KINGOONYA
SOIL CONSERVATION BOARD

KINGOONYA SOIL CONSERVATION BOARD DISTRICT PLAN

Produced with the assistance of

Government of South Australia

Soil Conservation Council South Australia

PRIMARY INDUSTRIES AND RESOURCES SA

KINGOONYA SOIL CONSERVATION BOARD DISTRICT PLAN

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NOVEMBER 2002

Produced with the assistance of
the National Landcare Program
and Primary Industries and Resources SA

FOREWORD

In her foreword to our first District Plan in 1996, then Chairperson Kate Gibson wrote:

"Through our District Plan the Kingoonya Soil Conservation Board (SCB) is providing a reference document to all interested people. This document, it is hoped, will provide all land users with information important for the continuance of viable and sustainable industries while maintaining and improving the natural vegetation and soils.

The Board wishes to stress that the District Plan provides guidelines for sustainable land use and is not a document which imposes regulations.

This District Plan will be reviewed every three years and will take into account changing and improved land management practices.

As land users in this District, we have an interest in taking charge of our own destiny. It behoves us therefore, to inform, help and educate all land users to manage the land in a sustainable way and to appreciate the country of which we are the current custodians. We take this opportunity to remind land users that the duty of care for the land rests with them, and that it is crucial the land be used within its capability so that its productivity is maintained for use by future generations."

Our first edition will stand as a tribute to Kate, who contributed greatly to this District in many spheres.

This first review should reflect and contribute to the increasing knowledge and understanding of the area. To this end, the land system descriptions, naming and mapping have been reviewed to provide a more accurate information base and to integrate with neighbouring Soil Board systems. Other information has of course been updated where necessary.

Our Board has changed membership considerably over the years, but has always and still reflects a commitment to improving and growing our expertise in the prudent management of the District.

I sincerely thank all who contributed to the first District Plan and to this document, especially Frank Badman who has done a huge amount of work while on the Board and since leaving the District, as a consultant.

Keith Greenfield
Chairman Kingoonya Soil Conservation Board.
2002

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ACKNOWLEDGMENTS

The development of this District Plan has been a co-operative and consultative process involving many people as well as board members. The Board wishes to thank:

The many people who contributed to the first District Plan, upon which this review is based.

Past and present Board members (see list on p. 4) and other pastoralists from within the District.

Pastoral Program, Primary Industries and Resources, South Australia (PIRSA) for the use of their Land Systems Map, which has been updated by Jan Rowlands of PIRSA.

Rick Mould for compiling the information on the radioactive waste repository.

Frank Badman of Badman Environmental and John Read of WMC (Olympic Dam Corporation) Pty Ltd, Roxby Downs for plant and animal species lists.

Peter Alexander and Barb St John of the Department of Environment and Heritage for material on kangaroo density surveys and the South Australian Kangaroo Management Program.

Andrew Breeding designed the soil board logo and the cover.

Frank Badman took the land system photographs. All other photographs are from the original District Plan (KSCB 1996).

SUMMARY

The Kingoonya Soil Conservation District (SCD) is located approximately 600 km north-west of Adelaide in South Australia and is 65 815 km^2 in size. The population of the District is estimated to be about 5000, and consists in the main of people associated with the mining industry and with the Immigration Receiving and Processing Centre at Woomera. This centre has been established since the publication of the original District Plan and its population fluctuates greatly. Therefore, these people are not included in the total population figure. Closure of the Nurrungar defence establishment near Woomera has resulted in the loss of one of the largest workforces in the District. The pastoral community continues to makes up a small proportion of the population but manages the vast majority of the land.

The climate of the District is hot and dry with a short cool winter. The year-to-year variability of rainfall is very high and average annual totals, which range from less than 150 mm in the north-east to around 200 mm in the south-west, are among the lowest in Australia. No seasonality of rainfall is apparent. On average, once in ten years annual rainfall totals of less than 75 mm in the south-west and 50 mm in the north-east can be expected. Highest daily falls of rain occur in the warmer months when between 100 mm and 200 mm have been recorded in a single day. Slightly more wet days occur during the cooler months.

Land use in the Kingoonya District consists of stock grazing on native pastures, mining, tourism, limited rural living, defence industry operations and the temporary low level radio-active waste storage facility that may soon become a permanent establishment.

Sustainable management of the soil, vegetation and water resources is achieved by sound stock management practices and in the case of mineral extraction, exploration and defence operations, through effective rehabilitation.

Sound management of stock in paddocks and during stock handling procedures such as crutching and shearing are crucial to the maintenance of rangeland condition. Factors which need to be considered when placing stock in paddocks or on waters include; quality and quantity of water, feed type and quantity, maintenance of the vegetation resource, soil type, season, amount and intensity of rainfall, fencing and water location. It is essential that stock handling procedures be carefully planned so that livestock are held for minimum periods and in the smallest possible mobs. Reserving the feed in holding paddocks is a good strategy for avoiding vegetation and soil degradation.

Soil and vegetation degradation issues that are likely to occur in the District include; degradation of rangeland vegetation by stock, rabbits and large populations of kangaroos, scalding of texture contrast soils[1] where vegetation has been removed, wind erosion of light textured soils, gully erosion of clay soils of the gilgai[2] (crab hole) land types, bush fire, drought, mining and mineral

[1] Texture contrast soils are soils in which there is a lighter textured or sandy soil overlying a heavier textured or clay soil.

[2] Gilgai - surface micro-relief associated with expansion and contraction of cracking clay soils, consisting of hollows of varying size, shape and frequency bordered by a “shelf” formed from the formerly overlying stone cover.

exploration, defence operations and off road vehicle use.

The District Plan outlines the nature, causes, extent, management and rehabilitation methods for each of these land degradation issues. The key to sustainable land management in the region is to prevent degradation. The low and highly variable rainfall provides limited opportunities for vegetation re-establishment and makes rehabilitation difficult in the short term. The native vegetation is resilient and adapted to the environment and will establish where soil and rainfall provides suitable conditions for germination.

A long-term survey of the management of six stations with chenopod shrubland (Appendix D) provides a significant insight into the long-term effects of stocking, drought and fire on the perennial chenopod vegetation of the District. The survey indicated that current management practices of these stations are sustainable.

There are no Government conservation areas within the Kingoonya SCD, although several salt lakes that border the District are within government reserves. Privately initiated conservation initiatives, including the Arid Recovery Project at Olympic Dam, are the core of a potentially large and effective conservation strategy for pastoral and mining lands in the District.

Pastoral enterprises are run in a high-risk economic and climatic environment where there is little room for sub-optimal management. The Board recommends that land managers plan their operation and work to their plan. This needs to include monitoring the rangeland condition and developing strategies for dry seasons.

INTRODUCTION

THE KINGOONYA SOIL CONSERVATION BOARD

The Kingoonya Soil Conservation Board (Kingoonya SCB) was formed in 1990. The Board consists of seven land managers who live within the District and have suitable knowledge of, and experience in, land management.

The members of the Kingoonya SCB who under took this review are:

Keith Greenfield (chairman), Billa Kalina Station; **Lorraine Greenfield,** Billa Kalina Station; **Richard Armour,** Commonwealth Hill Station; **Rick Mould,** Coondambo Station; **Paul Ayliffe,** Wilgena Station; **David Oag,** Arcoona Station; **John Read,** Roxby Downs.

Kingoonya SCB members (l to r): Rick Mould, Lorraine Greenfield, Paul Ayliffe, Richard Armour, Keith Greenfield and David Oag (absent: John Read)

The current members of the Kingoonya SCB are:

Richard Armour (Chair), Commonwealth Hill Station; **Rick Mould,** Coondambo Station; **Julie Mould,** Coondambo Station, **Paul Blight,** Bon Bon Station, **Michael Simons,** Mulgathing Station; **Colin Greenfield,** Billa Kalina Station, **John Read,** Roxby Downs.

Appointment and termination dates for past and present members of the Kingoonya SCB are:

Brian Materne	29th Aug 1990 - 3rd March 1991	Chair from 29/08/90 to 3/03/91
Ian Read	29th Aug 1990 - 16th April 1992	
Kate Gibson	29th Aug 1990 - 1st June 1996	Chair from 5/04/91 to 1/06/96
Wayne Rankin	29th Aug 1990 - 30th June 1996	
Marcus Moore	29th Aug 1990 - 30th Nov 1998	
Frank Badman	29th Aug 1990 - 30th July 1999	
David Oag	29th Aug 1990	Chair from 22/11/96 to 5/11/99
Keith Greenfield	9th Aug 1991	Chair from 5/11/99
Rick Mould	20th Aug 1992	
Andrew Lillecrapp	22nd Nov 1996 - 30th Nov 2000	
Lorraine Greenfield	22nd Nov 1996	
Richard Armour	23rd Sept 1999	
Leigh Ridge	23rd Sept 1999 - 24th Nov 2000	
Paul Ayliffe	9th Feb 2001	
John Read	30th Oct 2001	

The Kingoonya Rabbit Control Group is a Landcare group incorporated under the Board. This group is investigating the economic viability and effectiveness of rabbit control works on pastoral land. Several reports have been produced on this work (Badman 1998, 2000a, 2000b, 2001, 2002.).

DUTY OF CARE

The Board feels that all people have the responsibility to care for soil, vegetation, water and other natural resources.

The *Soil Conservation and Land Care Act, 1989* provides that it is the duty of all landholders to take all reasonable steps to prevent degradation of the land under their control.

Degradation of land means a decline in the quality of soil, vegetation, water and other natural resources of the land that result from various activities or the failure to take appropriate action to prevent that degradation.

Legislation

Numerous Acts of Parliament apply within the area covered by the District. The most important acts that affect the Board and the District are:

State Legislation

Aboriginal Heritage Act 1988
Animal and Plant Control Act 1986
Controlled Substances Act 1984
Country Fires Act 1989
Crown Lands Act 1929
Dangerous Substances Act 1979
Development Act 1993

Dog Fence Act 1946
Environment Protection Act 1993
Explosives Act 1982
Heritage Act 1993
Highways Act 1926
Mines and Works Inspection Act 1920
Mining Act 1971
National Environment Protection Council (South Australia) Act 1995
National Parks and Wildlife Act 1972
Native Title (South Australia) (Validation and Confirmation) Amendment Act 1999
Native Vegetation Act 1991
Occupational Health, Safety and Welfare Act 1986
Outback Areas Community Development Trust Act 1978
Pastoral Land Management and Conservation Act 1989
Planning Act 1982
Public and Environmental Health Act 1987
Radiation Protection and Control Act 1982
Road Traffic Act 1961
Roxby Downs (Indenture Ratification) Act 1982
Roxby Downs (Indenture Ratification) (Amendment of Indenture) Amendment Act 1996
Soil Conservation and Land Care Act 1989
Water Conservation Act 1936
Water Resources Act 1990
Wilderness Protection Act 1992

Commonwealth Legislation

Aboriginal and Torres Strait Islander Commission Act 1989
Aboriginal and Torres Strait Islander Heritage Protection Act 1984
Aboriginal Sacred Sites Act 1989
Australian Heritage Commission Act 1975
Endangered Species Protection Act 1992
Environmental Protection (Impact of Proposals) Act 1974
Environmental Protection (Nuclear Codes) Act 1978
Environment Protection and Biodiversity Conservation Act 1999
Industrial Chemicals (Notification and Assessment) Act 1989
Migration Act 1958
National Parks and Wildlife Conservation Act 1975
Native Title Act 1993
Nuclear Non-Proliferation (Safeguards) Act 1987
Occupational Health and Safety (Commonwealth Employee) Act 1991

This list is by no means exhaustive and several other acts may be applicable to current or potential enterprises within the District.

