVER ABUNDANCE VALUES

Group 14 9 Members

Species	Cover/Abun	Freq>40%	Group Signif. chi squ	std resid
Chenopodium auricomum	2.5560	1.0000	22.2160	4.71
Muehlenbeckia cunninghamii	1.0110	0.7778	0.0576	0.24
Eucalyptus microtheca	0.4578	0.5556	0.0082	-0.09
Sclerolaena intricata	0.3444	0.4444	0.0865	0.29
Marsilea drummondii	0.2444		0.0338	-0.18
Haloragis aspera	0.2333		0.0144	0.12
Rutidosis helichrysoides	0.2333		0.0431	0.21
Senecio cunninghamii var. se	0.1233		0.0143	-0.12
Sporobolus mitchellii	0.1222		0.5887	-0.77
Dentella pulvinata	0.1111		0.1967	0.44
Lavatera plebeia	0.1111		1.2289	1.11
Frankenia cupularis	0.0333		0.1496	-0.39
Teucrium racemosum	0.0233		0.2263	-0.48
Einadia nutans ssp. eremaea	0.0222		0.0248	0.16
Enchylaena tomentosa var. gl	0.0222		0.0231	-0.15
Malacocera albolanata	0.0122		0.1475	0.38
Osteocarpum acropterum var.	0.0111		0.0240	-0.15
Glinus lotoides	0.0111		0.1276	-0.36
Eragrostis parviflora	0.0111		0.0094	-0.10
Sclerolaena calcarata	0.0111		0.0017	-0.04
Eragrostis dielsii var. diel	0.0111		0.0601	-0.25
Boerhavia schomburgkiana	0.0111		0.0135	-0.12
Chenopodium nitrariaceum	0.0111		0.1257	-0.35
Sclerolaena decurrens	0.0111		0.0002	0.01
Atriplex nummularia ssp.	0.0111		0.2473	-0.50
Eremophila bignoniiflora	0.0022		0.0167	-0.13
Goodenia fascicularis	0.0011		0.0002	0.01
Minuria rigida	0.0011		0.0193	-0.14
Acacia salicina	0.0011		0.0468	-0.22
Goodenia glauca	0.0011		0.0013	0.04
Acacia stenophylla	0.0011		0.0688	-0.26
Solanum oligacanthum	0.0011		0.1973	-0.44

STUDY AREA

GROUP DISTRIBUTION



• GROUP 14

3.1.4 Ordination

The centroids of each of the 14 groups were ordinated to reveal the extent of the similarity in floristic composition between all groups, and to identify possible environmental gradients accounting for the distribution in Appendix I. Whilst the ordination clearly shows the range of floristic relationships between all the groups, the identification or even a tentative suggestion of environmental gradients based on floristic ordination proved to be difficult.

The expected influential gradients such as soil salinity, soil texture, and water relations could not be readily differentiated from the arrangement of the groups. The floodplain system displays a subtlety and complexity with the vegetation appearing as a mosaic of types, sometimes clearly delineated, but most often displaying a gradual continuum of change from one type to another. The hydrology of the floodplain system is so subtle that slight variations in local relief give rise to a range of conditions influencing the vegetation. The most significant influence is the dynamic variable nature of flood events; creating a range of inundations of varying depth and duration, producing an effect not unlike a vast, dynamic ecotone between channel and dunefield.

The inclusion of biennials in the analysis possibly contributed to the proximity in the clustering of Groups 1-6 (Complex I in the dendrogram), compared with Groups 7-14 in the ordination. The inclusion of biennials was felt to be warranted in order to describe the range of vegetation types to be found on the intermittent lakes following an extended period of inundation. Many of the lakes were in different stages of vegetative response, from an initial wave of colonising species through an apparent seasonal succession of species after lakes dried out. This process of succession warrants further study for verification and to contribute to the understanding of the vegetative dynamics of the floodplain system.

Another factor contributing to the complexity of the ordination could be the extended period of the survey. Three field trips were undertaken over the period April to August, introducing a seasonal influence as summer grasses gave way to an expression of winter forbs.

An additional influence on the ordination was the analysis of floristic data without the inclusion of physical data. During the surveys the intention was to cover as much ground as possible in the limited time available, which meant the identification and collection of a minimum data set. As the main aim was a floristic inventory of the floodplain system, only superficial physical data were collected. Thus the collection of edaphic data, such as soil salinity, pH and texture, and their subsequent inclusion in an ordination would contribute jointly to a clarification of environmental gradients and to an increased insight into the autecology of floodplain species. A subset of sites from each of the 14 groups identified from the analysis could be the subject of such a survey in future work.

3.2 Birds

3.2.1 Observations

A total of 47 waterbird species were observed in the Study Area during the survey period. A list of waterbirds present for each visit, along with an abundance rating, is presented in Table 2. A list of all birds noted in the floodplain area for each visit, with relative abundance ratings, is provided in Appendix K. Counts of waterbirds were made on 17 lakes during the study period and of these, nine lakes held more than 1000 waterbirds, and on two sites over 10 000 birds were noted (Appendix K). Counts were also taken on two non-lake sites; a section of the Kanowana Channel and at Thykamingana Swamp.

Eight species of waterbirds - Australian Pelican, Great Cormorant, Grey Teal, Pink-eared Duck, Maned Duck, Black-tailed Native-hen, Eurasian Coot and Red-necked Avocet - were present in numbers greater than 1000, while a further 11 species were present in numbers greater than 100 at one or more sites. A list of waterbird species by order of abundance is presented in Table 3.

Overall, the most frequently observed waterbirds were: the Australian Pelican, Darter, Great Cormorant, White-faced Heron, Royal and Yellow-billed Spoonbill, Black Swan, Grey Teal, Pink-eared Duck, Maned Duck, Masked Lapwing, Red-necked Avocet, Silver Gull and Caspian Tern (Table 2).

Breeding records were also noted for waterbirds on Kanowana. In April 1991, a rookery containing nests of Pied and Great Cormorants was present on Lake Bulpanie at the mouth of the inlet channel. Also nesting at the site were Great Egrets (eight nests with four young) and a Pacific Heron. A group of Australian Pelicans with 20 young were observed on a nearby island. Holmes (1992) reported 46 nests of Great and Pied Cormorants on this rookery in September 1991, and also reported a Great and Pied Cormorant rookery in the north west area of Lake Cooroomunchena.

A Great Cormorant rookery with 58 nests containing six young was observed in April 1991 on Lake Coonamooranie. Sixteen Grey Teal ducklings were seen during this period on the south end of the Kanowana Channel, and three Black Swan cygnets were present on Thykamingana Swamp. No other waterbird breeding evidence was observed during the survey period.

3.2.2 Discussion

The majority of the species of waterbirds observed on the Study Area are common to the region and represent the array of feeding types that are associated with the different environmental conditions found within the Cooper floodplain system following a flood event. Flooding regimes, along with waterbird responses, have been described for the Coongie area by Reid and Gillen (1988), and for other areas on the Cooper by Badman (1988) and Kingsford and Porter (1991).

The major fish feeding species were largely associated with the deeper lakes and included the Australian Pelican, Great and Pied Cormorant, Silver Gull and Caspian Tern. The most common waterfowl were Grey Teal and Pink-eared Ducks, which were present in very large numbers on shallow floodouts and lakes in the draw-down phase. Other birds typically associated with shallow sites were Red-necked Avocets and Royal and Yellow-billed Spoonbills.

Another group of birds commonly associated with shallow flooded habitats are the migratory waders. Holmes (1992) found a total of eight species of Palaeartic waders on Kanowana, with Sharp-tailed Sandpipers as the most common species. A total of four migratory wader species were observed in the present survey with only one, the Sharp-tailed Sandpiper, found in any numbers (Table 2).

The results for the migratory waders are not surprising considering that most of the bird surveys on Kanowana were done at times of the year when these species are not expected in the area. However, the Cooper system is now known to support large numbers of migratory birds during appropriate seasons and under favourable conditions (Kingsford & Porter 1991).

The Maned Duck, noted in the hundreds and on several occasions in the thousands, was typically associated with the fresh vegetation found growing on the receding shorelines of lakes. The largest number of Black-tailed Native-hens observed in the area was on the Kanowana Channel when it was covered with shallow water, while the largest concentration of Eurasian Coots was on Lake Tooroopoolina in association with large numbers of Australian Pelicans and Cormorants (Appendix K).

The Freckled Duck, listed as vulnerable and one of the rarest waterfowl in the world, was not observed in the Study Area until August 1992, when it was seen on seven different lake sites. All of the sightings were of less than 50 individuals, with the highest number (45) seen on Lake Apanburra. Interestingly, in August 1988 approximately 120 Freckled Ducks, amongst which were 15 males sporting bright red bills, were observed on this Lake.

Table 2: Waterbirds Observed on the Study Area, and their Abundance Rating

Species	Kanowana 4/91	Kanowana 9/91	Kanowana 4/92	Kanowana 5/92	Kanowana 8/92	Innamincka 8/92
Hoary-headed Grebe		P		P	C	N
Australasian Grebe					C	P
Australian Pelican	N	N	N+	N+	N+	N+
Darter	P	P	C	N	C	N
Great Cormorant	N	P	N	N	N+	N+
Pied Cormorant	P		C	N	N	N+
Little Black Cormorant		P			N	C
Little Pied Cormorant		P	C			
Pacific Heron	N			P	P	P
White-faced Heron	N	P	N	P	P	C
Great Egret	P	P	P			P
Rufous Night Heron		P	P			P
Sacred Ibis	P		P			
Straw-necked Ibis		P				C
Royal Spoonbill	C	P	C	P	P	P
Yellow-billed Spoonbill	C	P	C	P	C	C
Black Swan	C	C	P	P	P	C
Freckled Duck					C	C
Australian Shelduck	P				P	P
Pacific Black Duck		P	P			P
Grey Teal	N	N+	N	N+	N	N+
Australasian Shoveler					P	C
Pink-eared Duck	C	N+	N+	N+	N+	N+
Hardhead		N	C	C	N	C
Maned Duck	C	N	N+	N	N	N+
Blue-billed Duck					P	P
Musk Duck	P	P				P
Black-tailed Native-hen		N+	C	P	P	N
Purple Swamphen		P				
Eurasian Coot		C	P	N		N+
Brolga			P	P	C	N
Masked Lapwing	P	C	N	N	N	N
Banded Lapwing	C		P	P	P	P
Red-kneed Dotterel		P				P
Red-capped Plover			C			N
Black-fronted Plover	P	P	C			
Black-winged Stilt	P	C	N			P
Red-necked Avocet	N	N	N	N+	N	N
Greenshank		P				
Marsh Sandpiper		P				
Sharp-tailed Sandpiper		N				
Curlew Sandpiper		P				
Australian Pratincole		C			P	N
Silver Gull	C	P	C	P	C	C
Whiskered Tern		C			C	C
Gull-billed Tern	P	C				
Caspian Tern	P	C	C	P	C	C

***Rating**: based on estimates of birds present at a site and does not represent cumulative or regional counts. Results provide a relative indice to species abundance.

P	Present	(1-9)
C	Common	(10-49)
N	Numerous	(>50)
N+	thousands	

Reid and Gillen (1988) reported that Freckled Ducks were present in the Coongie area year round, and estimated a local population of 1000 birds. Marchant and Higgins (1990) have described this species as particularly associated with shallow productive waters, and cited evidence suggesting that irruptions of Freckled Ducks occur irregularly following extensive flooding on inland rivers, and concentrate on Lake Eyre Basin wetlands.

Brolgas were seen on five different lake sites in the Area, with the largest group (55) at Lake Kanbakoodnanie; a treeless floodout on the Northern Overflow. Brolgas were noted to have been feeding on the tubers of *Cyperus gymnocaulos* at most of the sites.

In May 1992 large numbers of Great and Pied Cormorants were observed departing from Lakes Toontoowaranie and Goyder in the morning, flying south westerly, and returning in the evenings. In August, upward of 8000 Cormorants, as well as some 3000 Australian Pelicans, were observed arriving at Lake Tooroopoolina in the morning. Following the day's feeding activity, the birds departed in the late afternoon for Coongie Lakes; a flight of at least 22km each way. Similar patterns of Cormorant movement were reported by Badman (1988) from the Lake Hope area, where the birds may have been flying up to 65km between feeding and roosting sites.

Hundreds of Great and Pied Cormorants were also observed on several occasions at Parachirrina and Deparanie Waterholes; departing in the morning and returning in the evening to roost. These birds were known to be feeding at nearby Lake McKinlay, and were also seen moving west of the waterholes to unknown sites.

Other waterholes within the Study Area noted to support significant numbers of waterbirds included Round, Tindilpie, Narie, Cartoonganie, Chillimookoo and Cooroomunchena, and Tythampana Dam. Waterbirds commonly observed at these sites included Australian Pelicans, Darters, Cormorants, Herons, Spoonbills and various species of duck. Unfortunately, many of these waterholes are becoming degraded by the impact of rabbits and the traditional grazing practice of placing livestock on these sites until they dry out.