THE ROLE OF THE BOARD

The role of the Board is one of education, coordination and cooperation and is directed towards preventing land degradation through responsible land management. Other aspects of the Board's role are to:

- implement the provisions of the *Soil Conservation and Land Care Act 1989*;
- cooperate with the Pastoral Board in the implementation of the *Pastoral Land Management and Conservation Act 1989*;
- develop community awareness and understanding of land conservation issues;
- promote the principle that land must be used within its capabilities;
- develop and support community projects for land conservation and rehabilitation;
- provide advice and assistance to landholders on land conservation and rehabilitation;
- seek landholder cooperation to ensure land is not degraded;
- act as a prescribed body under the Animal and Plant Control Act;
- prepare District Plans and Three Year Programmes;
- approve property plans.

AIMS OF THE BOARD

The aims of the Kingoonya SCB are to:

- protect the long term viability of the industries in the District;
- promote the sustainable use of the land by maintaining and protecting the soil and native vegetation resources;
- provide for, and promote the creation of, an inventory of the natural resources of the District and monitoring of the condition of those resources;
- ensure the involvement of local managers in the administration of natural resource management;
- investigate land management practices with a view to developing improved management methods;
- record expertise in sustainable management of the land for use by those with local and administrative land management responsibilities and, make this information available for use by school and community educators;
- review and revise the Soil Conservation Board District Plan on a regular basis.

These aims form the basis for the development of the Board's programmes and activities.

AIMS OF THE DISTRICT PLAN

This District Plan has been developed as required by section 36 of the *Soil Conservation and Land Care Act 1989* and aims to:

- describe the district, including land systems, biodiversity, land capability, land uses and infrastructure;
- describe the existing and potential soil and vegetation degradation problems;
- identify the land management options best suited to preventing those problems and to rehabilitating degraded land;
- enhance community awareness of optimum land management practices.

COMMUNITY CONSULTATION

A survey of land managers in the Kingoonya SCD was one of the first activities undertaken by the Kingoonya SCB when it was formed in 1990 (KSCB 1996). The survey asked each land manager/lessee to list in priority order the three main land care concerns on their property and to provide some explanation. Twenty-one surveys were sent out and ten were returned.

The issues were weighted by giving the top priority issue three points, the second two points, and the third priority one point. The priority issues determined in this way were:

1. rabbits;
2. fire;
3. erosion;
4. mining exploration;
5. kangaroos; and
6. grazing.

The results of this survey were presented in Appendix A of the original District Plan (KSCB 1996).

This District Plan has been prepared on behalf of the Board by Frank Badman of Badman Environmental, with the comments of Board members and local land managers in mind. The Plan was released in draft form for a 90-day period during and public submissions were considered by the Board and incorporated into the final document.

REVIEW

The District Plan will be reviewed every three years when concerns and guidelines presented in this plan will be updated. Ongoing consultation with the community is recognised by the Board as necessary to maintain the relevance of the plan and the Board's activities to the current land management issues within the District.

DESCRIPTION OF THE DISTRICT

INTRODUCTION

The Kingoonya SCD is located in the north-west pastoral area of South Australia. It is approximately 600 km north-west of Adelaide, extends for about 450 km from east to west and 275 km from north to south and covers an area of 65 815 km^2. It lies within latitudes 29^0 30'S and 31^0 30'S and within longitudes 133^0 00'E and 136^0 30'E.

Salt-lakes form much of the southern and eastern boundaries of the district. The Dog Fence forms much of the northern boundary and the entire western boundary. The Maralinga Tjarutja Aboriginal Lands lie to the west and north-west of the District.

The District contains 22 pastoral runs; Andamooka, Arcoona, Billa Kalina, Bon Bon, Bosworth, Bulgunnia, Commonwealth Hill, Coondambo, Ingomar, Kokatha, McDouall Peak, Millers Creek, Mobella, Mount Eba, Mount Vivian, Mulgathing, North Well, Parakylia, Purple Downs, Roxby Downs, Wilgena and Wirraminna. The large Olympic Dam mining lease, Andamooka precious stones field, Challenger mining lease, the Woomera Rocket Range, three gamma ray telescopes and a temporary low-level radioactive waste storage facility are also situated within the District.

The east-west railway line passes through the district, as do the Tarcoola to Alice Springs railway, the sealed Stuart Highway and Woomera to Roxby Downs road. Since the completion of sealing of the Stuart Highway, the highway has taken over from the railway as the means of transporting stock and produce and for bringing in supplies.

Sheep run predominantly for wool production are the mainstay of most stations. Two stations run entirely cattle, while several others run at least some cattle.

The district has a population of about 5000 people, mainly concentrated in the towns of Roxby Downs and Woomera. Roxby Downs has a population of about 4000 and Woomera about 300. Other population centres are the settlements of Andamooka, Pimba, Glendambo, Kingoonya and Tarcoola, although only a few people now live in the latter two places. Shopping facilities are concentrated in the eastern side of the district, although most stations obtain their supplies by mail truck or bus from Port Augusta.

Topography of the district is flat to undulating, with variations in altitude from just above sea level to about 300 m above sea level. Drainage over the southern and eastern parts of the district is into salt-lakes by way of minor drainage lines. The northern parts drain into Lake Eyre South via larger creek systems. Drainage of much of the central and western parts is into numerous small salt-lakes and claypans.

Vegetation is predominantly mulga low woodland in the west and chenopod[3] low shrubland in the east, although integration of these vegetation types does occur.

[3] Chenopods are plants of the family Chenopodiaceae; this family of plants includes saltbushes, bluebushes, bindyis and fat hen.

Figure 1: The Kingoonya Soil Conservation District

CLIMATE

The following summary of the climate of the Kingoonya SCD has been drawn from "Climate of the Kingoonya SCD" prepared by the Bureau of Meteorology SA for the first District Plan (KSCB 1996).

Climatic Controls

The Kingoonya SCD has a hot arid climate with a short cool winter (Laut *et al. 1977*). There is little variation across the district due to the inland location and lack of major orographic[4] features. The most dominant influence on local climate is the passage across the District of high-pressure systems that form part of the sub-tropical ridge (Figure 2).

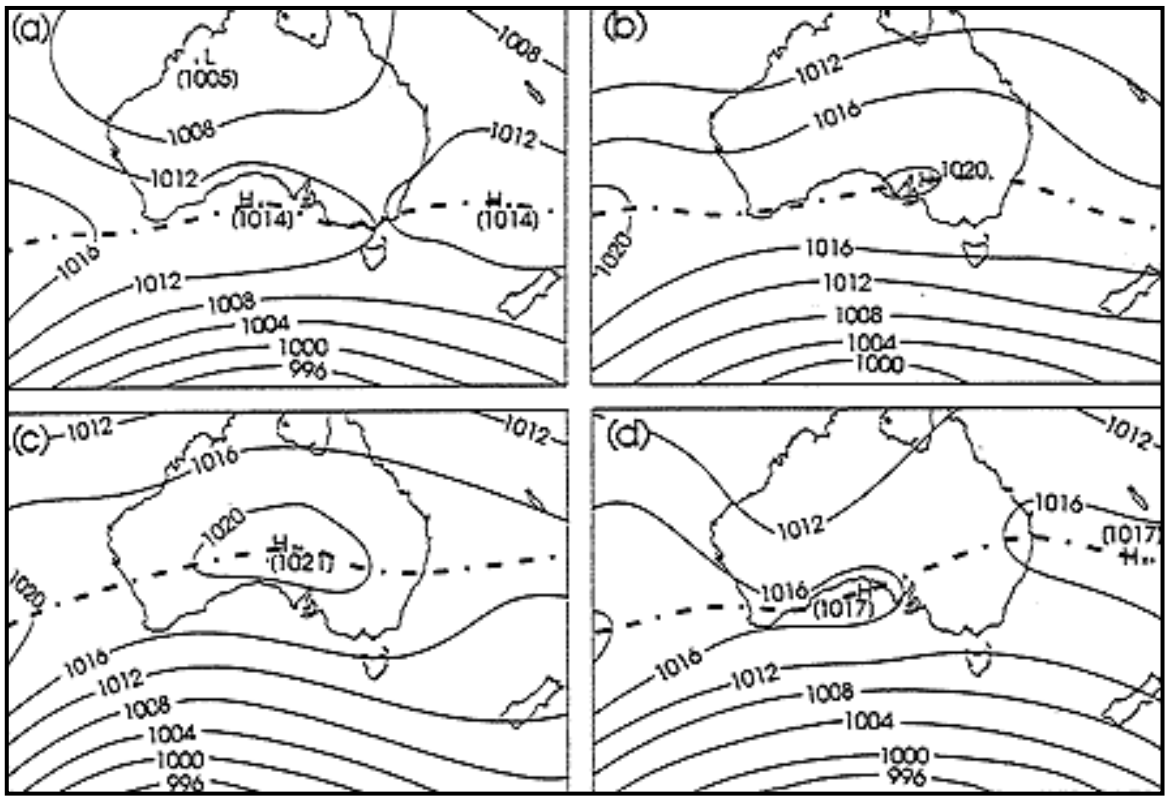

Figure 2: The average mean sea level pressure patterns for (a) January, (b) April, (c) July and (d) October

(Units are in hectoPascals[5].) The subtropical ridge (-- · --), south of the continent in January, moves northwards in April and is located near the northern boundary of the Kingoonya District in July. (Source: National Meteorological Operations Centre, Bureau of Meteorology.)

During the hotter part of the year (October to March), the mean position of the ridge is located to the south of the continent and the prevailing surface winds over most of the District are from the

[4] The passage of air over mountain or ridge.

[5] One hectoPascal is equivalent to one millibar.

south-east to south-west. Occasionally, moist tropical air moves into the District from the north, producing thunderstorms with intense but short-lived rain showers; less frequently, tropical inflow may produce widespread rains.

In autumn, the mean position of the sub-tropical ridge moves north and remains over the continent from April to September. For most of this period, due to the close proximity of the ridge, winds have little directional preference and the weather is fine. Occasionally north-west cloud bands, originating over the Indian Ocean, are a source of rain, although less than half of these features bring significant falls to the District.

Winds

While the broad-scale prevailing winds are determined by the atmospheric pressure features which influence the area (Figure 2), topography can have a marked effect on local wind speed and direction, particularly overnight and early in the morning. Wind observations for the Kingoonya District are available from four sites: Tarcoola, Woomera, Olympic Dam and Coober Pedy.