3.2.3 Conclusions

Results of this study demonstrate that the Cooper floodplain can at times support very large numbers of waterbirds. These findings are consistent with other studies undertaken of birds on the Cooper system (including Reid 1984, Badman 1988, Reid & Gillen 1988, Kingsford & Porter 1991, Drewien & Best 1992, and Holmes 1992). Results of the Kanowana bird survey support the view that the various flooding and drawdown regimes are important for providing habitat for different types of waterbirds.

The more permanent lakes and waterholes serve as important refuge sites during drying and drought periods. From these areas, birds are able to respond to flood events and move into newly available habitat. The most important of these refuge areas is the Coongie Lakes system on the North West Branch of Cooper Creek (Reid & Gillen 1988). Another important site within the Coongie Lakes Wetland of International Importance is Lake Hope, which has been reported by Badman (1988) as providing important drought refuge for this area of the Cooper, and as an important fish feeding site for thousands of Australian Pelicans and Cormorants.

On a local scale, waterholes provide important roosting sites and serve as intermittent drought refuge areas for both terrestrial and waterbird species. They also provide important habitat for fish and aquatic invertebrates upon which many of the waterbirds depend for food. Waterholes are located throughout the Kanowana floodplain, and often contain water for up to three years following a flood event. In the case of drawdowns and new floods within these periods, these sites provide fish and other food stocks to colonise surrounding areas.

The diversity and numbers of waterbirds found in the region are a result of the habitat variation and productivity associated with the different phases of flooding and drying, and as birds are highly mobile they are able to take advantage of these changes over a large area. The Cooper Creek floodplain and associated overflows also provides important habitat in an otherwise arid environment to a diverse number of terrestrial birds, and serves as a corridor allowing for movement of birds throughout the district (Reid & Gillen 1988), including significant numbers of migratory waders (Kingsford & Porter 1991).

Upon reviewing known activities and responses of waterbirds on a regional scale within the Cooper Creek wetlands of South Australia, patterns are discernible; birds are seen to utilise the more permanently watered sites within the system as refuge areas during the drier phases, and move into newly flooded areas as they become available.

Reid and Gillen (1988) identified that "it will require further systematic, long-term studies, such as Badman's (1988), before a sound understanding of the region's birdlife, in terms of habitat preferences, seasonality and breeding patterns, can be assembled and presented". However, it is apparent that the long term maintenance of the habitats and conservation values of the Cooper Creek wetlands will depend on the development of approaches that provide an understanding of the physical and biological dynamics, wildlife requirements and management needs on a local, regional and catchment basis.

Table 3: Relative Abundance of Waterbirds Observed on the Study Area

Waterbird	Abundance* 1000+	1000-100	100-10	< 10
Australian Pelican	•			
Great Cormorant	•			
Grey Teal	•			
Pink-eared Duck	•			
Maned Duck	•			
Black-tailed Native-hen	•			
Eurasian Coot	•			
Red-necked Avocet	•			
Hoary-headed Grebe		•		
Pacific Heron		•		
White-faced Heron		•		
Pied Cormorant		•		
Little Black Cormorant		•		
Black Swan		•		
Hardhead		•		
Masked Lapwing		•		
Sharp-tailed Sandpiper		•		
Silver Gull		•		
Caspian Tern		•		
Australasian Grebe			•	
Darter			•	
Little Pied Cormorant			•	
Straw-necked Ibis			•	
Royal Spoonbill			•	
Yellow-billed Spoonbill			•	
Freckled Duck			•	
Australasian Shoveler			•	
Brolga			•	
Banded Lapwing			•	
Red-capped Plover			•	
Black-fronted Plover			•	
Black-winged Stilt			•	
Australian Pratincole			•	
Whiskered Tern			•	
Gull-billed Tern			•	
Great Egret				•
Rufous Night Heron				•
Sacred Ibis				•
Australian Shelduck				•
Pacific Black Duck				•
Blue-billed Duck				•
Musk Duck				•
Purple Swamphen				•
Red-kneed Dotterel				•
Greenshank				•
Marsh Sandpiper				•
Curlew Sandpiper				•

Ratings are based on estimates of birds present at a site and do not represent cumulative or regional counts. Site details are listed in Appendix K.

4 DISCUSSION

Arid Australia, covering some 70% of the continent, is considered as unique when compared with desert systems globally (Stafford-Smith & Morton 1990). This distinction is attributed to a number of factors, particularly the unpredictable nature of rainfall over this geographically vast area, and soils which are highly weathered, highly sorted and unusually poor in nutrients (ibid p261). On a global scale, both the Cooper Creek and Diamantina River systems appear to be unique in possessing catchments located within an arid zone, unlike most other desert river systems which originate in wetter regions (Puckeridge et al. 1993). Both rivers are exceptional in the scale of their floodplain development and the spatial and temporal variability of their flood events (Puckeridge 1993).

The presence of the extensive Kanowana Wetlands provides a highly significant and biologically rich oasis in an otherwise arid environment. The intermittent floodwaters and productive grey clay floodplains together with a subtle hydrological gradient with gentle variations in local relief have resulted in a myriad of nutrient enriched habitat niches. The relatively continuous production of riverine channels coupled with the intermittently rich production of associated floodouts and swamps support a rich and diverse biota. The result is a biologically dynamic and productive floodplain system of great significance both on a National and International scale, fully worthy of the status accorded to a Ramsar Wetland of International Importance.

During this survey, some 173 sites were established on the Study Area, 163 plant taxa were identified and 14 different floristic groups, one of which was previously considered as rare, were mapped. Opportunistic observations identified a total of 47 different waterbird species on the area with 8 species present in numbers greater than 1000 and a further 11 species present in numbers greater than 100 at one or more of the 19 sites surveyed for waterbird use. In addition several waterbird breeding rookeries were located on the Kanowana Block.

A recent study of the distribution and abundance of waterbirds following flooding of Lake Eyre - Cooper Creek found that the densities of waterbirds at the mouth of the Cooper and Warburton systems were comparable with the Alligator River region of the Northern Territory. The extensive integrated wetland systems of these Lake Eyre Basin wetlands could be viewed as a "desert Kakadu" (Kingsford & Porter 1991).

A biological survey of the Coongie Lakes district, which adjoins the Kanowana area, revealed over 350 species of plants, a highly diverse and at times abundant waterbird population, a diversity of reptiles and mammals, a significant fish community, a previously undescribed species of tortoise, and the richest frog community known in central Australia (Reid & Gillen 1988, Reid & Puckeridge 1990).

The nutrient enhanced floodplain corridors and immediately adjacent dunefields of North Eastern South Australia were known to support some 35 species of native mammals, unfortunately some are no longer found in the area and others are extinct (Kemper 1990). These extinctions were no doubt due in part to adverse impacts resulting from the ten species of introduced and feral animals that have been recorded from the region.

In comparison with seven other fauna studies conducted in the arid region of Australia, the channel country on the Cooper Creek in South West Queensland was found to have the highest diversity of all faunal terrestrial classes (McFarland 1992). Comparisons with other biogeographic regions within Queensland, including Cape York, revealed that the highest diversity of reptiles occurred in the Cooper region (ibid p37).

The great significance of the Cooper Creek and Lake Eyre Basin rivers is that they are relatively unmodified hydrologically, providing an increasingly rare opportunity to both protect and study the dynamics of naturally functioning desert river systems. This is especially relevant considering the ecological problems associated with the highly modified Murray-Darling River system and how the knowledge of these relatively unmodified systems could contribute to the rehabilitation and improved management of the Murray-Darling Basin wetlands.

Because the Cooper Creek system is dynamic, extensive and interdependent, management of declared conservation areas cannot be in isolation but must be viewed within the framework of total catchment management. The opportunity yet exits to develop integrated management programs within the Lake Eyre Basin that will avoid the fate that has befallen the Murray-Darling system.

Two recent events provide examples where seemingly isolated occurrences have the potential to impact detrimentally upon the ecology of the Cooper wetland system. In 1989 the Queensland Department of Primary Industries introduced the Murray Cod into the upper reaches of the Cooper. This species, which is entirely exotic to the Lake Eyre Basin, is a predator of other fish and the impacts on the existing fish communities and populations are unknown.

More recently, in 1992 the Department of Fisheries in South Australia granted a licence for the commercial exploitation of Callop on the lower Cooper in the Lake Hope area which is located within the Coongie Wetlands of International Importance. The Callop of the Lake Eyre Basin has recently been identified as a separate species (Puckeridge pers.comm.).

The establishment of commercial fishing on the Cooper system could prove detrimental to the numerous pelicans, cormorants and other birds that depend on fish as a food source and interfere with the movement of fish during flood events. In both cases, the lack of appropriate research and monitoring programs precludes sufficient understanding of these events on the dynamics of the system.

There is an obvious need to identify the different users and activities along with the possible adverse impacts on the ecology of the Lake Eyre Basin and associated catchment areas. Such a review needs to determine how multiple use interacts in a synergistic manner and the cumulative nature of impacts over time. A recent approach used in a study of the cumulative impacts of oil fields in Northern Alaskan landscapes could serve as a useful model (Walker et al. 1987).

The coexistence of the oil-gas and pastoral industries in the Kanowana Wetlands highlights how individual industries not only have identifiable direct impacts when reviewed separately, but may also contribute to and compound additional impacts. While it is recognised that both industries have improved practices in recent times, past and continuing activities are still of concern and the understanding of cumulative impacts is yet to be addressed.

The impact of cattle grazing within the Cooper Creek system has been well documented (Dixon 1892, Reeves 1975, Division of Land Utilisation 1980, EPRG 1980, Mollenmans et al. 1984, Harrington et al. 1984, Land Assessment Branch 1986, Reid & Gillen 1988, Wright et al. 1990 and McFarland 1992).

Over the past decades the Kanowana Block was relatively free of stock until the recent floods. During the Kanowana survey (April-August 1992) cattle presence was observed at 51% of all sites assessed. Grazing pressure and affiliated impacts varied in intensity and severity across the Study Area (Plates 1-5). As would be expected, the heaviest impact was noted around the major waterholes of the Main and Kanowana Channels and the Northern Overflow. Specific impacts included heavy grazing and trampling of vegetation fringing waterholes, loss of ground litter and compaction and pulverisation of soil. In more severe instances, such as encountered in the area of Salt Well Waterhole, even the less palatable species such as *Muehlenbeckia cunninghamii* (lignum) were severely grazed.

Many of the recently dried lake beds displayed signs of soil compaction and pugging with grazing pressure being particularly high on lake beds carrying an extensive cover of the nitrogen fixing legume, *Trigonella suavissima* (Cooper clover). Lakes McKinlay, Watchiewatchina and Moolionburrina, all terminally draining from the Northern Overflow and all still containing water during the survey period, contained heavily grazed lake margins with severe denudation of vegetation and grazing of less palatable species. Also many of the dune areas adjacent to the lakes and channel areas still containing water showed clear evidence of disturbance as cattle foraged further afield from water following a decline in the availability of feed on the lake and channel margins.

To date, limited data exists on the long term effects and impacts of cattle on the wetland systems of Cooper Creek. Associated with the production and marketing of cattle is the concomitant removal of nutrients from the floodplain and the wetland system. The long term ecological consequences of the cumulative export of nutrients from the wetland habitats is unknown. Research and monitoring programs are warranted to gain a better understanding of the impacts and sustainable viability of this major land use in the region.

Exploration activities associated with the oil and gas industry have left an extensive network of seismic tracks and occasional rig roads across much of the Cooper floodplain. This access network has developed over several decades and although the practice associated with their creation has improved in recent years, the presence of these roads continues to exert an influence on the area.

Seismic track production involved extensive soil disturbance across floodplain and dunefield, with the concomitant clearance of most vegetation. As discussed, gentle floodplain gradients, low local relief and the variability of flood events mean that even minor physical barriers, such as that presented by windrows associated with track creation, can disrupt the natural inundation of considerable areas of floodplain (Plates 6-8). The indirect impact of seismic tracks along with the cumulative hydrological disruption caused by multiple barriers on flooding and floodplain vegetation should be examined.

An additional consequence of the track and road network provided by the oil and gas industry is their use by the pastoral industry and recreationists to gain access to hitherto relatively inaccessible areas of the floodplain. The abundance of access tracks readily enables pastoralists to quickly respond to local rain and flood events throughout the floodplain area. The resulting grazing use could be exploitative and have deleterious implications for the long term recovery and sustainability of the wetland habitats and vegetation resources.

The Innamincka Regional Reserve, adjoining the Kanowana Block and containing significant wetland habitat including the Coongie Lakes, was dedicated to reconcile the obvious need for conservation management in an area subject to multiple use, principally for hydrocarbon exploration and production, pastoralism and tourism. However there are concerns that this reconciliation process has not displayed an equal commitment to enhancing conservation, but has merely maintained the status quo. Although agreements have been established regarding oil and gas exploration activities in the sensitive wetland areas of the Coongie Lakes on Innamincka, the lease for pastoralism provides for continued livestock use of areas deemed to be significant for wildlife management and conservation (LAB 1986, Reid & Gillen 1988).

It should be recognised that areas exist within the Cooper Creek floodplain whose conservation values will be degraded by continued livestock grazing. Currently no areas within the Coongie Lakes Wetland of International Importance are protected from commercial livestock use. Prior studies have identified the Coongie Lakes (Reid & Gillen 1988) and Lake Hope (Badman 1989) as key biological areas. The latter site is now subject to both livestock grazing and commercial fishing.

This study has shown that the Kanowana Block contains significant wetland habitat. It is recommended that the grazing rights be purchased, and the area managed principally for its conservation values. State Cabinet has approved that the Block be acquired and added to the State's reserve system. Federal assistance with the purchase of Kanowana, and with the management of the Coongie Lakes Wetland of International Importance would enable the South Australian National Parks and Wildlife Service to manage for conservation objectives and expectations on a significant section of the Cooper floodplain.

5 FURTHER WORK

The development of integrated catchment management programs is the best approach to ensuring long term retention and protection of the hydrological integrity and associated biodiversity of the Cooper Creek and Lake Eyre Basin wetlands. A review needs to be undertaken of the multiple users operating within the Basin to examine their activities, associated impacts and most importantly their cumulative effects over time.

Essential to the process of catchment management is the requirement for an understanding of the biological components comprising the Lake Eyre Basin system, how they relate to each other and how they change over time. The continued vegetation mapping of the Cooper Creek system and expansion of the program to other rivers of the Basin would provide an inventory of these systems and the basis for further biological and monitoring investigations. This approach has been adapted successfully at a regional level in South Australia, with a preliminary mapping program enabling the efficient location of sites for subsequent faunal surveys.

Further surveys should incorporate a soil survey component in order to contribute to the necessary clarification of possible factors determining the range and distribution of plant species and associations. A network of long term monitoring points should also be established in conjunction with vegetation work to enable the quantification of change over time, particularly relevant considering the potential impact of global climate change together with increased commercial and recreational use of the region.

Fundamental to an understanding of the biological dynamics of the wetlands of the Cooper Creek and Lake Eyre Basin, is an understanding of the complex hydrology of the wetland systems. The existing network of hydrometric stations has been recognised as being inadequate for assessment of surface water processes in the Basin (Kotwicki 1986, Allan 1988) and a systematic approach needs to be developed to provide basic data. Studies should also be undertaken of water quality as changes in land use could impact these factors in the future.

It is recommended that within the Kanowana Wetlands Study Area a flow monitoring station could be usefully sited on Hamilton Creek at the beginning of the Northern Overflow to gauge floodwaters entering the wetlands from the Coongie Lakes system via the North West Channel. An additional monitoring station on Christmas Creek and one further south on the Main Channel towards Lake Hope would further enhance an understanding of the hydrologic regimes of the Kanowana Wetlands.

To successfully develop and implement integrated management will require the involvement and cooperation of the multiple-use interests within the Lake Eyre Basin including various State and Federal Government agencies.

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Description of Plates

Plate 1: The atypical form of a grazed *Muehlenbeckia cunninghamii* (lignum) shrub. Evidence of the extent of cattle grazing pressure at Salt-well Waterhole.

Plate 2: Soil disturbance and heavy grazing pressure evident on a lake bed south east of Horseshoe Waterhole.

Plate 3: A *Sporobolus mitchelii* (rat's tail couch) grassland in the vicinity of Chillimookoo Waterhole. The Plate clearly shows heavily grazed grassland in the foreground contrasting with ungrazed grassland beyond the fence.

Plate 4: A vast *Sporobolus mitchellii* grassland on Lake Karangie in the north east of the Study Area, strongly contrasting with the situation illustrated in Plate 3.

Plate 5: A dune adjacent to Lake Massacre reveals the impact of cattle foraging for feed further afield from the floodplain.

Plate 6: A seismic track associated with the exploration activity of the hydrocarbons industry. Methods have improved, however, older tracks such as this can still be effective barriers to the inundation of areas of floodplain.

Plate 7: Localised ponding of water illustrates the potentially disruptive effect on floodplain hydrology of the network of seismic tracks and access roads.

Plate 8: A rig road providing access to a hydrocarbon well site in Thykamingka Swamp is also utilised by the pastoral industry. In the background are portable cattle yards.

Plate 1

Plate 2

Plate 3

Plate 4

Plate 5

Plate 6

Plate 7

Plate 8

Appendix A: Wetlands of International Importance

A wetland is suitable for inclusion in the List if it meets any one of the criteria set out below.

1 Criteria for assessing the value of representative or unique wetlands

A wetland should be considered internationally important if it is a particularly good example of a specific type of wetland characteristic of its region.

2 General criteria for using plants or animals to identify wetlands of importance

A wetland should be considered internationally importance if it:

a) supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species; or

b) is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna;

c) is of special value as the habitat of plants or animals at a critical stage of their biological cycles; or

d) is of special value for its endemic plant or animal species or communities.

3 Specific criteria for using waterfowl to identify wetlands of importance

A wetland should be considered internationally important if:

- it regularly supports 20 000 waterfowl;
- it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity; or
- where data on populations are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

4 Guidelines for application of the criteria

A wetland could be considered for selection under Criterion 1 if it:

- is an example of a type rare or unusual in the appropriate biogeographical region;
- is a particularly good representative example of a wetland characteristic of the appropriate region;
- is a particularly good representative of a common type where the site also qualifies for consideration under criteria 2a, 2b, or 2c;
- is representative of a type by virtue of being part of a complex of high quality wetland habitats. A wetland of national value could be considered of international importance if it has a substantial hydrological, biological or ecological role in the functioning of an international river basin or coastal system; or
- is a wetland in a developing country, which because of its outstanding hydrological, biological or ecological role, is of substantial socio-economic and cultural value within the framework of sustainable use and habitat conservation.

The wise use of wetlands is their sustainable utilization for the benefit of humankind in a way compatible with maintenance of the natural properties of the ecosystem.

Appendix A (Cont.)

The contracting parties meet every three years to discuss national programs, to review the status of sites on the List, to hear reports from international organisations and to make decisions on the functioning of the Convention. In 1987 the Conference established a financial regime, a Standing Committee and a Bureau. The Standing Committee, which is comprised of representatives of contracting parties, carries out interim activities between Conferences. The independent Ramsar Bureau, administered by IUCN in cooperation with International Waterfowl Research Bureau, provides a permanent structure for administrative, scientific and technical support. UNESCO acts as Convention Depositary.

The IUCN definition for wetlands, adopted by the Ramsar Convention under Article 1 states that: "Wetlands are areas of marsh, fen, peatlands 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 of which at low tide does not exceed six metres".

Wetlands of International Importance in South Australia

Title of Wetland	**Designation Date**	**Area (ha)**
Riverland	September 1987	30 600
Bool and Hacks Lagoon	November 1985	3 200
Coongie Lakes	June 1987	1 980 000
Coorong and Lakes Albert and Alexandrina	November 1985	Coorong 47 700, Albert 16 800 Alexandrina 76 000

The modified Ramsar Convention's Wetland Classification System for use in the South Australian Directory of Important Wetlands is presented below.

A Marine and Coastal Wetlands

1 Marine waters - permanent shallow waters less than six metres deep at low tide; includes sea bays, straits
2 Subtidal aquatic beds; includes kelp beds, sea-grasses, tropical marine meadows
3 Coral reefs
4 Rocky marine shores; includes rocky offshore islands, sea cliffs
5 Sand, shingle or pebble beaches; includes sand bars, spits, sandy islets
6 Estuarine waters; permanent waters of estuaries and estuarine systems of deltas
7 Intertidal mud, sand or salt flats
8 Intertidal forested wetlands; includes slalt-marshes, salt meadows, saltings, raised salt marshes, tidal brachish and freshwater marshes
9 Intertidal forested wetlands; includes mangrove swamps, nipa swamps, tidal freshwater swamp forests
10 Brackish to saline lagoons with one or more relatively narrow, permanent and/or intermittent connection with the sea
11 Freshwater lagoons and marshes in the coastal zone; includes delta lagoon and marsh systems

Appendix A (Cont.)

B Inland Wetlands

1 Permanent rivers and streams; includes waterfalls
2 Seasonal and irregular rivers and streams
3 Inland deltas (permanent)
4 Riverine floodplains; includes river flats, flooded river basins, seasonaly flooded grassland, savanna and palm savanna
5 Permanent freshwater lakes (> 8 ha); includes large oxbow lakes
6 Seasonal/intermittent freshwater lakes (> 8 ha), floodplain lakes
7 Permanent saline/brackish lakes
8 Seasonal/intermittent saline/brackish lakes
9 Permanent freshwater ponds (< 8 ha), marshes and swamps on inorganic soils; with emergent vegetation waterlogged for at least most of the growing season
10 Seasonal/intermittent freshwater ponds and marshes on inorganic soil; includes sloughs, potholes; seasonaly flooded meadows, sedge marshes
11 Permanent saline/brackish marshes
12 Seasonal/intermittent saline/brackish marshes
13 Shrub swamps; shrub-dominated freshwater marsh, shrub carr, alder thicket on inorganic soils
14 Freshwater swamp forest; seasonally flooded forest, wooded swamps; on inorganic soils
15 Peatlands; forest, shrub or open bogs
16 Alpine and tundra wetlands; includes alpine meadows, tundra pools, temporary waters from snow melt
17 Freshwater springs, oases
18 Geothermal wetlands
19 Inland, subterranean karst wetlands

C Man-Made Wetlands

1 Water storage areas; reservoirs, barrages, hydro-electric dams, impoundments (generally > 8 ha)
2 Ponds, including farm ponds, stock ponds, small tanks (generally < 8 ha)
3 Aquaculture ponds; fish ponds, shrimp ponds
4 Salt exploitation; salt pans, salinas
5 Excavations; grave pits, borrow pits, mining pools
6 Wastewater treatment; sewage farms, settling ponds, oxidation basins
7 Irrigated land and irrigation channels; rice fields, canals, ditches
8 Seasonally flooded arable land, farm land
9 Canals

Appendix B: Japan Australia Migratory Birds Agreement

Agreement Between the Government of Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment

The Government of Australia and the Government of Japan,

Considering that birds constitute an important element in the natural environment and play an essential role in enriching the natural environment and that this role may be enhanced by proper management thereof,

Recognising the special international concern, as expressed, for example, at the United Nations conference on the Human Environment, for the protection of migratory birds and birds in danger of extinction,

Noting the existence of bilateral and multilateral agreements for the protection of migratory birds and birds in danger of extinction,

Considering that many species of birds migrate between Australia and Japan and live seasonally in the respective countries and that there are certain species of birds which are in danger of extinction and also that co-operation between the two Governments is essential for the conservation of these birds, and

Desiring to co-operate in taking measures for the management and protection of migratory birds and birds in danger of extinction and also for the management and protection of their environments,

Have agreed as follows:

Article I

1 In this Agreement, the term "migratory birds" means:
   a) the species of birds for which there is reliable evidence of migration between the two countries from the recovery of bands or other markers; and
   b) the species of birds with subspecies common to both countries or, in the absence of subspecies, the species of birds common to both countries (excepting those whose nonmigratory nature is biologically evident). The identification of these species and subspecies shall be based upon specimens, photographs or other reliable evidence.

2 a) The list of the species defined as migratory birds in accordance with paragraph 1 of this Article is contained in the Annex to this Agreement.
   b) The competent authorities of the two Governments shall review from time to time the Annex and, if necessary, make recommendations to their respective Governments to amend it.
   c) The Annex shall be considered amended three months after the date upon which the two Governments confirm, by an exchange of diplomatic notes, their respective acceptance of such recommendations.

Appendix B (Cont.)

Article II

1 Each Government shall prohibit the taking of migratory birds or their eggs. However, exceptions to the prohibition of taking may be permitted in accordance with the laws and regulations in force in each country in the following cases:
a) for scientific, educational, propagative or other specific purposes not inconsistent with the objectives of this Agreement;
b) for the purpose of protecting persons and property;
c) during hunting seasons established in accordance with paragraph 3 of this Article; and
d) to allow the hunting and gathering of specified birds or their eggs by the inhabitants of certain regions who have traditionally carried on such activities for their own food, clothing or cultural purposes, provided that the population of each species is maintained in optimum numbers and that adequate preservation of the species is not prejudiced.

2 Each Government shall prohibit any sale, purchase or exchange of migratory birds or their eggs, whether they are alive or dead, except those taken in accordance with the second sentence of paragraph 1 of this Article, or of the products thereof or their parts.

3 Each Government may establish seasons for hunting migratory birds taking into account the maintenance of normal annual reproduction of those birds.

Article III

1 Each Government shall take special protective measures, as appropriate, for the preservation of species or subspecies of birds which are in danger of extinction.

2 Whenever either Government has determined the species or subspecies of birds which are in danger of extinction and taken special protective measures therefore, the Government shall inform the other Government of such determination and of any cancellation thereafter of such determination.

3 Each Government shall control the exportation or importation of such species or subspecies of birds as are determined in accordance with paragraph 2 of this Article, and of the products thereof.