From December to March, early-morning winds are most frequently from the south-east quadrant but typically shift to the south/south-west during the day. Between April and June, winds are generally light with little directional preference. During July and August the wind direction is most frequently from the north-west to south-west but a north to north-easterly flow is also common. Prevailing winds again become easterly from September to November. On average, winds are strongest during September and October (based on 9.00 am and 3.00 pm observations) and it is at this time of year that strong and gale-force winds are most likely.

Rainfall

The year-to-year variability of rainfall in the Kingoonya District is very high. Mean (or average) annual totals, which range from less than 150 mm in the north-east to around 200 mm in the south-west, are among the lowest in Australia. No seasonality in rainfall is apparent. Median rainfall (the point at which half the records are higher and half are lower) is probably a better indication of annual rainfall, particularly in the north of the District. Mean and median values are closer in the south of the District and further apart in the north. They are also closer in winter than in summer. This is indicative of the more predictable nature of winter rainfall compared to summer rainfall.

The historical rainfall records for selected stations are graphed in Figures 3 to 6, (see Figure 1 on Page 9 for the location of these stations – The Twins is part of the McDouall Peake lease). These show the annual, November to April and May to October totals for each year since records began. Median and mean annual rainfall is also given for each station.

Based on the historical record, an average of one in ten years receives less than the Decile 1 value or alternatively nine in ten years will receive more than this amount. An explanation of deciles was given in Appendix B of the original District Plan (KSCB 1996). The annual Decile 1 value varies from around 80 mm in the south of the district to near 50 mm in the north-east. Therefore on average, in one in ten years property managers in the south can expect to receive an annual total less than 80 mm, while in the north-east, the one in ten year expectation falls to around 50 mm or lower.

Highest *daily* falls occur during the warmer months when, under suitable conditions, humid tropical air may reach the District. Falls between 100 and 200 mm have been recorded in a

single day, with the highest recorded fall of 194 mm reported at Purple Downs in March 1989.

Drought Years

The term drought refers to an acute rainfall shortage and is a natural phenomenon in the Australian arid zone. Although the amount of available water depends to a large extent on storage (in the soil, in vegetation, in artesian basins and in dams and reservoirs) and losses from evaporation, the best single indicator of water availability is rainfall. Gibbs and Maher (1967) showed that years when the annual rainfall lies in the first decile range (i.e. the lowest 10% of falls) correspond well with droughts recorded by other sources. Using this simple guide and rainfall records from a number of stations across the District, 20 years (since 1885) have been identified as periods in which drought affected extensive areas of the District. These years are 1888, 1902, 1905, 1928, 1929, 1934, 1936, 1940, 1943, 1944, 1957, 1961, 1962, 1967, 1970, 1972, 1977, 1982, 1991 and 1994.

Local areas have experienced droughts that were not district wide and may not be recorded here. Some major droughts extended beyond two years, particularly those occurring during 1928-1929, 1943-1944, 1961-1962 and 1982-83. The droughts of 1940 and 1967 are notable because it was in these years that many stations recorded their lowest ever rainfall totals.

More rigorous methods, such as those used in the Drought Review - Australia[6] identify slightly different periods, including those of shorter duration.

Evaporation

The average annual evaporation ranges from less than 2800 mm in the south-west of the District to more than 3200 mm in the north.

The mean monthly evaporation values across the District for the mid-season months are shown in Table 1.

Table 1: Estimates of mean monthly evaporation for the mid-season months

(Estimates to the nearest 25mm.)

	January	**April**	**July**	**October**
North	450	225	125	300
South	400	200	100	275

Growing Season

The extremely variable rainfall and high evaporation rates throughout the District means there is no distinct growing season for herbaceous plants (Lange and Fatchen 1990).

[6] The Drought Watch Service provided by the Bureau of Meteorology. Areas of serious or severe rainfall deficiencies are identified based upon the six month (or more) accumulated rainfall totals (Drought in Australia, Bureau of Meteorology, 1989).

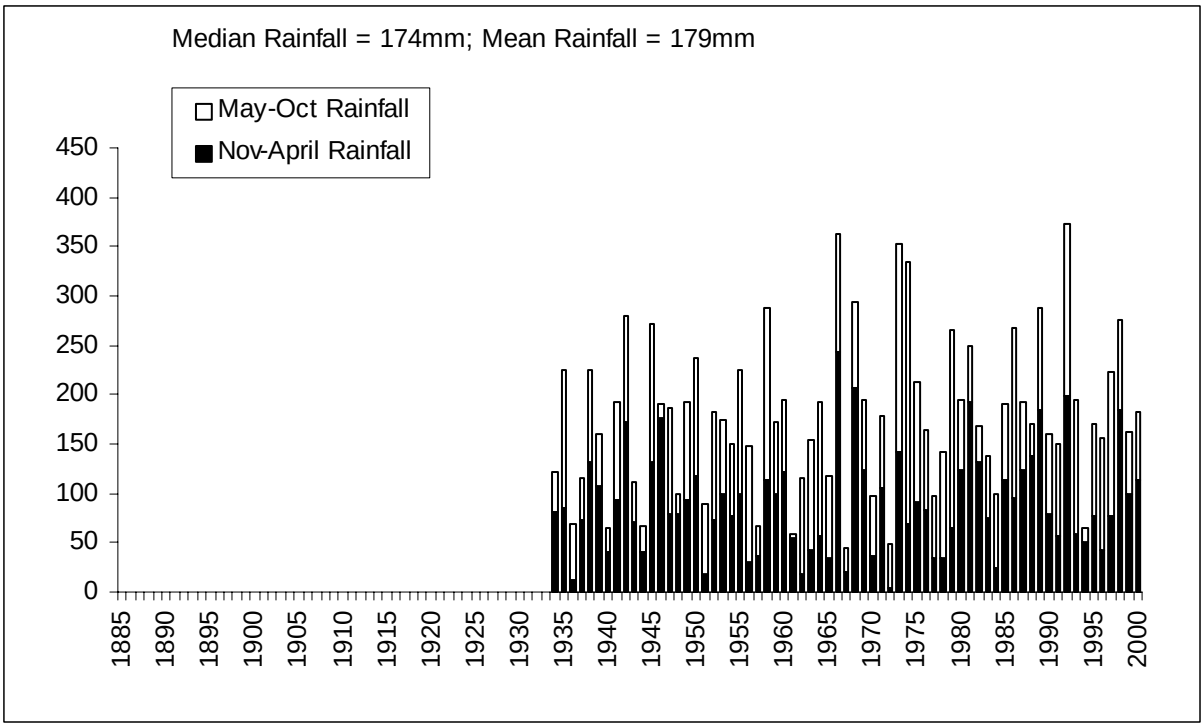

Figure 3: The long-term rainfall record for Mulgathing

(Station No. 16031 at 30° 15'S, 133° 59'E, elevation 198m.)

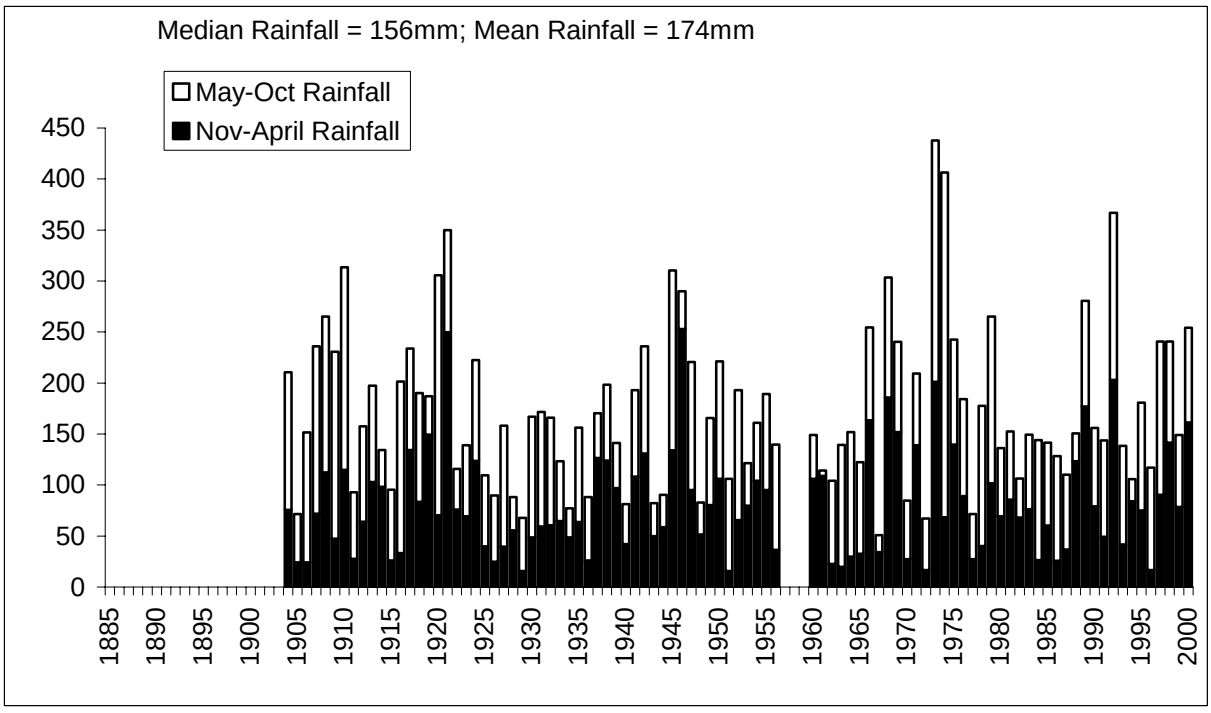

Figure 4: The long-term rainfall record for Tarcoola

(Station No. 16044 at 30°43'S, 134°34'E, elevation 120m). Data are missing from 1957-1959.

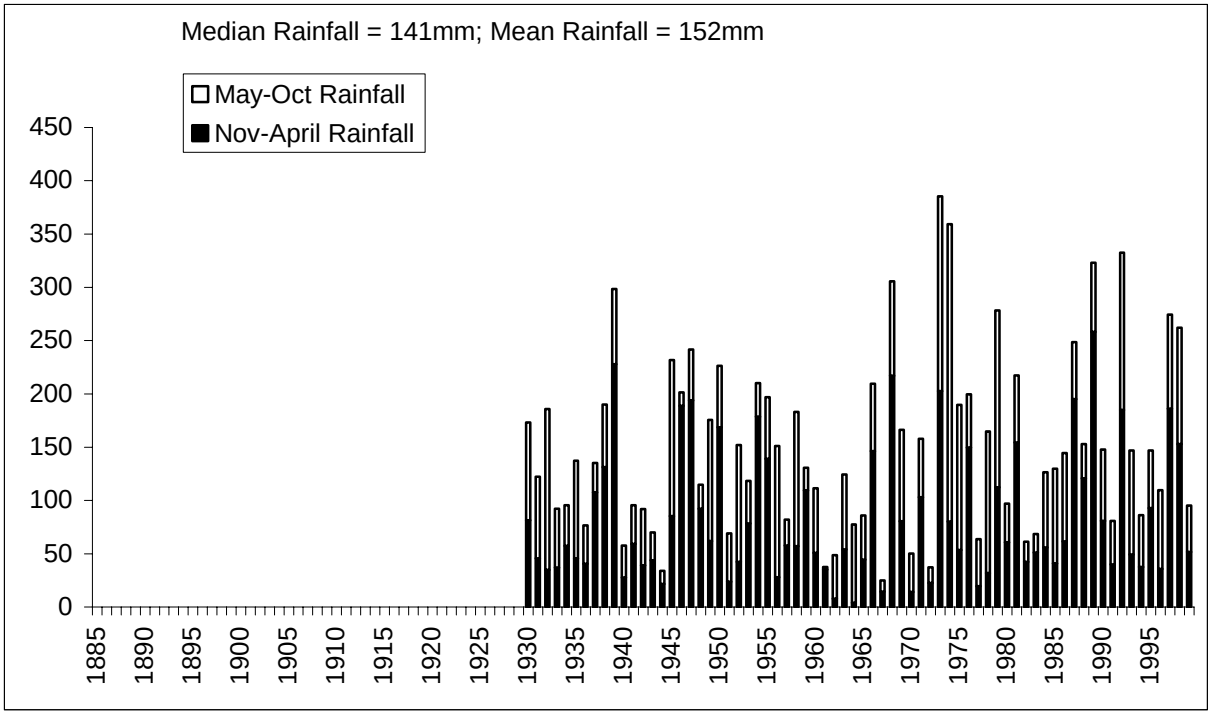

Figure 5: The long-term rainfall record for The Twins

(Station No. 16048 at 30°00'S, 135°24'E, elevation 150m).

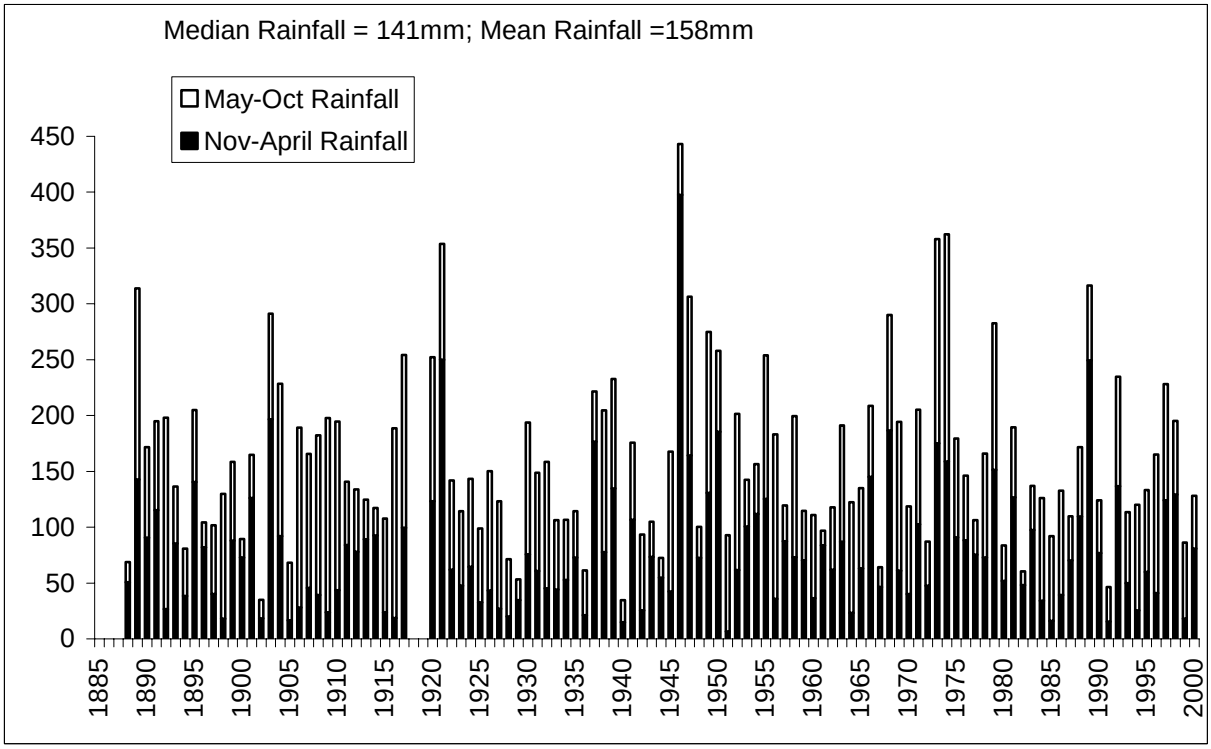

Figure 6: The long-term rainfall record for Arcoona

(Station No. 16000 at 31°02'S, 137°03'E, elevation 150m.) Data are incomplete for 1919-20.

Temperature

In the hotter part of the year (late November to March), mean maximum temperatures exceed 30°C over most of the District and average near 35°C during January and February. Temperatures over 40°C have been recorded across the District in each month between October and March. Mean minimum temperatures for the period December to March range between 16°C and 20°C.

For the cooler months (April to October), average maximum daily temperatures range from the upper teens in June and July to the mid to upper twenties in April and October. Maxima in excess of 30°C have been recorded at Tarcoola and Coober Pedy in all months other than June. Average minimum temperatures are less than 15°C and fall to around 5°C in July. In the south-west, minimum temperatures below zero have been recorded in each month between May and September, while in the north (Coober Pedy) records of extreme temperatures below zero are limited to July. Temperature data for selected stations are given in Appendix A.

Frosts

Frost occurs in the cooler part of the year, generally on clear and calm or near calm nights when there is little moisture in the air. The frequency of frost is dependent on local surface features including vegetation, soil moisture and topography. An air temperature[7] below 2.3°C is a good indicator of ground frost, while an air temperature below zero indicates a heavy or severe frost.

Frosts have been recorded in all months from May to October, but the typical frost season[8] extends from May to September at Tarcoola in the south-west and from June to August across the north and east. During winter (June to August) frost-days are observed, on average, one day per month at Woomera and Coober Pedy and 6 to 9 days per month at Tarcoola, with the greatest frequency in July. Frosts tend to be more common in drought years and severity is very much site dependent.

Sunshine Hours

The number of hours of bright sunshine per day varies from an average of 11 hours in January to just over 7 hours in July. The annual average is just over nine hours per day.

[7] Air temperature as measured in a Stevenson Screen at a standard height of 1.2 metres above ground level.

[8] The frost season is defined here as that period of the year in which, on average, at least one frost day occurs per month.

GEOLOGY

Mines and Energy SA have prepared the following summary of the regional geology for the Kingoonya SCB District Plan (see also Figure 7).

The Kingoonya SCD covers an area in which rocks of a wide variety of ages and characteristics are found. The topography is mainly subdued, with only a limited number of prominent hills and low ranges. This reflects the dominance of relatively young and flat-lying sediments that have not been subjected to major earth movements or uplift.

Scattered over the south western part of the region, from its western end to Lake Gairdner, are a large number of low rocky rises and hills which are the only exposures of a complex group of very old basement rocks that underlie all of this area at shallow depth. These basement rocks formed from a succession of sedimentary, volcanic, metamorphic and igneous rock between 2600 and 1600 million years ago. A few outcrops of iron formation near and north-east of Tarcoola are remnants of a younger sedimentary phase. Granite was intruded into the oldest rocks at about 1700 million years ago but is not widely exposed. At the northern edge of the Kingoonya SCD, south-east of Coober Pedy, there are isolated rock outcrops of granitic and metamorphic rocks of approximately the same age. Near Tarcoola and Kingoonya there are a number of low ranges composed mainly of quartzite, about 1660 million years old. These sediments are folded and tilted as a result of continuing crustal movements.

By contrast, the next youngest group of rocks have not been greatly disturbed since they were formed. Again occurring as scattered outcrops in the south-western part of the region, these volcanic rocks are outliers of a more extensive volcanic province which now forms the Gawler Ranges to the south-east. These flat-lying rhyolites[9], rhyodacites[10] and dacites[11] were poured out on to the older rocks during a violent, short-lived episode of volcanism almost 1600 million years ago. This was followed about seven million years later by the intrusion of granite into the base of the volcanic pile and surrounding areas.

From Lake Hanson past Woomera to the shores of Lake Torrens lies a plateau tilted to the west and formed from flat-lying Adelaidean Sandstone, siltstone and shale overlain by younger Andamooka Limestone and shale. These rocks were deposited on top of the older rocks of the region about 750 to 530 million years ago from a major sedimentary basin to the east and are the same rocks as those that later formed the Flinders Ranges.

Deposition resumed about 150 million years ago with the sediments of Eromanga Basin, which include the river-deposited Algebuckinna Sandstone followed by marginal marine sandstone and siltstone and finally marine mudstone (Bulldog Shale). These sediments occur in the low area between the outcrops of older rocks north of Lake Gairdner and north-west of Tarcoola as well as near Andamooka and Roxby Downs. To the north they coalesce into a thick basin of sediments that extends beyond the north-eastern corner of the State through Queensland to the Gulf of Carpentaria. Through most of the District these sediments have been bleached to white, yellow and pale grey colours by a weathering event that took place about 65 million years ago.

[9] A very fine grained granite.

[10] A very fine grained igneous rock containing quartz, feldspar and mica.

[11] An igneous rock extruded from the earth during volcanic activity, it contains quartz, feldspars and other minerals.

Opal occurring in these rocks at Andamooka and Coober Pedy may be related to this event.

Capping the southern extension of the Stuart Range south-east of Coober Pedy and forming the flat tops of the typical breakaway cliffs of the region, is a thin unit comprising sand, silt, conglomerate and breccia[12]. Deposited about 60 to 50 million years ago, these sediments have been strongly cemented by silica, rendering them very resistant to erosion. About 15 to 10 million years ago a lake formed in the Roxby Downs - Billa Kalina region. As it dried up it left a series of sandy beach ridges on its eastern margin as it shrank to the west. White dolomite was then deposited near Billa Kalina as the lake disappeared. A later weathering event cemented the beach ridge sands with hard silica.

Much of the country in the northern and north-eastern part of the Soil Conservation District is strewn with gibbers, which are pebbles of the silica-cemented capping left behind as subsequent erosion has slowly worn back the breakaways.

Later sediments are mainly less than two million years old and were deposited in three major environments during a period of increasingly arid climate that continues to the present day. Reddish gravel, sand, silt and clay form aprons around many of the higher rocky hills in the south-west as a result of deposition on alluvial slopes and in ephemeral creeks. Away from the hills, these sediments accumulated on alluvial plains which commonly also have a layer of gibbers on the surface. Limestone formed in these and older sediments in the west of the District due to the evaporation of groundwater as the climate became drier. Salt lakes contain gypsum-rich and salty sand, silt and clay deposited from present and past lakes and rivers. Longitudinal dunefields and sand spreads, formed 10 000 to 15 000 years ago, are found south-west of Coober Pedy, in the area from Kingoonya to Andamooka and Billa Kalina and south of Lake Hanson. They have resulted from wind forming extensive areas of dunes and spreads from sand blown from areas to the west.