Article IV

1 The two Governments shall exchange data and publications regarding research on migratory birds and birds in danger of extinction.

2 Each Government shall encourage the formulation of joint research programs on migratory birds and birds in danger of extinction.

3 Each Government shall encourage the conservation of migratory birds and birds in danger of extinction.

Article V

Each Government shall endeavour to establish sanctuaries and other facilities for the management and protection of migratory birds and birds in danger of extinction and also of their environment.

Article VI

Each Government shall endeavour to take appropriate measures to preserve and enhance the environment of birds protected under the provisions of this Agreement. In particular, it shall:

a) seek means to prevent damage to such birds and their environment;
b) endeavour to take such measures as may be necessary to control the importation of animals and plants which it determines to be hazardous to the preservation of such birds; and
c) endeavour to take such measures as may be necessary to control the introduction of animals and plants which could disturb the ecosystems of unique island environments.

Appendix B (Cont.)

Article VII
Each Government agrees to take measures necessary to carry out the purposes of this Agreement.

Article VIII
Upon the request of either Government, the two Governments shall hold consultations regarding the operation of this Agreement.

Article IX
1 This Agreement shall be ratifies and the instruments of ratification shall be exchanged at Canberra as soon as possible.
2 This Agreement shall enter into force on the date of the exchange of the instruments of ratification. It shall remain in force for fifteen years and shall continue in force thereafter until terminated as provided herein.
3 Either Government may, by giving one year's notice in writing, terminate this Agreement at the end of the initial fifteen year period or at any time thereafter.

IN WITNESS WHEREOF the undersigned, being duly authorised by their respective Governments, have signed this Agreement.

DONE in duplicate, in the English and Japanese languages, each text being equally authentic, at Tokyo, this sixth day of February, one thousand nine hundred and seventy-four.

For the Government of Australia

DJ Horne
L.S.

For the Government of Japan

Masayoshi Ohira
L.S.

JAMBA and CAMBA Listed Birds Recorded in the Coongie Lakes Wetland of International Importance

Species*	JAMBA	CAMBA	Species*	JAMBA	CAMBA
Cattle Egret	•	•	Latham's Snipe	•	•
Great Egret	•	•	Black-tailed Godwit	•	•
Glossy Ibis		•	Red Knot	•	•
			Pectoral Sandpiper	•	
Northern Shoveler	•	•	Sharp-tailed Sandpiper	•	•
White-bellied Sea-eagle		•	Red-necked Stint	•	•
Painted Snipe		•	Curlew Sandpiper	•	•
Grey Plover	•	•	Ruff	•	•
Lesser Golden Plover	•	•	White-winged Tern	•	•
Oriental Plover	•		Caspian Tern	•	•
Whimbrel	•	•			
Wood Sandpiper	•	•	Fork-tailed Swift	•	•
Common Sandpiper	•	•	Rainbow Bee-eater	•	
Greenshank	•	•			
Marsh Sandpiper	•	•	Night Parrot (Endangered)	•	

* Species list derived from: Reid 1984, May 1986, Reid & Gillen 1988, Badman 1989, Reid et al. 1990, Holmes 1992.

Appendix C: Cooper and Strzelecki Creeks Flow Classes
(from Mollemans et al. 1984)

Flows caused by rainfall in the catchment of the Cooper Creek have been divided into four main classes, while local rains can also initiate flow. The four flow classes are:

- **Class 1 Flows** - average flows which generally occur annually between April and July, and are contained within channels. Water flows as far as Cuttapirie Corner on the Main Channel and Coongie Lake on the North West Channel. The outer limit of this regular inundation is clearly delineated by remnants of northern river red gum (*Eucalyptus camaldulensis var. obtusa*).
- **Class 2 Flows** (Level I Floods) - moderately above average flows stimulated by above average rainfall in the catchment. Occur every three to four years on average. May push floodwater as far as Lake Hope on the Main Channel, and Lake Goyder on the North West Branch, with floodwaters creeping out onto the floodplain in lower lying areas.
- **Class 3 Flows** (Level II Floods) - well above average flows occurring more rarely, in response to much greater than average rainfall in the catchment (about every six to ten years on average). Result in significant inundation of much of the Cooper Creek floodplain. Floodwaters may reach Lake Eyre, and usually fill Lake Hope to capacity. In an historical summary of flood data on the Cooper Creek, Badman (1989) has determined that floods reach the Birdsville Track crossing of the Main Channel about once every five years.
- **Class 4 Flows** (Level III Floods) - extreme flows during rare events, as a result of heavy rainfall over an extended period. May be associated with the anti-ENSO phase. Extended periods of rainfall in the catchment area result in the floodplain system being submerged, with incursions of water into interdunal areas, and floodwaters reaching Lake Eyre. Occur every 40-60 years on average. An appreciation of the scale and nature of such a flood event can be gained from comparing the Landsat image of the 1974 floods with images portraying the same area under more typical conditions (Appendix E).

The amount and intensity of rainfall events in the catchment are not the only determinants of the magnitude of flows along the Cooper Creek. Time of year in which flow events occur is an important consideration, as in summer high evaporation rates may significantly reduce the area affected by floodwaters. Also, the main channel and parts of the floodplain may be blocked by wind blown sands. Only the more significant flow classes would have sufficient velocity to clear the channels and open up the pathway to Lake Eyre. Additional factors are the time between flow events, and the number of drought years between such events. Level 2 and 3 floods are from more than one rainfall event. Channel floors and margins are saturated (and cleared) by the initial pulse, enabling subsequent pulses to travel faster and further before loss of impetus occurs.

Appendix D: Classification of Study Area Wetlands
(after Paijmans et al. 1985)

Wetlands are defined as "Land permanently under water or waterlogged. Temporary wetlands must have surface water or waterlogging of sufficient frequency and/or duration to affect the biota. Thus the occurrence at least sometimes, of hydrophytic vegetation or use by waterbirds are necessary attributes. This wide definition includes some areas where wetland nature is arguable, notably land subject to inundation but having little or not hydrophytic vegetation, and bare 'dry lakes' in the arid interior" (Paijmans et al. 1985 p1).

The wetlands present at Kanowana have been classified into the following categories and classes:

Lakes

- permanent and near permanent floodplain lakes including permanent and near permanent waterholes
- intermittent floodplain lakes
- intermittent floodplain lakes in terminal drainage basins
- episodic lakes in terminal drainage basins

Swamps

- seasonal floodplain swamps
- intermittent floodplain swamps
- intermittent swamps in terminal drainage basins

Land Subject to Inundation

- seasonally inundated floodplains
- seasonally inundated river and creek banks
- intermittently inundated floodplains
- intermittently inundated river and creek banks

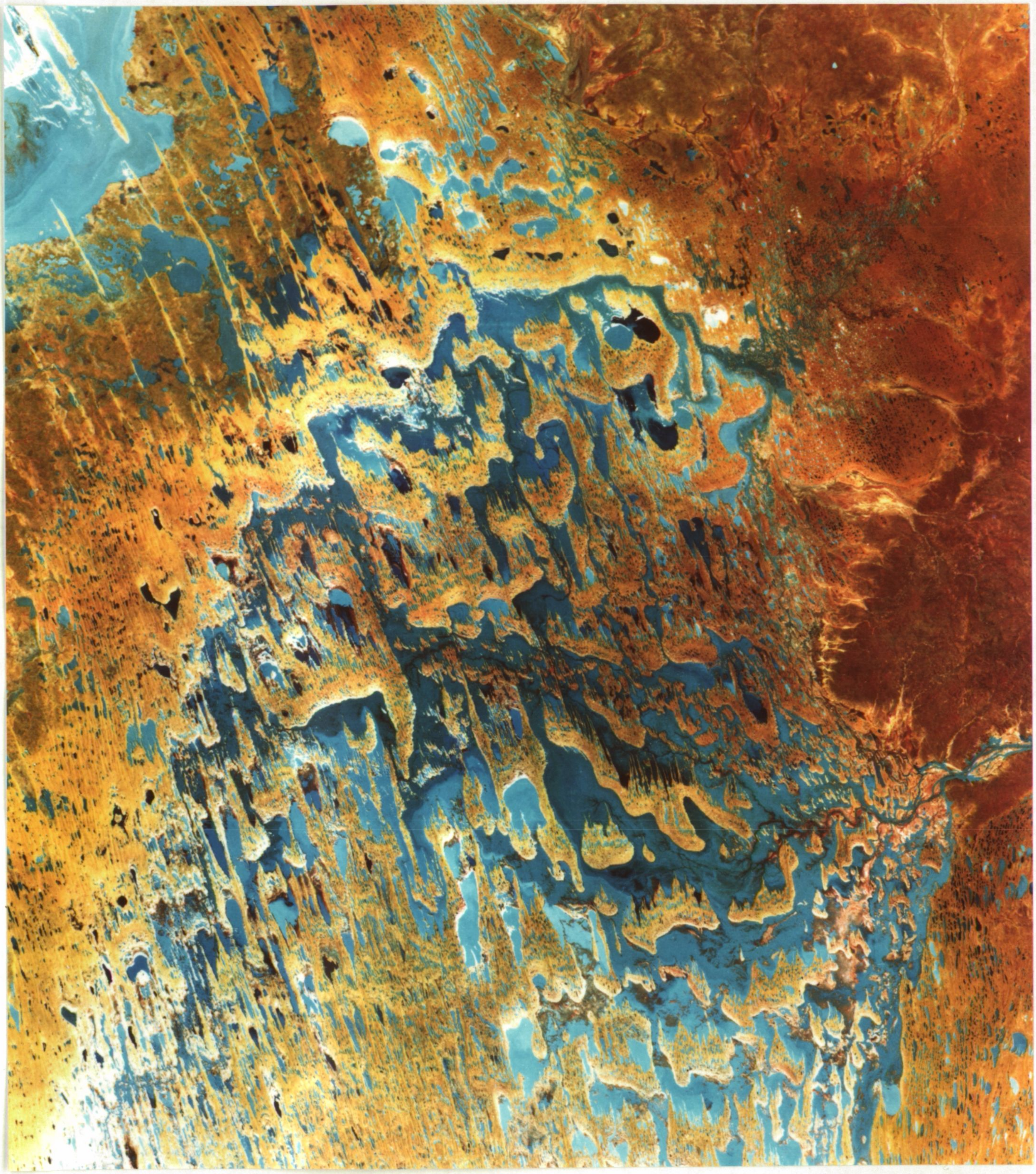
River and Creek Channels

- seasonal silty/clayey channels
- intermittent silty/clayey channels
- episodic silty/clayey channels

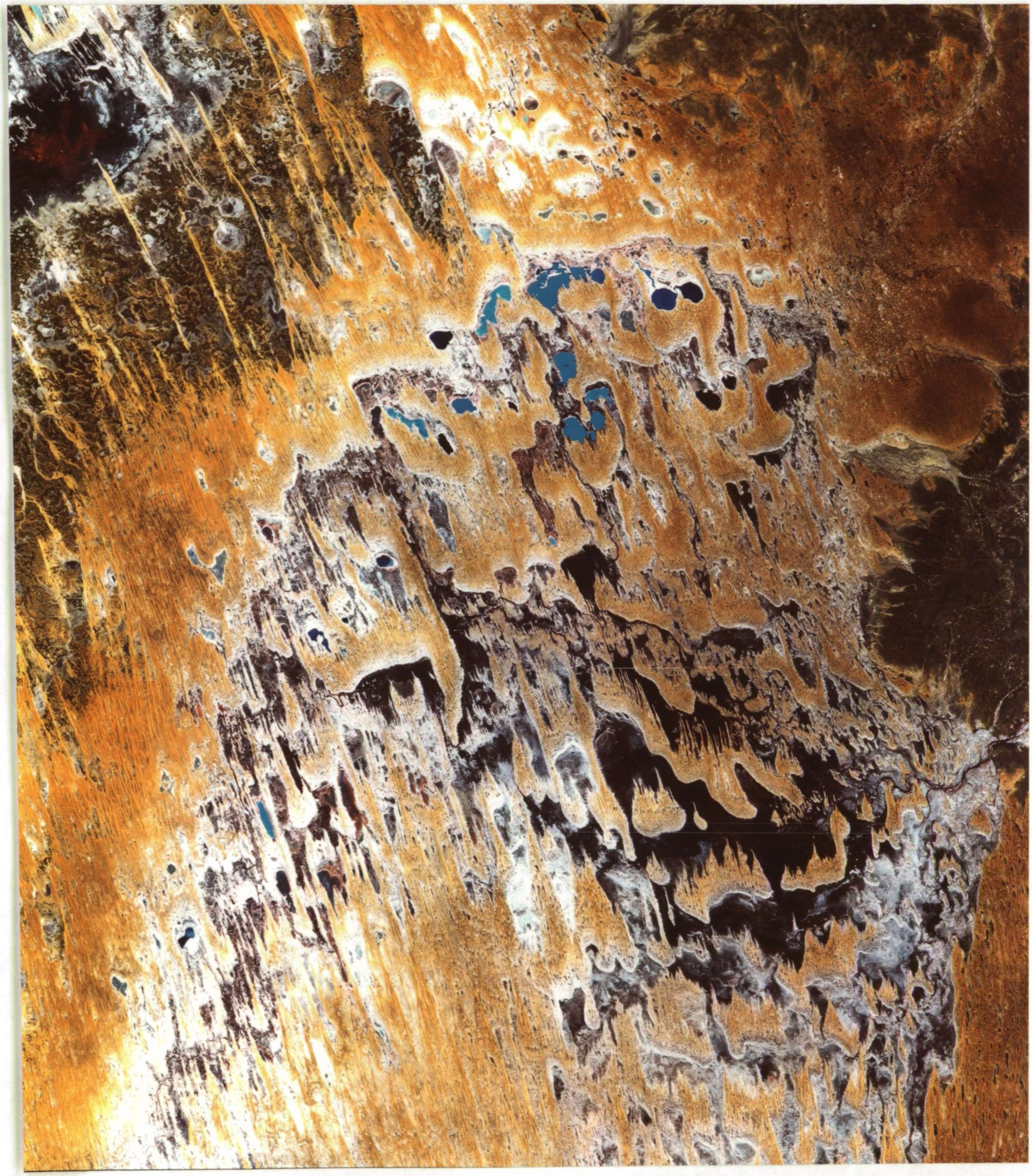
Appendix E: Satellite Images - North East Wetlands

1 (Landsat 1, 7.2.74)
The flood events of 1974 fully inundated the floodplain system of the Cooper. The Cooper is shown entering South Australia from Queensland in the bottom right corner of the image. The Kanowana Wetlands Study Area extends from left of centre to the bottom left corner of the image. The great expanse of blue in the top left represents the flood-waers of Goyders Lagoon; part of the extensive Diamantina floodplain system.