[12] A rock made up of angular course fragments, similar to conglomerates.

LAND SYSTEMS

The vegetation, soils, topography, and geology of the Kingoonya SCD are described collectively as land systems. Land systems are an area or group of areas throughout which there is a recurring pattern of geology, topography, soils and vegetation.

The texture, fertility and position in the landscape of soils determine which plants will occur and is related to the underlying geology. Soils in low lying or run-on areas receive nutrient subsidies while eroded soils from run-off areas become nutrient deficient. Soils therefore provide a variety of habitats for plants and plants in turn reflect the nutrient status and texture of soils. The soils and the plant communities that grow upon them are mutually dependent upon each another.

The Pastoral Management Branch of the Department of Environment and Natural Resources (now the Pastoral Program of the Department of Water, Land and Biodiversity Conservation) mapped the land systems of the Kingoonya SCD (KSCB 1996). Badman (2001) revised the land system descriptions (Appendix B) and mapping (Figure 8).

The legend to the Land Systems Map provides the names of the land systems, a brief description of each and the groups into which they fall. More detailed descriptions and photographs of the land systems are given in Appendix B.

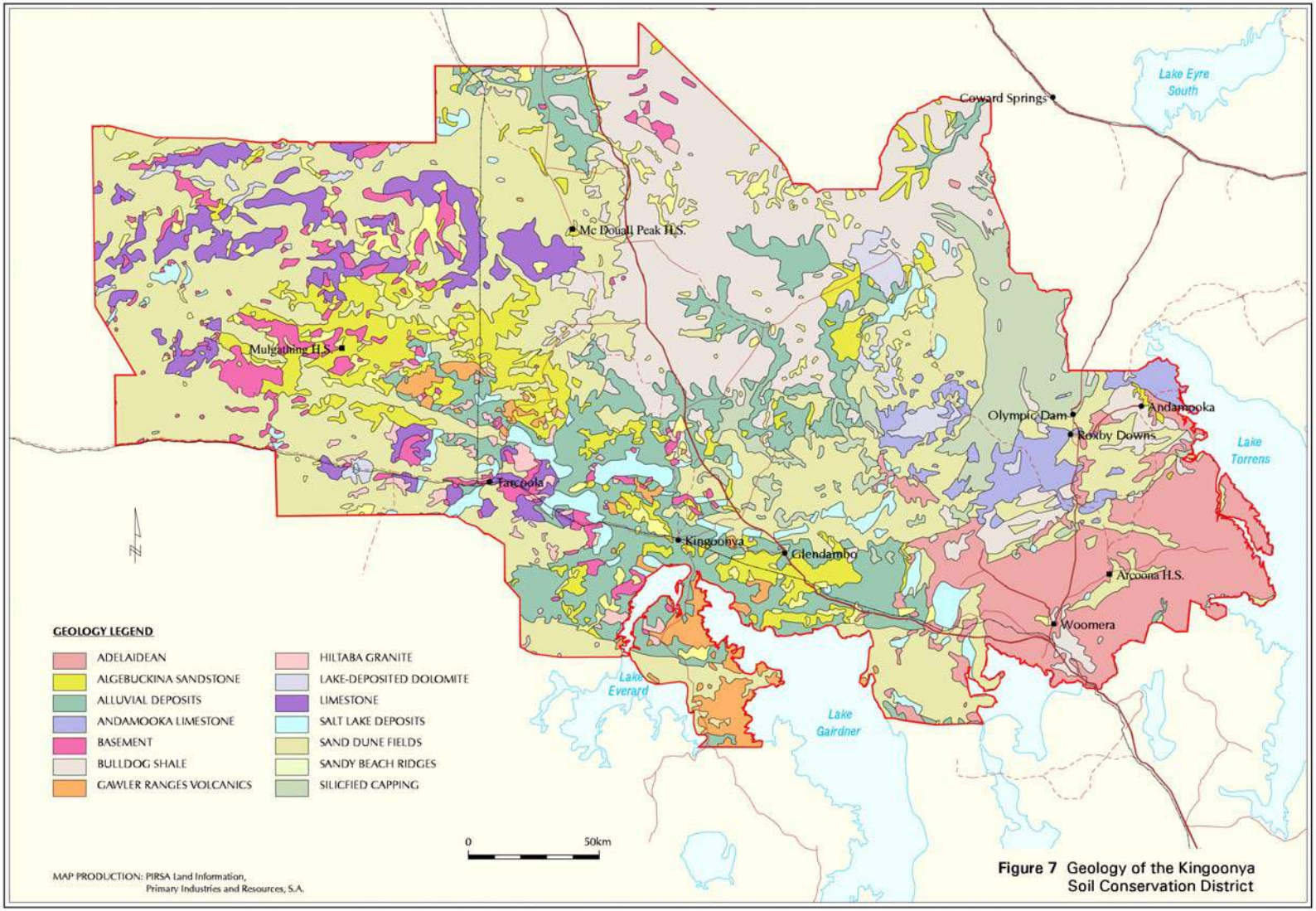

Figure 7: Geology of the Kingoonya Soil Conservation District

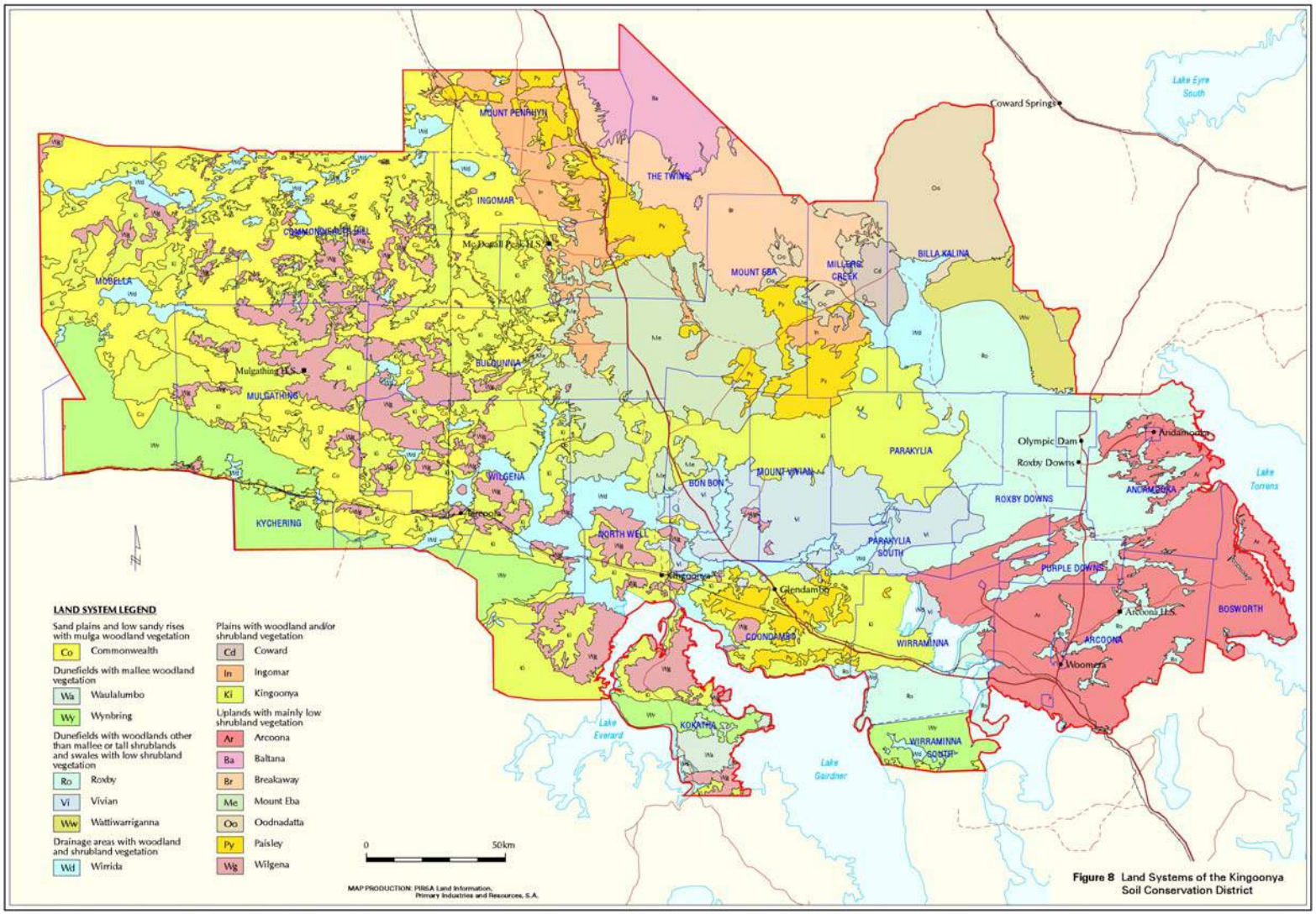

Figure 8: Land Systems of the Kingoonya Soil Conservation District

WATER RESOURCES

There is virtually no naturally occurring permanent potable[13] water in the district.

The district lies within the 150 - 200 mm isohyets with very variable rainfall and very high evaporation rates. There is no potential source of water suitable for irrigation.

Water resources suitable for domestic purposes and stock are necessary before sheep/wool and cattle production is possible. The sustainable use of the region for pastoral purposes relies on the distribution of water, which in turn determines the distribution of stock. Water is therefore one of the most important factors affecting production and is also a powerful tool in the management of the stock and pasture condition.

Domestic, industrial and stock water is derived from:

- local ground water or the Great Artesian Basin (GAB), tapped by bores or wells;
- local surface water stored in excavated earth tanks or dams;
- reticulation systems originating outside the district or on properties;
- ephemeral natural water;
- rainwater tanks.

Groundwater

Groundwater in the Kingoonya SCD is generally of poor quality when compared to other regions, but is still significant in providing a water supply for the pastoral industry.

Groundwater is very variable in depth, quality and quantity and in many areas care has to be taken not to over-use the supply or quality deteriorates, especially during dry periods. Aquifer depths range from 5 m to more than 150 m and salinities vary from under 500 mg/l to well over 20 000 mg/l. Supply varies from negligible to 10 000 litres/per hour.

Sediments of the GAB, including the main aquifer within the Cadna-Owie Formation and the underlying Algebuckinna Sandstone, underlie much of the District. Impervious fine-grained Bulldog Shale overlies these. Whilst the area covered by these sediments is extensive, the aquifer system is poorly developed within the District and is often discontinuous or absent. It is only in the extreme north-east of the District that the GAB surfaces at a few small mound springs and flowing bores with low yields and poor quality water. Salinity ranges from approximately 2000 mg/L to greater than 10 000 mg/L. The aquifer system is largely non-artesian in the District and is unconfined over large areas, which allows recharge to occur by direct infiltration of rainfall. However, recharge occurs infrequently and in low quantities, which means that the saline aquifer is rarely diluted by fresh water.

Groundwater supplies from other aquifers are scarce and unreliable. Whilst groundwater may be present at relatively shallow depths, salinity is usually too high for either human or stock

[13] Potable - fit for humans to drink.

consumption. Small supplies of relatively fresh groundwater are sometimes obtained from wells drilled into fractured rocks and sediments near outcropping basement rocks, where increased local recharge has caused a freshening of the water in the aquifer system.

Surface water

The use of dams and earth tanks is often constrained by the availability of catchment areas occurring in conjunction with suitable water-holding clay. Surface waters are more widely used in the east of the District, where good ground water is scarce and dam sites are relatively plentiful. Dams more than 10 m deep have been built to achieve near permanent supplies, but these are often curtailed by seepage of saline ground water, poor clay or rock. Small catch-holes are often more appropriate than large dams and these are used to spell permanent waters. Well-made and maintained catchments are vital because of the low and erratic rainfall.

Natural water holes occur in watercourses and creeks, but none provide a source of permanent stock water. Many natural water holes have been enlarged or banked to increase capacity.

Isolated rock-holes occur in the west of the district but these are of no commercial value.

Natural Wetlands

Wetlands are areas of either permanent or ephemeral shallow flooding. They include lakes, swamps and waterholes and may be of fresh, brackish or saline water. Wetlands are important habitats for fish, invertebrates, plants and birds and are complex and delicate systems. Ephemeral wetlands are found in the District and are mainly of value to invertebrates and birds.

Relatively large fresh water internal drainage systems (e.g. Lake Phillipson, Millers Creek) and many smaller swamps and lakes can supply water for up to four years but are extremely unreliable and rarely catch water. Read and Ebdon (1998) considered the Arcoona lakes system to be a significant ephemeral wetland for water birds, including migratory waders.

Water Supply Systems

Woomera, its rocket range and Pimba import water from the River Murray via a branch of the Morgan to Whyalla pipeline from Port Augusta. This also provides limited stock water to properties along its route.

Roxby Downs and the Olympic Dam mine pump their water through private pipelines from two borefields in the Great Artesian Basin. The water is used untreated in the mine and desalinated for domestic use. Limited stock water is made available to properties en route. Ongoing research and improvements in processing techniques have resulted in a gradual decrease in the amount of water used in processing each tonne of ore at Olympic Dam.

Glendambo was built to replace Kingoonya when the Stuart Highway was re-routed and sealed in the 1980s. The settlement now faces a serious problem with its water supply because the local aquifer that lies beneath cannot meet the ongoing demand. The Glendambo water supply is not fit for human consumption. As water quantity diminishes, the quality is also further deteriorating.

Andamooka obtains water from local dams and has to cart water from Roxby Downs when they go dry.

Station homestead water supplies vary widely in quality and quantity. Many are unfit for human

consumption and residents rely on rainwater tanks for water for drinking and cooking.

Property pipeline systems range from short, simple supplies to one-tank units, to complex networks supplying many water points from multiple supply sources.

The availability of polythene and PVC pipe has greatly facilitated on-property systems.

LAND USE

Pastoral

By far the most extensive land use by area is the production of wool, mutton, beef cattle and kangaroo products.

There are no local markets for produce so the cost of freight becomes a major inhibiting factor in the net profits of the stations. Road transport is now used exclusively for all produce and incoming freight. The ongoing maintenance of the Stuart Highway is therefore very important to the district.

The South Australian Dog Fence, which forms all of the western and much of the northern boundary of the district, is vital to the ongoing production of wool. Early experience demonstrated that sheep production is not viable without protection from dingoes.

Being a low rainfall area (average annual falls range from 140 mm to 200 mm) the country carries relatively low numbers of stock per square kilometre, but the dry climate also restricts the number of parasites of stock that can survive. Therefore expenditure on animal health is correspondingly low. Low rainfall combined with a high evaporation rate means there is no permanent surface water, so the provision of water for stock becomes a major part of the activities on a station.

Mining

WMC (Olympic Dam Operations) Pty Ltd produces high quality copper, uranium oxide, gold and silver from its Olympic Dam mine. The ore body consists of a proven resource of 450 million tonnes and the mine is expected to have a very long life. The purpose built town of Roxby Downs, 16 kilometres to the south of the mine, accommodates service industries and mine workers. The mine and processing plant are part of a highly mechanised modern operation that concentrates and refines the ore before dispatch to customers by road and sea. The owners of the operation have a commitment to conservation of the environment. Regeneration of disturbed areas is undertaken as an ongoing process.

Andamooka opal field is a collection of small mines dug using backhoes and bulldozers. The opal field covers an area of six square kilometres with housing built at random. It is one of the world's major sources of precious opal and is contained within a Precious Stones Field.

Recent exploration has revealed the potential for several new mining ventures.

The Challenger open-cut gold mine on Mobella Station commenced operation in 2002.

Government Installations

Woomera was built as the service town for the rocket range activities after the end of the Second World War and supports a military airfield, practice-bombing range and a temporary low-level radioactive waste storage facility on the Woomera Prohibited Area. The Joint Defence Satellite Receiving Station at Nurrungar was built in 1970 and closed down in March 2000. Two separate users, Kistler Aerospace and Spacelift Corporation, are currently investigating the possibility of satellite launch facilities at Woomera.

The University of Adelaide in collaboration with the University of Tokyo maintains three gamma ray telescopes on the outskirts of Woomera.

During the last few years Woomera has become the site of an Immigration Receiving and Processing Centre, which is now the largest employer in the town.

Tourism

By comparison with other areas with more defined tourist interests, the district has limited tourist potential and is relies heavily on artificial attractions such as Olympic Dam, Woomera and Andamooka. Most tourism stems from travellers along the Stuart Highway. All towns in the area provide accommodation and services for visitors to the region.

Native Title

Six native title claims, which overlap in some areas, cover the whole of the District. These claims are:

Antakirinja (SG6007/98);
Arabunna (SG6025/98);
Gawler Ranges (SG6020/98);
Kokatha Munta (SG6003/99);
Kujani (SG6004/98);
Ted Roberts (SG6005/98).

As an alternative to lengthy and costly litigation, the South Australian Farmer's Federation, the South Australian Government, the Aboriginal Legal Rights Movement and the South Australian Chamber of Mines and Energy are currently taking part in negotiations aimed at developing Indigenous Land Use Agreements.

Value of Primary Production

Primary production in the District is from both pastoralism and mining.

About 83 000 kangaroos were harvested from the District in the last financial year. Each animal yielded an average 17kg of meat at a value of $0.50/kg, or a total return of just over $700 000.

Production from the Olympic Dam mine from the 2000 WMC Limited Annual Report was:

Copper	200 423 tonnes
Uranium oxide	4539 tonnes
Gold	70 000 ounces

Total value of production was $798 000 000. In addition to these main metals, about 200 000 ounces of silver is produced from the mine each year.

No figures are available on the value of pastoral operations or opal production from the Andamooka Opal Field.

HISTORY OF THE KINGOONYA DISTRICT

The predominant Aboriginal group occupying the Kingoonya Soil Board area prior to European contact was the Kokatha, but other groups such as the Wirangu and Kujani also inhabited parts of the District (Hemming and Clarke 1989). Evidence of their past presence is still visible on many sand dunes bordering swamps and claypans.

Between 1858 and 1880, the early explorers, John McDouall Stuart, B.H. Babbage, Peter

Warburton and Ernest Giles travelled through this country and reported on its potential. The local Aboriginal people, whose knowledge of the harsh environment enabled them to occupy or travel through the whole area when surface water was available, assisted these early explorers.

Around the 1870s and 1880s, pastoralists also organised their own expeditions to investigate the suitability of the country and where reports were favourable, leases were applied for.

The Government's interest at this time focussed on occupation, development and the collection of rent.

Under the Crown Lands Act of 1884 (No. 321), land taken up for pastoral purposes had to be stocked with a minimum of five sheep or one head of cattle per square mile by the end of the third year of occupation, or to have improvements to the value of 30 shillings per square mile. By the seventh year of occupation lessees were required to stock with 20 sheep or four head of cattle or to invest £3 per square mile. These conditions were to be maintained for the term of the lease (Tynan 1992).

Since the time the first Pastoral Act was passed in 1893, when three classes of land were established corresponding with proximity to the railway, the criteria have changed to suit the needs of the day. Following recommendations of a Commission of Inquiry into the state of the runs, the regulations were changed to disallow overstocking in the last three years of the term.

As many people were leaving because of financial hardships caused by drought, incentives in the form of rent remissions and extensions of leases were provided in 1885 for development of water resources and occupation of the land. However, by the late 1890s many small blocks had been surrendered, while leases on the larger runs were not re-applied for because of low wool prices and huge stock losses due to dingoes. Added to this, a disastrous drought occurred between 1895 and 1903. In 1894 the stocking provision after six years of occupation was halved. If the lease was inferior, waterless or vermin infested, the lessee was not bound to increase stocking rates to more than 10 sheep per square mile at any time if £5 was spent per square mile on improvements or vermin control (Tynan 1992).

Gold was discovered at Tarcoola in 1893 and at Glenloth in 1894. By 1900, serious prospecting had put some life into the north-west, but by 1906 the short lived gold rush was over and Tarcoola's population of 2000 had dwindled to 200. The drought, high freight costs, disease, the hardness of the ground and the problem of water seeping into the mines all made life tough for the prospectors and contributed to the difficulty of extracting the gold. By 2000, the population of Tarcoola was reduced to two. Modernisation of the rail lines and traffic has meant that work gangs are no longer stationed here and this has led to the drifting away of the rest of the town's population and gradual closure of the town's businesses.

In 1880, the Great Northern Railway reached Coward Springs and this made a huge difference to stations such as Mount Eba, Parakylia and McDouall Peak, which obtained supplies and forwarded wool by rail. This railway also served Tarcoola and for a short period during the gold rush a stagecoach ran between Coward Springs railway siding and Tarcoola.

In 1917 the Trans-Australian Railway was completed, with camels proving invaluable in the transporting of the heavy timber sleepers. As soon as the railway was opened, the Tea and Sugar, originally known as the Service Train, started to run. The Tea and Sugar provided supplies, welfare services (e.g. Mothers and Babies) and the focus for social contact for railway workers and pastoralists along the line. It stopped at Wirrappa, Pimba, Burando, Lake Hart

(where salt was mined), Wirraminna, Coondambo, Kultanaby, Kingoonya, Ferguson, Wilgena, Tarcoola and Malbooma within the District on its way to Western Australia. The service was gradually reduced as sidings closed. The railway gave residents greater access to convenient transport of materials and stores into the District and export of produce until 1994 when the final offer of service to the pastoralist was withdrawn.

The Tarcoola - Alice Springs railway line was operating through Soil Board areas in 1978. It serviced Bulgunnia, Commonwealth Hill and Ingomar Stations until 1986. The service was reduced and by 1994 the railways ceased to carry stock. This was the last of the rail services to the District.