2 (Landsat 1, 15.11.72)
A contrasting image representing the Cooper floodplain system before the 1974 floods. The blue cluster of lakes associated with the Coongie Lakes complex is sharply defined in the top centre of the image. Lakes associated with the Northern Overflow to the left of Coongie Lakes are also shown to be inundated. On the Main Channel in the lower left of the image, a thin extended streak of blue represents a fully inundated Lake Coogiecoogina depicted on the front and rear covers of this report.



1



2

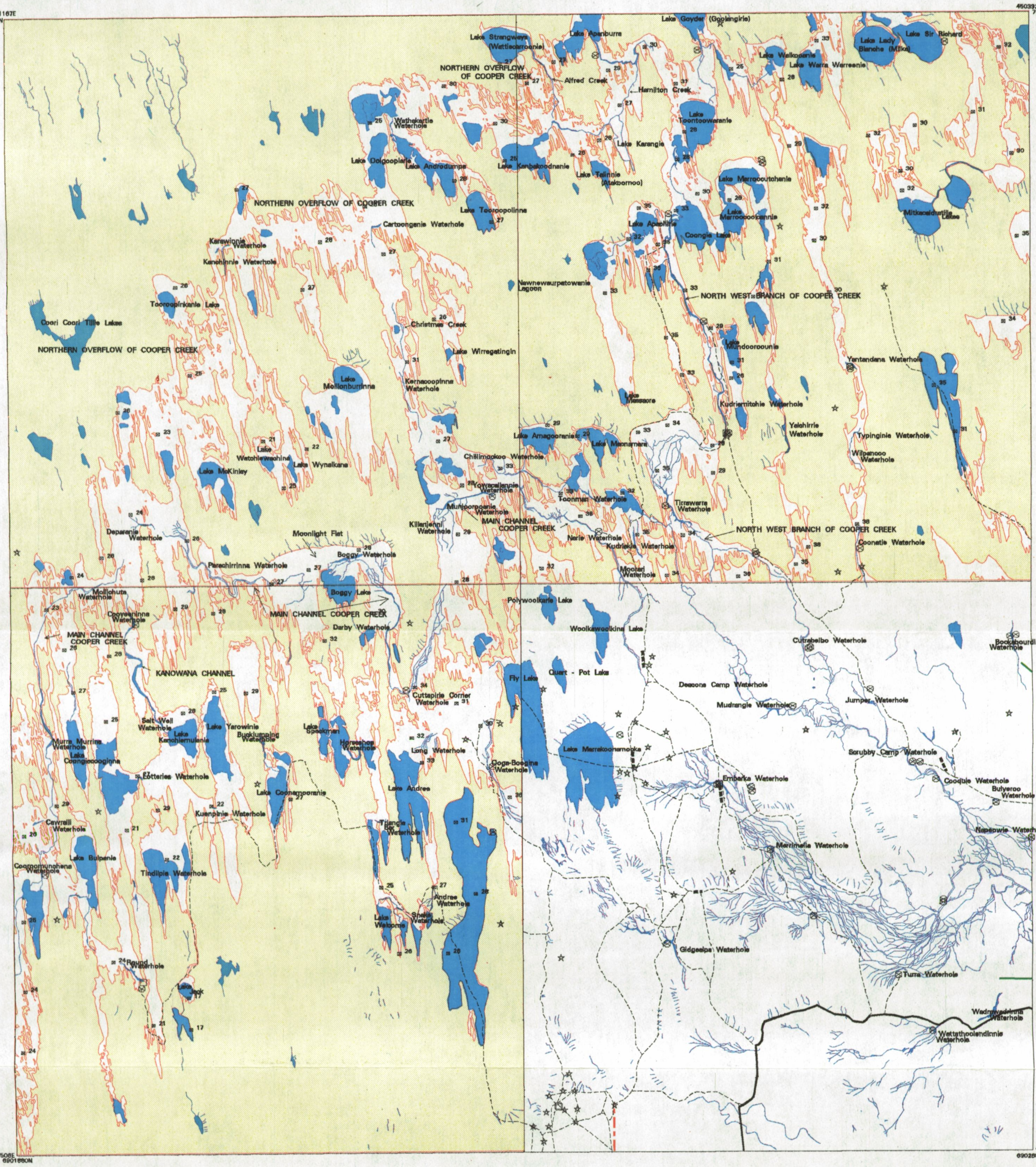
Appendix F: Maps of the Study Area

1 Floodplain Characteristics

2 Survey Site Distribution

3 Vegetation Associations

KANOWANA WETLANDS STUDY AREA



ONE LANE, UNSEALED ROAD
VEHICULAR TRACK
LANDING GROUND, AIRSTRIP
NON ACCESS (e.g. pipeline,fence)
CLEARED LINE
CREEKLINE
DRAINAGE
DUNEFIELD (including floodplain dunes)
VEGETATION

CLEARED POINT (e.g. quarry,dam,yard,mine)
OCCUPIED BUILDING (e.g. homestead)
UNOCCUPIED BUILDING (e.g. ruin,shed)
OTHER STRUCTURES (e.g. trig stations,tank,well)
ELEVATION (m)

ENVIRONMENTAL DATABASE

24-FEB-1993

GIS Section
S.A. Office of Planning and Urban Development

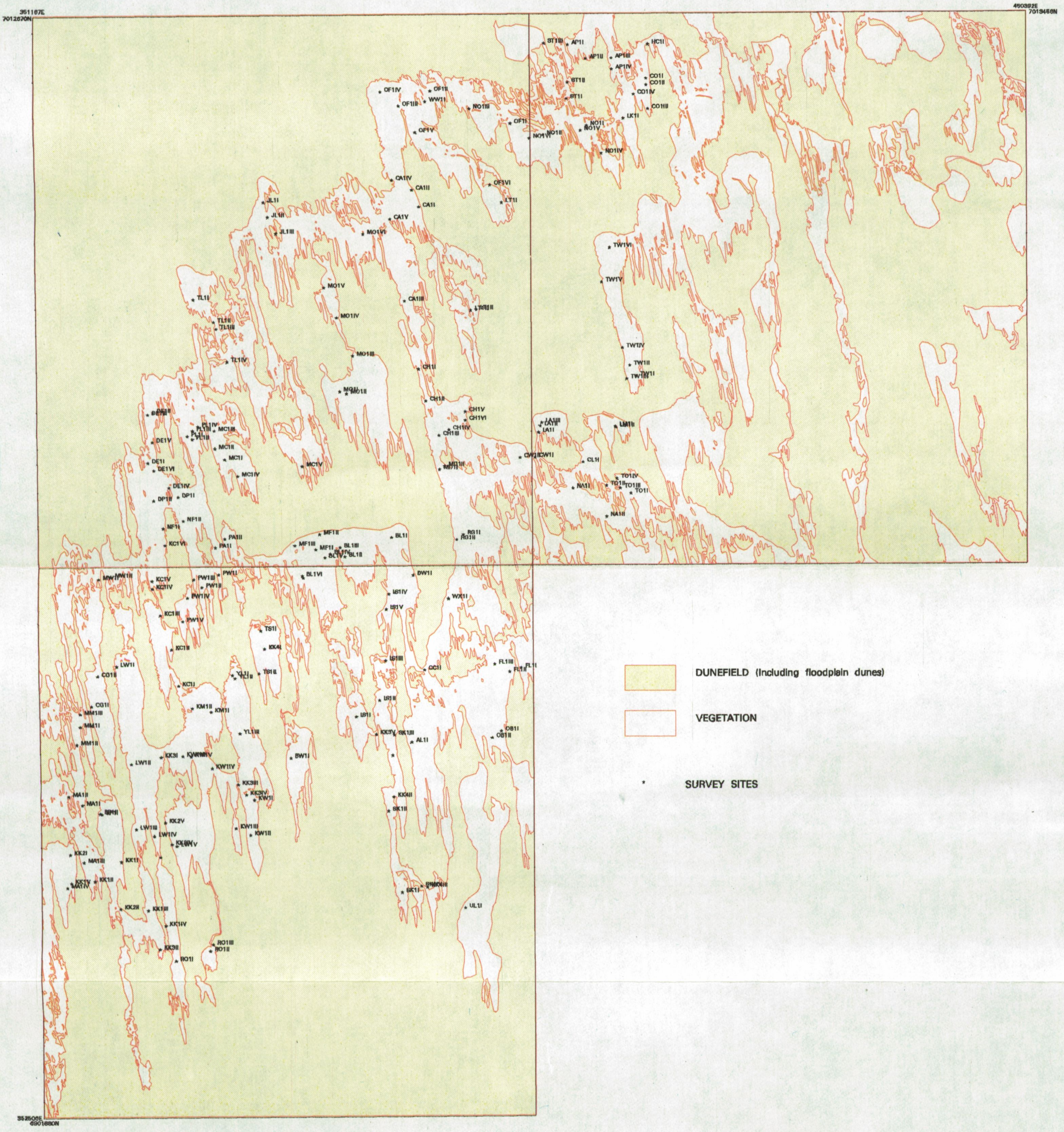
0 20km

FUNDED BY: AUSTRALIAN NATIONAL PARKS & WILDLIFE SERVICE

PROJECTION : Transverse Mercator
G.I.S. SOFTWARE : E.S.R.I.'s ARC/Info

KANOWANA WETLANDS STUDY AREA

FLOODPLAIN EXTENT & SITE DISTRIBUTION



DUNEFIELD (including floodplain dunes)