All pastoral properties within the Kingoonya SCD utilise the Stuart Highway. The Highway is named after John McDouall Stuart, who led the first successful south to north crossing of Australia in 1862. It developed from a series of tracks linking homesteads until, in 1979, State and Federal transport ministers announced that the sealing of the "Highway of Horror" between Port Augusta and the Northern Territory border would be completed in seven years. The sealed highway by-passed the township of Kingoonya on the Transcontinental Railway and the new town of Glendambo was created 44 kilometres to the east on the new highway.

Olympic Dam is the largest mining venture in the district. The mine and metallurgical plant officially opened in November 1988, with a major expansion completed 10 years later. It produces copper, uranium oxide, gold and silver. In recent years the mine's owners have purchased several surrounding pastoral properties, which continue to carry some stock, mainly on agistment from other runs.

The town of Roxby Downs lies 16 kilometres south of the mine and is named after the pastoral lease on which it was established. By 1992 the town had a population of 2500, which increased to 4000 following the expansion. The Olympic Dam site is named after a livestock-watering dam that was constructed in 1956, the year of the Melbourne Olympic Games.

In stark contrast to Roxby Downs is the sprawling township of Andamooka. John McDouall Stuart first visited the Andamooka area in 1858 and, together with later explorers, gave favourable reports of the area. A pastoral lease was taken out for Andamooka Station in 1872. Fifty-eight years later (in 1930) opal was first discovered and miners came to the field.

In 1946 the Chifley Federal Government joined in equal partnership with the British Government to establish a guided weapons experimental range and village at Woomera. In 1947 the Woomera Range and township site were chosen and work commenced. By the early 1950s the town was completed and the population reached 3500 in 1951. The range was used extensively through the 1960s and 1970s, but since then has been used intermittently by the RAAF, Australian Army and overseas forces for defence exercises. The Joint Defence Facility at Nurrungar was established 19 kilometres from the Woomera Village in 1970 and closed in 2000. Contractors made use of accommodation facilities in Woomera during the Olympic Dam expansion. The Immigration Receiving and Processing Centre was established at Woomera West in 1999 and has since undergone considerable upgrades. It held 1400 people in May 2000, but numbers fluctuate as applications for refugee status pass through the system. Today there are around 300 people in Woomera, the majority of whom are associated with the immigration centre.

In 1953, £16 000 was spent on telephone lines and sets for 10 pastoral properties within the Woomera Range for the purpose of early warning of missile firing. They provided the first

reliable telephone system to these homesteads.

By the late 1980s and early 1990s the whole area was updated by Telecom so that all outposts now have access to STD telephones. Also since the 1980s, homestead satellite receivers have enabled outposts to receive television.

The Kingoonya SCD is bounded on the north and west by the vermin proof fence known commonly as the Dog Fence. It was constructed at property owners' expense early in the 20th Century to save the early wool industry from marauding dingoes. There are records on some properties of sheep numbers declining by half from dingo attacks during a single year. Originally there were several Vermin-Fenced Districts, but in 1937-38 the suggestion was made to abandon these districts and rely on a single Dog Fence across the north of the State. This became a firm suggestion by the 1940s but was shelved during the war. In 1943 a four-person committee was formed to investigate the single fence proposal. This comprised I.R. McTaggart, B.H. McLachlan, W.H. Mengerson and the Surveyor General.

The present Dog Fence spans the State from Fowlers Bay to north of Broken Hill. It enters the District on the western side of North Well Station and follows the western boundaries of Wilgena, Mulgathing and Commonwealth Hill stations before leaving the District to go around the western and northern boundaries of Mabel Creek Station (in the Marla-Oodnadatta SCD). It re-enters the District as the northern boundaries of Mount Penrhyn, Mount Eba and Millers Creek stations. It then heads north along the west and north of Parakylia Station (this section is an electrified fence) before leaving the District along the northern boundary of Roxby Downs Station.

There are approximately 615 kilometres of Dog Fence in the District, comprising 579 kilometres of 5' 6" high netting fence and 36 kilometres of plain wire electric fence.

Ownership and maintenance of the fence originally rested with the properties adjacent to and inside the fence, but since May 1996 the State Government has resumed ownership, with a few leases electing to own and maintain their own section of fence. A group known as the Central Local Dog Fence Board manages the government sections. The fence is patrolled and maintained by two contracted patrolmen and inspected by an employed fence inspector and members of the local board.

The Central Local Dog Fence Board consists of four pastoralists, who do not necessarily live next to the fence and of whom one is Chair, and one government representative who acts as secretary. This Board is responsible for the section of fence from Mabel Creek Station to Mulgaria Station inclusive. Funding for the maintenance of the fence is partly from government funds, with the rest from dingo rates collected from sheep graziers inside the fence and from a levy on sheep sales. The western section of the fence continues to be maintained by the adjoining inside lessees.

All leases in the District are inside the Dog Fence except Billa Kalina Station, which runs cattle outside the fence.

The lessees manage approximately half of the stations within the District; employed managers run the remainder. With a few exceptions, this appears to have been the pattern since the country was taken up for pastoral lease.

Low commodity prices and mechanisation of the pastoral industry have caused staff numbers to

be reduced and they are now at the lowest level since the early days of development. The Aboriginal population in the area has also declined. In contrast, the population involved in mining and tourism is now at its highest level.

INFRASTRUCTURE AND SERVICES

Transport

Road

The Stuart Highway is the main access route through the District. For many years a dirt road, it was bituminised and re-aligned during the 1980s. Other bitumen roads are the Pimba to Roxby Downs via Woomera and various roads within the Woomera Range. Transport SA is responsible for these and for unsealed designated access roads (Figure 1).

Upkeep of station tracks is the responsibility of the owner/manager. These tracks are not public roads. Under the *Pastoral Land Management and Conservation Act 1989*, the general public are not permitted to drive on station tracks without prior permission of the lessee.

Rail

Both the Transcontinental line (east-west) and the Ghan line running from Tarcoola to Alice Springs pass through the District (Figure 1). The goods train known as the Tea and Sugar no longer travels on the Transcontinental line and the services it used to provide for settlements and station properties have been discontinued. Trains also deliver and collect mailbags from Kingoonya and Tarcoola. All movement of stock from rail sidings within the Kingoonya SCD has ceased.

Air Services

Military airstrips at Woomera are maintained by the RAAF and are normally restricted to service aircraft. A registered airstrip is situated at Olympic Dam and this serves the town of Roxby Downs. The regular passenger service between Adelaide and Olympic Dam no longer lands at Woomera.

Bus services

Buses provide a passenger service in, out and through the area. The main routes are along the Stuart Highway to Alice Springs, and to Roxby Downs and Andamooka Opal Field.

Tourist bus companies

Tourist bus companies tour throughout the District. One company operates tours around Roxby Downs, Andamooka and Olympic Dam.

Stock and wool carting

All stock and wool carting is by road since Australian National ceased servicing this District by rail in February 1994.

Communications

Mail

Commercial bus services drop off and collect mailbags at station turn-offs and at Glendambo, usually three times a week. Trains deliver mail to Kingoonya and Tarcoola.

There is one official mail run by a contractor, which goes from Woomera to Parakylia, Billa Kalina, Millers Creek, Mt Eba and Mt Vivian stations. Andamooka Township has an Australia Post agency and receives its mail via Roxby Downs during the week with a delivery by bus at the weekend. Roxby Downs receives its mail by air from Adelaide and by courier from Port Augusta.

Telephone, Facsimile and E-mail

The District is served by the Single Mode Optical Fibre Network, which is owned and maintained, by Telstra. This line passes through the District on its way north to Darwin and west to Perth. All homesteads and townships are linked to this system by radio and through which the District has the services of telephone, facsimile and computer links. Mobile telephone services are available within a limited distance of Roxby Downs and Woomera. E-mail, including the broadband service, is now available. Data transmission speeds for those not using broadband are still very slow.

DUCT (Diverse Use of Communication Technology)

This enables groups of people to hold meetings or classes over the telephone; students doing Distance Education use this facility. One or more persons have their own microphone connected by telephone to others. Many community groups use DUCT to hold teleconferences in preference to travelling long distances to meetings. Open Access College uses this system to teach subjects such as music and Indonesian.

Transceivers

HF radios are used for contact with the Royal Flying Doctor Service (RFDS), for School of the Air lessons and for personal communication with outlying staff and neighbours.

The Radphone service through the RFDS is now no longer available except in the case of an emergency.

UHF Radio

Many properties use UHF radio for on station communication as UHF radios are much cheaper than HF radios. UHF repeater stations now cover most of the District.

Television/Radio

A satellite dish and decoder are used at each homestead to receive TV and FM radio broadcasts. ABC Regional Radio is available throughout the District.

Medical Services

The Royal Flying Doctor Service

Clinics

The RFDS runs clinic flights to Glendambo, Kingoonya, Commonwealth Hill, Mount Eba and Tarcoola on a monthly basis. Other stations can arrange a clinic during a clinic run if it is required.

Emergency evacuation

The RFDS will evacuate patients from any airstrip the pilot considers safe.

Emergency Radio

Radio contact with the RFDS is available on a 24-hour basis for anyone in an emergency. There are also three designated times each weekday for consultation via RFDS and HF radio with the duty doctor in Port Augusta.

Hospitals

Woomera has a well-equipped hospital. A fully equipped modern hospital opened at Roxby Downs in 1999 and Andamooka has a weekly clinic serviced from Roxby Downs. The hospital at Tarcoola was officially closed in September 1996, but remains functional in case of an emergency along the railway line. A monthly RFDS clinic is still held there.

Power Generation

Woomera, the town of Roxby Downs and the Olympic Dam Mine are supplied with power from the State grid. Both Woomera and the Olympic Dam Mine also have the capacity to generate their own power when necessary. Private power companies manage the power stations at Glendambo, Tarcoola and Kingoonya, with the latter also supplying North Well Station. Station properties generate their own power, with an increasing use of solar energy.

LAND MANAGEMENT

The following issues and their importance in the sustainable management of the land resource are discussed in this section:

Rangeland Condition
Land systems - production indicators and constraints
Rabbits
Other Feral Animals
Kangaroos
Insect Pests
Scalding
Wind Erosion
Water Erosion
Fire
Woody Shrub Increase
Weeds
Drought
Conservation
Property Management Planning
Mining and Exploration
Low Level Radioactive Waste Storage
Effluent Disposal
Defence Operations
Off-road Vehicles

RANGELAND CONDITION

A survey of District land managers conducted by the Kingoonya SCB (KSCB 1996) identified grazing management as a medium priority issue.

Rangeland condition is the 'health' of the plant and soil resources relative to their potential condition in that particular area. Condition is determined by comparing similar soil and vegetation sites under different grazing pressures. If the soil environment is changed the plant community will also change. Alterations to the soil resource, which result in a decline in the quality and condition of the soil, are called soil degradation. Soil degradation in pastoral areas is largely the result of accelerated (compared with natural) wind or water erosion.