VEGETATION

SURVEY SITES

ENVIRONMENTAL DATABASE

19-FEB-1993

GIS Section
S.A. Office of Planning
and Urban Development

0 20km

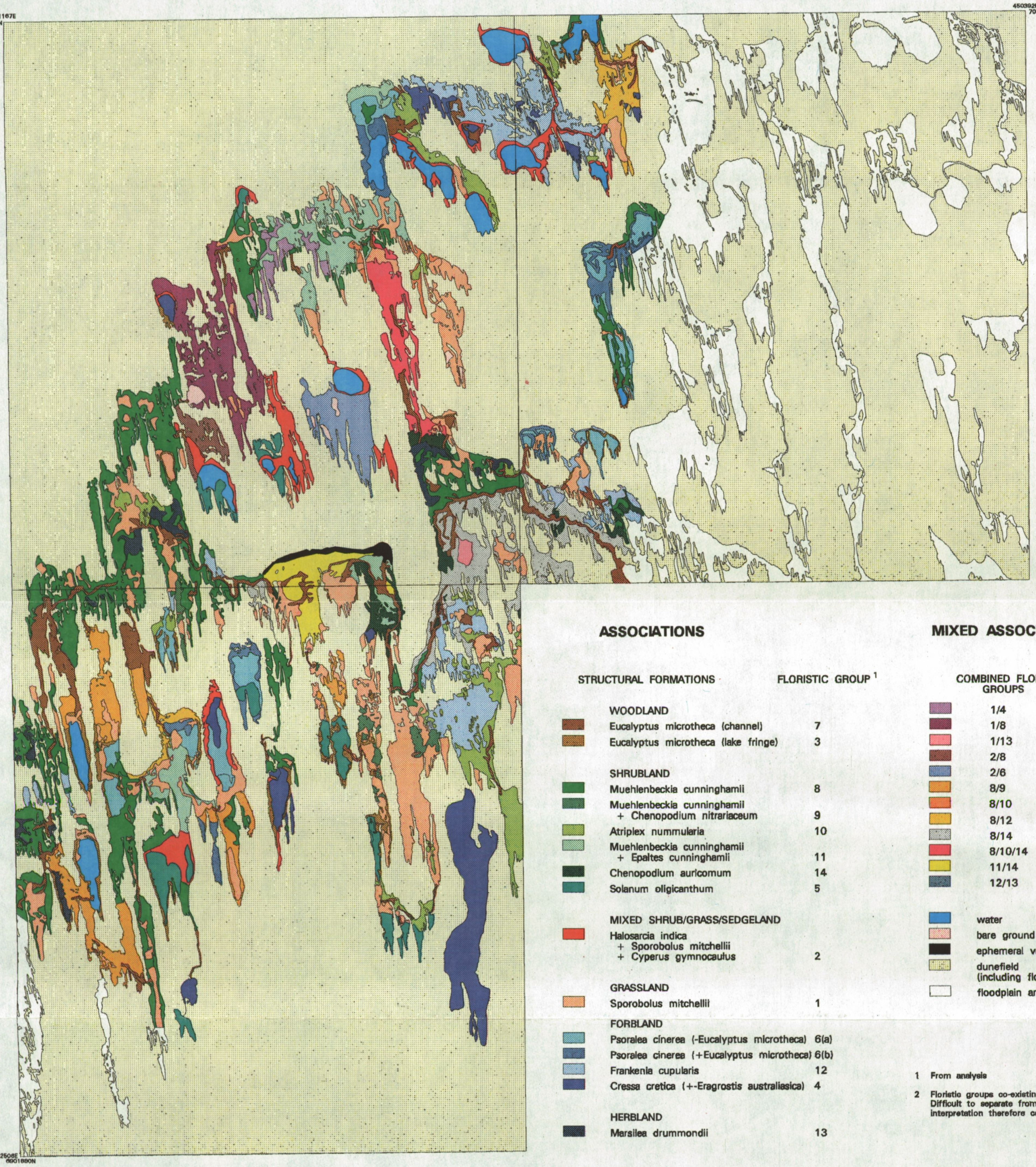
PROJECTION : Transverse Mercator

G.I.S. SOFTWARE : E.S.R.I.'s ARC/Info

FUNDED BY: AUSTRALIAN NATIONAL PARKS & WILDLIFE SERVICE

KANOWANA WETLANDS STUDY AREA

VEGETATION



ASSOCIATIONS

STRUCTURAL FORMATIONS — FLORISTIC GROUP [1]

WOODLAND

Structural formation	Floristic group
Eucalyptus microtheca (channel)	7
Eucalyptus microtheca (lake fringe)	3

SHRUBLAND

Structural formation	Floristic group
Muehlenbeckia cunninghamii	8
Muehlenbeckia cunninghamii + Chenopodium nitrariaceum	9
Atriplex nummularia	10
Muehlenbeckia cunninghamii + Epaltes cunninghamii	11
Chenopodium auricomum	14
Solanum oligicanthum	5

MIXED SHRUB/GRASS/SEDGELAND

Structural formation	Floristic group
Halosarcia indica + Sporobolus mitchellii + Cyperus gymnocaulus	2

GRASSLAND

Structural formation	Floristic group
Sporobolus mitchellii	1

FORBLAND

Structural formation	Floristic group
Psoralea cinerea (-Eucalyptus microtheca)	6(a)
Psoralea cinerea (+Eucalyptus microtheca)	6(b)
Frankenia cupularis	12
Cressa cretica (+-Eragrostis australiasica)	4

HERBLAND

Structural formation	Floristic group
Marsilea drummondii	13

MIXED ASSOCIATIONS [2]

COMBINED FLORISTIC GROUPS

1/4
1/8
1/13
2/8
2/6
8/9
8/10
8/12
8/14
8/10/14
11/14
12/13

water
bare ground
ephemeral vegetation
dunefield (including floodplain dunes)
floodplain area not surveyed

1 From analysis

2 Floristic groups co-existing in an area. Difficult to separate from photo interpretation therefore combined.

FUNDED BY: AUSTRALIAN NATIONAL PARKS & WILDLIFE SERVICE

ENVIRONMENTAL DATABASE
15 FEB 1993
GIS Section
SA. Office of Planning and Urban Development

PROJECTION : Transverse Mercator
G.I.S. SOFTWARE : E.S.R.I.'s ARC/Info

0 — 20km

Appendix G: Kanowana Land Units

Sandplain and Pale Dune

Pale Dune - Island

Major Lake

Minor Lake

Lake Foreshore

Waterhole

Major Channel

Minor Channel

Coolibah Low Woodland Floodplain

Coolibah/Lignum Floodplain

Lignum Sandy Floodplain

Perennial Grassland Floodplain

Lignum/Mixed Chenopod Floodplain

Dissected Lignum Floodplain

Ephemeral Floodplain

Appendix H: Incidence Of Plant Species Across All Sites (173)

Inc = Incidence (number of sites at which species was recorded)

Inc	Species
2	Abutilon malvaefolium
1	Acacia ligulata
1	Acacia oswaldii
15	Acacia salicina
27	Acacia stenophylla
1	Acacia victoriae ssp.
44	Alternanthera nodiflora
1	Amaranthus mitchellii
1	Ammannia multiflora var. multiflora
5	Amyema preissii
3	Atalaya hemiglauca
23	Atriplex crassipes var. crassipes
1	Atriplex eardleyae
36	Atriplex intermedia
5	Atriplex limbata
6	Atriplex lindleyi
28	Atriplex nummularia ssp.
7	Atriplex pseudocampanulata
1	Atriplex pumilio
43	Atriplex spongiosa
36	Atriplex sturtii
15	Atriplex velutinella
3	Bergia ammannioides
9	Bergia trimera
17	Boerhavia schomburgkiana
1	Bulbine alata
11	Calandrinia eremaea
3	Calocephalus platycephalus
4	Calotis hispidula
1	Calotis plumulifera
12	Calotis porphyroglossa
14	Centaurium spicatum
30	Chenopodium auricomum
1	Chenopodium cristatum
15	Chenopodium nitrariaceum
1	Compositae sp.
9	Convolvulus erubescens
51	Cressa cretica
4	Crinum flaccidum
1	Crotalaria smithiana
10	Cucumis melo
2	Cyperus exaltatus
16	Cyperus gymnocaulos
3	Cyperus pygmaeus
37	Dactyloctenium radulans
20	Dentella pulvinata
1	Dichanthium sericeum ssp. humilius
1	Dimorphocoma minutula
1	Diplachne fusca
8	Diplatia grandibractea
1	Dissocarpus biflorus var.
12	Einadia nutans ssp. eremaea
32	Enchylaena tomentosa var. glabra
2	Enneapogon avenaceus
33	Epaltes australis
35	Epaltes cunninghamii
4	Eragrostis australasica
29	Eragrostis dielsii var. dielsii
1	Eragrostis falcata
1	Eragrostis leptocarpa
19	Eragrostis parviflora
5	Eragrostis setifolia
13	Eremophila bignoniiflora
1	Eriochloa pseudoacrotricha
1	Erodium aureum
1	Erodium cygnorum ssp.
2	Erodium sp.
1	Eucalyptus camaldulensis var. obtusa
78	Eucalyptus microtheca
26	Euphorbia drummondii
36	Frankenia cupularis
2	Frankenia serpyllifolia
46	Glinus lotoides
1	Glycine canescens
5	Gnephosis eriocarpa
3	Goodenia fascicularis
2	Goodenia glauca
4	Goodenia sp.
1	Gramineae sp.
1	Grevillea striata
38	Haloragis aspera
47	Halosarcia indica ssp. leiostachya
23	Heliotropium curassavicum
30	Heliotropium supinum
2	Helipterum floribundum
1	Hibiscus sp.
3	Lavatera plebeia
2	Lawrencia glomerata
1	Lepidium muelleriferdinandi
9	Lotus cruentus
2	Ludwigia peploides ssp. montevidensis
3	Lysiana exocarpi ssp. exocarpi
3	Lysiana subfalcata
7	Lysiphyllum gilvum
3	Maireana coronata
2	Malacocera albolanata
40	Marsilea drummondii
3	Mentha australis
5	Mimulus repens
3	Minuria denticulata
11	Minuria rigida
71	Morgania floribunda
89	Muehlenbeckia cunninghamii
2	Mukia maderaspatana
14	Mukia micrantha
1	Myriocephalus stuartii
2	Myriophyllum verrucosum
10	Nicotiana velutina
17	Osteocarpum acropterum var. acropterum
4	Othonna gregorii
2	Owenia acidula
1	Panicum decompositum var. decompositum
2	Panicum laevinode
18	Phyllanthus lacunarius
1	Plantago drummondii
3	Pluchea rubelliflora
4	Polygonum plebeium
1	Portulaca intraterranea
73	Portulaca oleracea
2	Pseudognaphalium luteoalbum
43	Psoralea cinerea
3	Psoralea pallida
1	Psoralea patens
3	Pterocaulon sphacelatum
2	Rumex crystallinus
24	Rutidosis helichrysoides
42	Salsola kali
3	Santalum lanceolatum
4	Sauropus trachyspermus
2	Scaevola collaris
11	Sclerolaena bicornis
13	Sclerolaena calcarata
2	Sclerolaena constricta
5	Sclerolaena decurrens
6	Sclerolaena diacantha
62	Sclerolaena intricata
1	Sclerolaena muricata var. muricata
1	Sclerolaena parallelicuspis
46	Senecio cunninghamii var. serratus
1	Senna artemisioides nothossp. coriacea
15	Sesbania cannabina var. cannabina
2	Sida ammophila
1	Sida cunninghamii
2	Sida fibulifera
1	Sida trichopoda
11	Solanum esuriale
4	Solanum nigrum
62	Solanum oligacanthum
108	Sporobolus mitchellii
6	Swainsona oroboides
2	Tephrosia sphaerospora
18	Tetragonia tetragonoides
53	Teucrium racemosum
2	Tragus australianus
59	Trianthema triquetra
9	Tribulus terrestris
32	Trigonella suavissima
1	Triraphis mollis
17	Verbena officinalis
1	Wahlenbergia sp.
20	Wahlenbergia tumidifructa
7	Zaleya galericulata
7	Zygophyllum ammophilum

Appendix I: Dendrogram of FLoristic Classification

Figure 1
The dendrogram generated from the floristic pattern analysis reveals an initial division into two complexes, depicted as I and II on the diagram. Complex I contains almost all sites located on dry lake beds and on lake margins. Complex II contains sites located along channels, associated floodouts and floodplains. Cutting the dendrogram at the second level shown results in the identification of 14 Floristic Associations that, from field experience, best represent the range of vegetation types of the system.

Figure 2
Ordination using the centroids of each of the 14 Floristic Groups identified from the analysis.

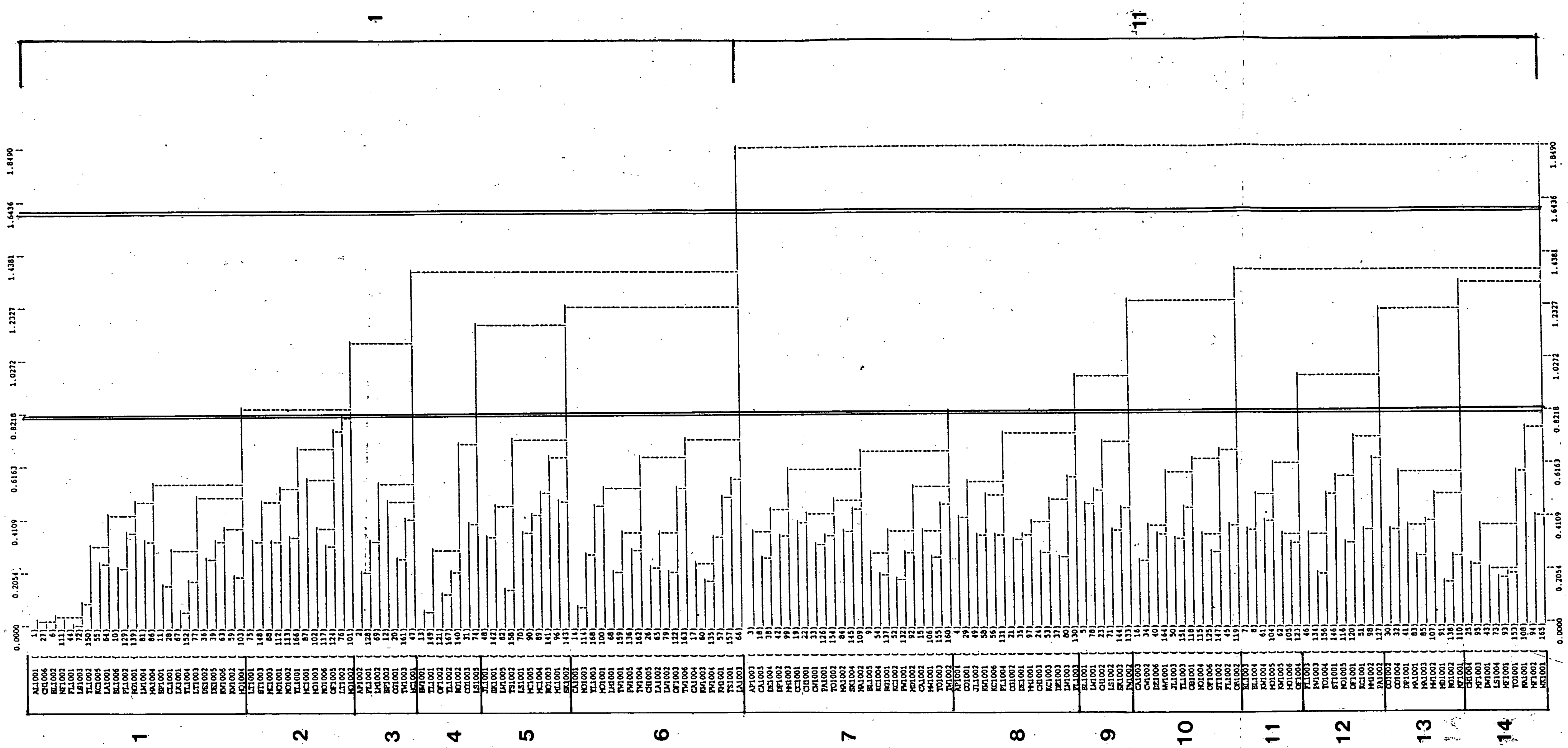


Figure 1: Dendrogram

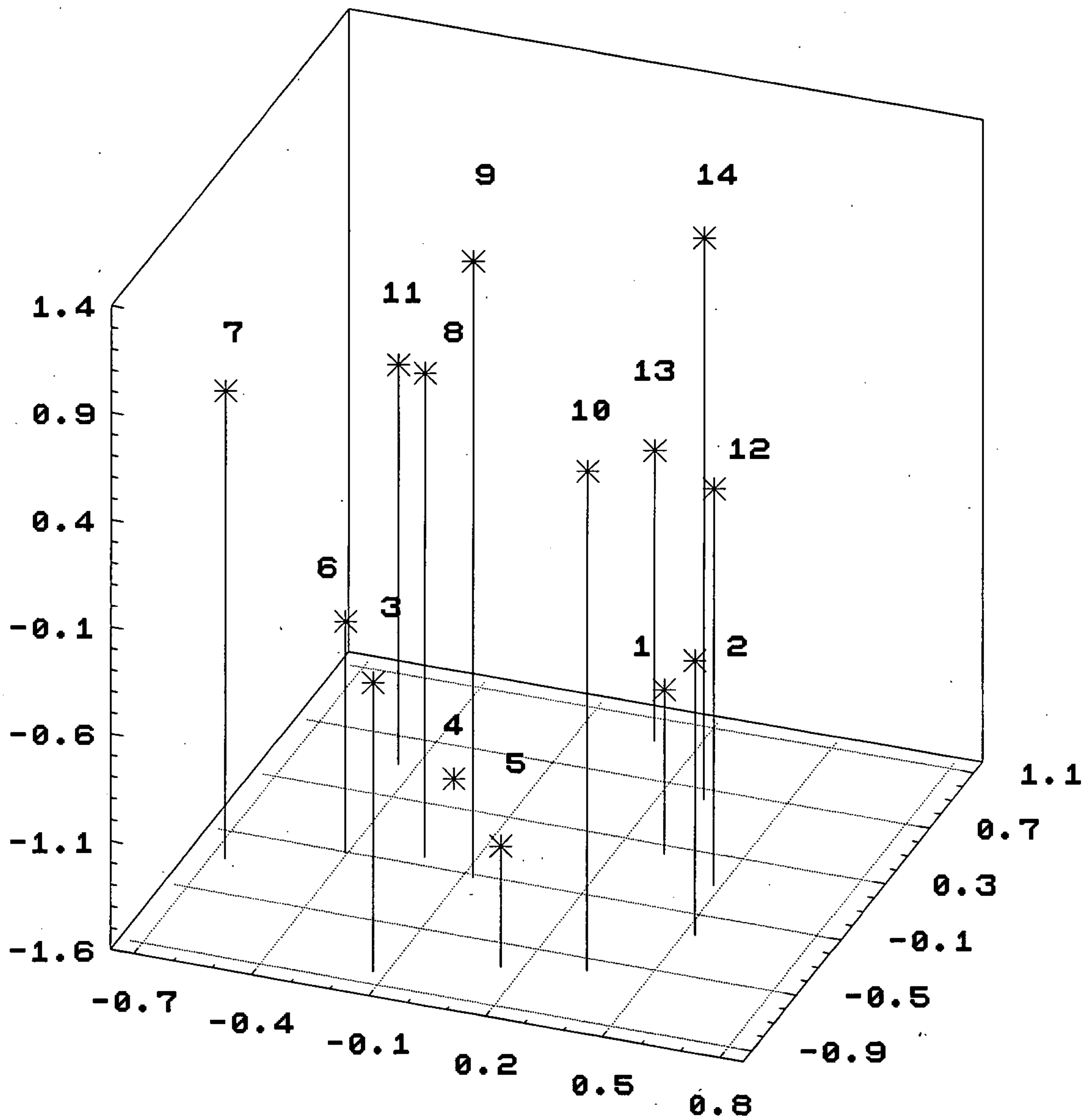


Figure 2: Ordination

Appendix J: Plant Species Collected

Key: • Naturalised Species
+ Species included in the Pattern Analysis

AIZOACEAE		+	Glinus lotoides
			Tetragonia tetragonoides
			Trianthema triquetra
		+	Zaleya galericulata
AMARANTHACEAE			Alternanthera nodiflora
			Amaranthus mitchellii
AMARYLLIDACEAE		+	Crinum flaccidum
BORAGINACEAE	•	+	Heliotropium curassavicum
	•		Heliotropium supinum
CAMPANULACEAE			Wahlenbergia sp.
		+	Wahlenbergia tumidifructa
CHENOPODIACEAE			Atriplex crassipes var. crassipes
			Atriplex eardleyae
			Atriplex intermedia
		+	Atriplex limbata
			Atriplex lindleyi
		+	Atriplex nummularia ssp.
			Atriplex pseudocampanulata
			Atriplex pumilio
			Atriplex spongiosa
			Atriplex sturtii
		+	Atriplex velutinella
		+	Chenopodium auricomum
			Chenopodium cristatum
		+	Chenopodium nitrariaceum
			Dissocarpus biflorus var.
		+	Einadia nutans ssp. eremaea
		+	Enchylaena tomentosa var. glabra
		+	Halosarcia indica ssp. leiostachya
		+	Maireana coronata
		+	Malacocera albolanata
		+	Osteocarpum acropterum var. acropterum
	•		Salsola kali
		+	Sclerolaena bicornis
		+	Sclerolaena calcarata
		+	Sclerolaena constricta
		+	Sclerolaena decurrens
		+	Sclerolaena diacantha
		+	Sclerolaena intricata
			Sclerolaena muricata var. muricata
			Sclerolaena parallelicuspis
COMPOSITAE			Calocephalus platycephalus
			Calotis hispidula
			Calotis plumulifera
			Calotis porphyroglossa
	•		Dimorphocoma minutula
			Epaltes australis
		+	Epaltes cunninghamii
			Gnephosis eriocarpa
			Helipterum floribundum
		+	Minuria denticulata
		+	Minuria rigida
			Myriocephalus stuartii
			Othonna gregorii
		+	Pluchea rubelliflora
			Pseudognaphalium luteoalbum
		+	Pterocaulon sphacelatum
		+	Rutidosis helichrysoides
		+	Senecio cunninghamii var. serratus

Appendix J (Cont.)

CONVOLVULACEAE	+	Convolvulus erubescens
	+	Cressa cretica
CRUCIFERAE		Lepidium muelleri-ferdinandi
CUCURBITACEAE		Cucumis melo
	+	Mukia maderaspatana
	+	Mukia micrantha
CYPERACEAE	+	Cyperus exaltatus
	+	Cyperus gymnocaulos
		Cyperus pygmaeus
ELATINACEAE		Bergia ammannioides
		Bergia trimera
EUPHORBIACEAE	+	Euphorbia drummondii
		Phyllanthus lacunarius
	+	Sauropus trachyspermus
FRANKENIACEAE	+	Frankenia cupularis
	+	Frankenia serpyllifolia
GENTIANACEAE		Centaurium spicatum
GERANIACEAE		Erodium aureum
		Erodium cygnorum ssp.
		Erodium sp.
GOODENIACEAE	+	Goodenia fascicularis
	+	Goodenia glauca
		Goodenia sp.
	+	Scaevola collaris
GRAMINEAE		Dactyloctenium radulans
		Dichanthium sericeum ssp. humilius
		Diplachne fusca
		Enneapogon avenaceus
	+	Eragrostis australasica
	+	Eragrostis dielsii var. dielsii
		Eragrostis falcata
		Eragrostis leptocarpa
	+	Eragrostis parviflora
	+	Eragrostis setifolia
		Eriochloa pseudoacrotricha
		Panicum decompositum var. decompositum
		Panicum laevinode
	+	Sporobolus mitchellii
		Tragus australianus
		Triraphis mollis
HALORAGACEAE	+	Haloragis aspera
	+	Myriophyllum verrucosum
LABIATAE	+	Mentha australis
	+	Teucrium racemosum
LEGUMINOSAE		Acacia ligulata
		Acacia oswaldii
	+	Acacia salicina
	+	Acacia stenophylla
		Acacia victoriae ssp.
		Crotalaria smithiana
		Glycine canescens
	+	Lotus cruentus
	+	Lysiphyllum gilvum
	+	Psoralea cinerea
	+	Psoralea pallida
		Psoralea patens

Appendix J (Cont.)

LEGUMINOSAE (Cont.)			Senna artemisioides nothossp. coriacea
			Sesbania cannabina var. cannabina
		+	Swainsona oroboides
		+	Tephrosia sphaerospora
			Trigonella suavissima
LILIACEAE			Bulbine alata
LORANTHACEAE		+	Amyema preissii
		+	Diplatia grandibractea
		+	Lysiana exocarpi ssp. exocarpi
		+	Lysiana subfalcata
LYTHRACEAE			Ammannia multiflora var. multiflora
MALVACEAE		+	Abutilon malvaefolium
			Hibiscus sp.
		+	Lavatera plebeia
		+	Lawrencia glomerata
		+	Sida ammophila
			Sida cunninghamii
		+	Sida fibulifera
			Sida trichopoda
MARSILEACEAE		+	Marsilea drummondii
MELIACEAE		+	Owenia acidula
MYOPORACEAE		+	Eremophila bignoniiflora
MYRTACEAE			Eucalyptus camaldulensis var. obtusa
		+	Eucalyptus microtheca
NYCTAGINACEAE		+	Boerhavia schomburgkiana
ONAGRACEAE	•	+	Ludwigia peploides ssp. montevidensis
PLANTAGINACEAE			Plantago drummondii
POLYGONACEAE		+	Muehlenbeckia cunninghamii
			Polygonum plebeium
			Rumex crystallinus
PORTULACACEAE			Calandrinia eremaea
			Portulaca intraterranea
			Portulaca oleracea
PROTEACEAE			Grevillea striata
RUBIACEAE		+	Dentella pulvinata
SANTALACEAE		+	Santalum lanceolatum
SAPINDACEAE		+	Atalaya hemiglauca
SCROPHULARIACEAE		+	Mimulus repens
		+	Morgania floribunda
SOLANACEAE			Nicotiana velutina
		+	Solanum esuriale
		+	Solanum nigrum
		+	Solanum oligacanthum
VERBENACEAE	•	+	Verbena officinalis
ZYGOPHYLLACEAE	•		Tribulus terrestris
			Zygophyllum ammophilum

Appendix K: Waterbird Observations

Species	Rating* Kanowana 4/91	9/91	4/92	5/92	8/92	Innamincka 8/92
Emu	C	P			P	C
Hoary-headed Grebe		P		P	C	N
Australasian Grebe					C	P
Australian Pelican	N	N	N	N	N	N
Darter	P	P	C	N	C	N
Great Cormorant	N	P	N	N	N	N
Pied Cormorant	P		C	N	N	N
Little Black Cormorant		P			N	C
Little Pied Cormorant		P	C			
Pacific Heron	N			P	P	P
White-faced Heron	N	P	N	P	P	C
Great Egret	P	P	P			P
Rufous Night Heron		P	P			P
Sacred Ibis	P		P			
Straw-necked Ibis		P				C
Royal Spoonbill	C	P	C	P	P	P
Yellow-billed Spoonbill	C	P	C	P	C	C
Black Swan	C	C	P	P	P	C
Freckled Duck					C	C
Australian Shelduck	P				P	P
Pacific Black Duck		P	P			P
Grey Teal	N	N	N	N	N	N
Australasian Shoveler					P	C
Pink-eared Duck	C	N	N	N	N	N
Hardhead		N	C	C	N	C
Maned Duck	C	N	N	N	N	N
Blue-billed Duck					P	P
Musk Duck	P	P				P
Black Kite	P	P	C	P	N	N
Black-breasted Buzzard	P	P				
Whistling Kite	P	P	P	P	N	C
Brown Goshawk	P					
Wedge-tailed Eagle	C	P	C	C	C	C
Little Eagle		P	P		P	P
Marsh Harrier						P
Black Falcon	P		P	P	P	P
Australian Hobby	P	P	P		P	P
Brown Falcon	C	P	C	C	C	C
Australian Kestrel	P	P	C	C	C	C
Black-tailed Native-hen		N	C	P	P	N
Purple Swamphen		P				
Eurasian Coot		C	P	N		N
Brolga			P	P	C	N
Australian Bustard			P			P
Bush Thick-knee		P	P	P		P
Masked Lapwing	P	C	N	N	N	N
Banded Lapwing	C		P	P	P	P
Red-kneed Dotterel		P				P
Red-capped Plover			C			N
Black-fronted Plover	P	P	C			
Black-winged Stilt	P	C	N			P
Red-necked Avocet	N	N	N	N	N	N
Greenshank		P				
Marsh Sandpiper		P				
Sharp-tailed Sandpiper		N				
Curlew Sandpiper		P				
Australian Pratincole		C			P	N
Silver Gull	C	P	C	P	C	C
Whiskered Tern		C			C	C
Gull-billed Tern	P	C				
Caspian Tern	P	C	C	P	C	C

Appendix K (Cont.)

Species	**Rating***					
	Kanowana					**Innamincka**
	4/91	**9/91**	**4/92**	**5/92**	**8/92**	**8/92**
Peaceful Dove	C	C	C	C	N	C
Diamond Dove	C		N	C	C	C
Common Bronzewing					P	P
Crested Pigeon	C	C	N	N	C	N
Galah	N	N	N	N	N	N
Little Corella	C	N	N	N	C	N
Budgerigar		C	P			
Mallee Ringneck			P			P
Red-rumped Parrot	C	C	N	N	C	N
Blue Bonnet	C	C	N	C	C	C
Pallid Cuckoo	P		P	P		
Horsfield's Bronze-cuckoo	C			P		
Barking Owl			P	P		P
Barn Owl	P			P		P
Tawny Frogmouth	P		P	P		P
Australian Owlet-nightjar	C	P	P	P		P
Fork-tailed Swift			N			
Red-backed Kingfisher	P	P		P		P
Rainbow Bee-eater		P				
White-backed Swallow	C		P	P	P	P
Welcome Swallow					C	
Tree Martin	N	P	N	N	N	N
Fairy Martin		P				P
Richard's Pipit		P	N	P	C	P
Black-faced Cuckoo-shrike	P	P	P	P	C	
Ground Cuckoo-shrike				P		
Red-capped Robin	P			P		P
Rufous Whistler	P					
Grey Shrike-thrush	P	P	P	C	P	P
Crested Bellbird	P			P		
Willie Wagtail	C	C	C	C	C	C
Chirruping Wedgebill	C	C	C	C	C	C
Cinnamon Quail-thrush		P	C	P	P	P
Chestnut-crowned Babbler	P	P	C	C		P
Rufous Songlark		P				P
Brown Songlark		P	P	P		P
Variegated Fairy-wren	P		C	P	P	P
White-winged Fairy-wren	C	C	C	N	C	C
Southern Whiteface	C		C	P		P
Banded Whiteface	P		P			
Brown Treecreeper			P			P
Spiny-cheeked Honeyeater	P					
Yellow-throated Miner	N	N	N	N	N	N
Singing Honeyeater	P		P	P		P
White-plumed Honeyeater	N	N	N	N	N	N
Crimson Chat						P
Orange Chat	P	P	P	P	P	P
Mistletoebird	P		P	P	P	P
Red-browed Pardalote	P		P	P		P
Striated Pardalote			P	P		
Zebra Finch	P		N	C		P
Australian Magpie-lark	N	N	N	N	N	N
White-breasted Woodswallow	P	C	C	C		C
Masked Woodswallow				P		P
White-browed Woodswallow						C
Black-faced Woodswallow	C	C	N	C	C	
Australian Magpie	P	P	N	C	C	C
Australian Raven	N	P	N	C	N	N
Little Crow			N	P	P	C

***rating**: based on estimates of birds present at a site and does not represent cumulative or regional counts. Results provide a relative indice to species abundance.

P	Present	(1-9)
C	Common	(10-49)
N	Numerous	(>50)

Appendix K (Cont): **Common Waterbirds Observed on Lakes, Channels and Swamps**

Ratings: P Present (1-9) C Common (10-49) N Numerous (>50)

	April 91	Sep 91	May 92	Aug 92
Lake Androdumpa				
Australian Pelican*				N(100)
Great Cormorant				C
Pied Cormorant				C
Yellow-billed Spoonbill				C
Grey Teal				N-00's
Pink-eared Duck				N-00's
Maned Duck				N-00's
Brolga				P
Masked Lapwing				N
Silver Gull				N
***note**: 000's of Pelicans present in April 92				
Lake Apanburra				
Australian Pelican				N(2620)
Yellow-billed Spoonbill				C
Freckled Duck				C(45)
Grey Teal				N
Pink-eared Duck				N
Maned Duck				C
Black-tailed Native-hen				C
Masked Lapwing				C
Red-necked Avocet				N
Lake Bulpanie				Dry
Australian Pelican*	N(500)			
Great Cormorant*	N(00's)			
Pied Cormorant*	P			
Pacific Heron*	P(1)			
White-faced Heron	C(14)			
Great Egret*	P(8)			
Royal Spoonbill	P(8)			
Yellow-billed Spoonbill	C(15)			
Grey Teal	N(370)		N(00's)	
Pink-eared Duck	C(42)		N(00's)	
Maned Duck	C(44)			
Brolga			P	
Masked Lapwing	P		N	
Red-necked Avocet			N(00's)	
Silver Gull	N(240)			
Gull-billed Tern	P(6)			

***note**: breeding records for April visit - Australian Pelicans with 20 young on island near Cormorant rookery; Black and Pied Cormorants on nests with young; 1 Pacific Heron on nest; 8 Great Egrets nesting with 4 young. Nesting colony in clump of flooded dead trees at mouth of southwest overflow channel; water flowing into lake.

Appendix K (Cont.)

Ratings: P Present (1-9) C Common (10-49) N Numerous (>50)

	April 91	Sep 91	May 92	Aug 92
Lake Coogiecooginna				
Australian Pelican			N(1000+)	C(27)
Great Cormorant			N	N(140)
Black Swan				C(12)
Freckled Duck				C(17)
Grey Teal			N(00's)	N(100+)
Pink-eared Duck			N(00's)	N(300+)
Hardhead			C	
Maned Duck			N(3500)	N(400)
Brolga				P
Masked Lapwing				C
Red-necked Avocet			C	N(150+)
Caspian Tern				C
Lake Coonamooranie				
Great Cormorant*	N(65)			
White-faced Heron	C(14)			
Black Swans	C(24)			
Australian Shelduck	P(1)			
Maned Duck	C(32)			
Musk Duck	P(1)			
Gull-billed Tern	P(7)			
***note**: Cormorant rookery in stand of flooded dead trees, south west side of lake. 58 nests with birds sitting on each, plus 7 birds roosting in trees. 6 young in nests.				
Lake Goyder				
Yellow-billed Spoonbill				C
Australian Pelican				N(200+)
Black Swan				C
Freckled Duck				P
Grey Teal				N(000's)
Pink-eared Duck				N(000's)
Maned Duck				N(000's)
Black-tailed Native-hen				N(00's)
Eurasian Coot				N(00's)
Red-necked Avocet				C
Lake Kanbakoodnanie				
Hoary-headed Grebe				C
Australian Pelican				N(1140)
Yellow-billed Spoonbill				C
Grey Teal				N
Pink-eared Duck				N(00's)
Maned Duck				N(1000)
Black-tailed Native-hen				C
Eurasian Coot				C
Brolga				N(55)
Masked Lapwing				C
Red-capped Plover				C
Red-necked Avocet				C
Australian Pratincole				C

Appendix K (Cont.)

Ratings: P Present (1-9) C Common (10-49) N Numerous (>50)

	Apr 91	Sep 91	May 92	Aug 92
Kanowana Channel	*			
Australian Pelican	C(10)			
Pacific Heron	N(150)			
White-faced Heron	N(120)			
Sacred Ibis	P(1)			
Royal + Yellow-billed Spoonbill	C(40)			
Grey Teal	C (30 + 16 young)	N		
Pink-eared Duck		N		
Black-tailed Native-hen		N(000's)		
Purple Swamphen		P		
Red-necked Avocets	N(1500)	N(00's)		
Sharp-tailed Sandpiper		N(350)		
Silver Gull	C(20)			
***note**: observed on lake at very south end of channel				
Lake Massacre				
Australian Pelican				C(20)
Great Cormorant				N(100+)
Pied Cormorant				N(35)
White-faced Heron				C
Straw-necked Ibis				C
Yellow-billed Spoonbill				C
Grey Teal				N(00's)
Pink-eared Duck				N(00's)
Hardhead				N(100+)
Maned Duck				N(300)
Masked Lapwing				N
Red-necked Avocet				C
Australian Pratincole				C
Lake Mckinlay				
Australian Pelican				N(2500)
Great Cormorant				N(2000+)
Pied Cormorant				N(00's)
Little Black Cormorant				N(00's)
Grey Teal				N
Pink-eared Duck				C
Maned Duck				N(260+)
Eurasian Coot				N(300)
Brolga				C(10)
Masked Lapwing				C
Silver Gull				C
Caspian Tern				C
Lake Miraditchie				
Australian Pelican		N		
Black-tailed Native-hen		N(000's)		
Grey Teal		N		
Pink-eared Duck		N(00's)		
Maned Duck		N(120)		
Red-necked Avocet		N(00's)		
Whiskered Tern		C		

Appendix K (Cont.)

Ratings: P Present (1-9) C Common (10-49) N Numerous (>50)

	Apr 91	Sep 91	May 92	Aug 92
Lake Moolionburrinna				
Hoary-headed Grebe				C
Australian Pelican				N(200)
Great Cormorant				C
Pied Cormorant				C
Yellow-billed Spoonbill				C
Grey Teal				N(00's)
Pink-eared Duck				N(00's)
Hardhead				N
Eurasian Coot				N(00's)
Masked Lapwing				C
Lake Oolgoopiarie				Dry
Royal Spoonbill	C			
Yellow-billed Spoonbill	N			
Grey Teal	N(5-7 000)		N(00's)	
Pink-eared Duck	N(10-12 000)		N(00's)	
Masked Lapwing	C			
Black-winged Stilt	N			
Red-necked Avocet	N(2000)			
Lake Strangways				
Hoary-headed Grebe				C
Australian Pelican				N(100+)
Darter				C
Black Swan				C
Freckled Duck				C(15)
Grey Teal				N(00's)
Pink-eared Duck				N(00's)
Hardhead				N(00's)
Eurasian Coot				N(00's)
Masked Lapwing				C
Red-necked Avocet				C
Lake Talinnie				
Hoary-headed Grebe				C
Black Swan				C
Freckled Duck				C(23)
Grey Teal				N(00's)
Pink-eared Duck				N(00's)
Hardhead				N
Eurasian Coot				N
Masked Lapwing				C
Lake Toontoowarannie				
Yellow-billed Spoonbill				C
Pacific Black Duck				C
Australasian Shoveler				C
Grey Teal				N
Pink-eared Duck				N(1000+)
Eurasian Coot				N

Appendix K (Cont.)

Ratings: P Present (1-9) C Common (10-49) N Numerous (>50)

	Apr 91	Sep 91	May 92	Aug 92
Lake Tooroopoolina				
Hoary-headed Grebe				N(100+)
Australasian Grebe				N
Australian Pelican				N(3000)
Darter				C
Great + Pied Cormorant*				N(8000)
Little Black Cormorant				N(00's)
Little Pied Cormorant				C
Black Swan				N(200)
Freckled Duck				P
Hardhead				N(200+)
Eurasian Coot				N(1500)
Masked Lapwing				N
Red-capped Plover				N(70)
Australian Pratincole				N
Silver Gull				N(100+)
Whiskered Tern				C
Caspian Tern				N(100+)
***note:** counts combined for Great and Pied Cormorant				
Thykamingana Swamp				
Australian Pelican		N(250)		
Black Swan*	N(56+3)			
Grey Teal		N(00's)		
Pink-eared Duck		N		
Banded Plover	C(14)			
Black-winged Stilt		C		
Red-necked Avocet		C		
Australian Pratincole		C		
Whiskered Tern		C		
***Note:** breeding - 3 cygnets				
Lake Watchiewatchina				
Hoary-headed Grebe				C
Australian Pelican				N(52)
Great Cormorant				N(60)
Pied Cormorant				N(100+)
Freckled Duck				C(17)
Grey Teal				N
Pink-eared Duck				N
Hardhead				C
Maned Duck				N(80)
Eurasian Coot				N
Red-necked Avocet				C