The production of sheep and cattle in the Kingoonya SCD is dependent on native vegetation as the grazing resource. The sustainable management of the land in this District must therefore conserve the density and diversity of the vegetation and its ability to respond to seasonal influences. Plants are therefore used as indicators of rangeland condition or the 'health' of the vegetation or pasture. The grazing impact on the more palatable species needs to be managed so that these species are maintained.

Changes in rangeland condition can occur over short or long periods of time and may be reversible or irreversible. These changes can be detrimental to long-term productivity. Rangeland condition is often a reflection of past management, but can also be influenced by other factors such as fire and storm damage, and vertebrate and invertebrate pests.

The two main factors that influence rangeland condition are seasonal conditions and total grazing pressure (from domestic, native and feral animals).

Indicators of high grazing pressure are:

- loss of the more palatable perennial species and/or the remaining perennial species in poor condition;
- replacement of perennial species with annual and ephemeral species;
- replacement of palatable species with less palatable species, e.g. replacement of low bluebush with black bluebush[14];
- bare unstable soil surface with associated water and wind erosion;
- increased grazing of less palatable species.

Grazing pressure is generally highest where stock congregate, such as at watering points and dam catchments. Poorly positioned waters are a major cause of poor rangeland condition.

The following summary of the condition of vegetation in the Kingoonya SCD is based on the combined "Land Condition Index" data collected by random samples from each station. These data give an indication rather than a measure of land condition within the District. For further information on the methodology see the Kingoonya SCD General Summary of Lease Assessment Findings (Pastoral Management Branch 1991). These are the most recent data available.

The Land Condition survey indicated:

- approximately 43% (26 118 km^2) of the district's vegetation resources were intact (condition class 3);
- approximately 28% (16 700 km^2) has been disturbed to a sufficient degree to be of concern (condition class 2);
- approximately 30% (18 222 km^2) has been severely disturbed as a result of grazing livestock, feral animals or fire, or combinations of these (condition class 1);
- a major portion of the severely disturbed areas is chenopod shrubland (approximately 13% of the district or 7890 km^2), showing loss of saltbush and no evidence of recruitment. A further 16% of the district (9710 km^2) has chenopod shrublands that are disturbed to a sufficient degree to be of concern;
- approximately 35% (21 230 km^2) of the district comprised chenopod shrublands in an intact state, and this was mostly accounted for by areas that are not grazed due to lack of water. The bluebush/saltbush calcareous plains component is the most disturbed component within the chenopod shrublands, with 6% of the district or 3445 km^2;

[14] Lists of plant species for the District are given in Appendices C and F.

- of the low woodlands pasture type, the mulga/horse mulga sand-dune component comprised the highest proportion (11% or 6565 km^2) of severely disturbed land for this type. Substantial areas of this type have been disturbed by bushfires and nearly half of this low woodlands pasture type was rated as condition class 1.

A subsequent industry-funded survey indicated an improving trend in land condition in the north-western and central parts of the District (John Maconochie, *in litt*. July 1995). Data are not available for other parts of the District. The results of this survey are presented in Appendix D.

Land management and rehabilitation

Conservative stock management is the best strategy pastoralists have for the maintenance of native pasture resources. Sound management of stock, both in paddocks and during stock handling procedures such as crutching and shearing, are crucial to the maintenance of rangeland condition.

Factors that need to be considered when placing stock in paddocks or on waters are:

- water - quality and quantity;
- feed - type and quantity;
- maintenance of vegetation;
- soil type;
- season of rainfall;
- fencing and water location.

Water

Water quantity

Sheep typically consume 7-8 litres and up to 14 litres of water per day and cattle up to 60 litres per day. Because stock usually drink at least once every two days and in dry seasons once or twice per day, care must be taken not to place undue stress on the vegetation in close proximity to the water.

Water quality

Cattle require better quality water than sheep. Dry beef cattle will tolerate up to 10 000 ppm salts and adult dry sheep up to 13 000 ppm salts. Lactating stock, lambs and calves require water in the 5-6000 ppm range or better.

Wethers are generally run on the poorer quality waters because they can tolerate a higher salt content than breeding ewes. Ewes and lambs require less saline water to maintain condition and if placed on poor quality water will stay around the water point, putting additional pressure on the nearby vegetation. In these situations, stock numbers need to be adjusted accordingly.

Feed

Annual feed

The timing and amount of rainfall and the land type determines the type and quantity of annual feed. Winter rains produce annual herbs and winter growing grasses (e.g. spear grasses). Summer rains give rise to summer grasses (e.g. button grass).

Annual grasses and herbs provide the bulk of nutritious palatable feed and these are selected by stock in preference to the perennial vegetation. As annual vegetation matures and becomes dry, rank and less digestible, stock turn to the perennial vegetation for feed.

Perennial feed

Most perennial bush species of shrublands are palatable to stock. These include bladder saltbush, low bluebush, pearl bluebush, black bluebush, old man saltbush, Oodnadatta saltbush and woolly bluebush.

Perennial grasses such as barley Mitchell-grass and neverfail, which occur mainly in gilgais and some watercourses, are a valuable source of stock feed when green, but are of low nutritional value when dry.

In the mulga woodlands, perennial grasses such as bandicoot grass and window mulga grass are palatable to stock and quickly respond to light rainfall. Crimson emubush and mulga are also palatable to stock. Woollybutt is less palatable and is grazed mainly when nothing better is available, making it a useful indicator species of the health of the pasture.

Maintenance of soil and vegetation

The objectives of sustainable management of soils and vegetation are to:

- maintain vegetation cover and bush density;
- allow bush and grasses to seed to ensure future recruitment of perennials and annuals;
- prevent soil erosion by maintaining soil surface cover;
- allow pastoralism to continue in a sustainable way.

A good strategy for ensuring that grazing management is achieving these objectives is to monitor rangeland condition. The simplest method of monitoring is by photographing a marked site and keeping notes on plant species present, season and stock movements.

The Pastoral Program of Primary Industries and Resources, South Australia (PIRSA) has established a network of approximately 1000 monitoring sites across the District, with at least one site in nearly every permanently stocked paddock. The photographs and related information such as location and species lists have been supplied in the form of a photo point manual to every station. An updated paddock plan showing the location of the photo points has also been supplied to all stations. The Program offers free film and developing to any managers wishing to revisit these photo points in return for the Branch retaining a copy of the photographs.

Soil type

There is a direct relationship between soil and pasture types in the Kingoonya district. Deep

sandy soils support mulga woodlands with grassy understorey. The loam and clay soils support chenopod shrublands. The growth response of annual feed is very quick on sandy soils, which wet quickly after rain. The heavier loam and clay soils require longer periods of steady rain to become wet and the feed response is therefore slower. However, run-off from these areas produces a rapid response in gilgais and other run-on areas.

Season of rainfall

The season in which rain falls will affect the resulting amount and type of plant growth. Summer rainfalls promote the growth of perennial grasses and a quick response by some annuals on sandy soils. However this growth may quickly be "cut off" by dry winds. Annual herbs and spear grass are the main feed species that grow in response to winter rains. There are several species of grasses (e.g. the bottle-washers) that respond to both summer and winter rains. Perennial chenopod shrubs require prolonged winter rainfall to ensure germination and successful establishment, although new leaf growth is produced following most rains.

Fencing and water location

Location of waters

Location of watering points is the most effective means of managing the efficiency and spread of stock grazing. Sheep tend to graze into the wind; therefore waters placed north of the centre of the paddock will encourage grazing of the whole paddock. At least two waters in each paddock, placed so as to evenly spread the effects of stock grazing, is also a good strategy. Where possible, watering points should be located in areas with hard soils.

Maximum and even use of pasture will be obtained on sheep properties by placing waters approximately 8 km apart to give a grazing radius of about 4 km per water and by placing fencing to manage sheep grazing patterns. To optimise the use of pasture where cattle are run, waters are best placed 8 - 10 km apart. Suitable rainfall, particularly during winter, enables stock to utilise areas well away from water. In most years, stock can utilise pastures outside the 4 km radius for several months.

Use of ephemeral waters

Perennial pastures benefit from spelling, especially after long dry periods during which the perennial species have been the main source of stock feed. Shifting stock off permanent waters on to non-permanent (ephemeral) waters such as dams, swamps and claypans gives the vegetation surrounding permanent watering points a chance to regenerate.

Appropriately located and adequate fencing

This is an important method for controlling grazing pressure. If fencing is in poor condition stock will tend to push through the fences and congregate around the fresher quality and/or southern waters. Sheep prefer to graze into the wind, leading to their congregation in the south of a paddock when waters are placed on or near the southern fence line.

The ideal paddock arrangement is to align the long side of a rectangular paddock with the dominant wind direction. Where winds are predominantly southerly, rectangular paddocks (but not long and thin) aligned north-south with waters located north of the centre are preferred.

The topography and mix of vegetation types needs also to be considered when designing paddock layout. If stock are concentrated by the combination of fence, water and/or topography

the condition of the vegetation is likely to deteriorate.

Sound stock management practices

Shearing, crutching and lamb marking require stock to be mustered and held in confined areas. Similarly, the increasing trend to sell cattle by specification in drafts to suit buyers can require the holding of stock while numbers are put together. The movement of stock for these procedures needs to be carefully planned to minimise the impact on vegetation and soils in holding paddocks.

Planning for these operations needs to include:

- the timing of mustering each mob - avoid mustering too early (use of aircraft with good ground to air communication can speed up and simplify mustering);
- the holding facilities for all mobs into and out of the shearing shed and/or yards;
- the size of shearing and mustering teams required to run the sheep through the process smoothly - determining how many sheep will be handled each day;
- holding mobs in paddocks of appropriate size so that vegetation condition is maintained, i.e. hold larger mobs in bigger paddocks;
- reserving holding paddocks for these operations - don't set stock these paddocks, and plan feed reserves for these processes;
- construction of suitable watering points where large mobs are handled;
- working to the principle that stock will be moved in for crutching, shearing or tailing and back to their home paddock as quickly as possible.

LAND SYSTEMS - PRODUCTION INDICATORS AND CONSTRAINTS

For each of the land systems occurring in the Kingoonya SCD, Table 2 summarises the following indicators of, and constraints to, sustainable management of the land:

- the indicative carrying capacity for the land system;
- the indicator plant species for units within the land system;
- susceptibility to soil erosion;
- other management problems of the land system;
- successful methods to overcome degradation and management problems.

Indicative Carrying Capacity

The average stocking rate or indicative carrying capacity assumes fair to good land and pasture condition and takes into account the limitations of the land type. It is described as the number of sheep or cattle per unit area.

Indicator Plant Species

The occurrence, abundance and intensity of grazing of certain plants indicate levels of range condition for a particular soil-vegetation association. Changes in vegetation are commonly used to describe land condition. There are several types of indicator plants; decreaser plants, increaser plants and invader plants. Decreaser plants are most commonly used for describing land condition. Monitoring (see "Maintenance of soil and vegetation" is useful in ensuring that the number and density of decreaser plants does not decline.

Decreaser plants

Plants that are preferred by stock and which decrease in density and are eventually eliminated from zones of high grazing pressure are known as ‘decreaser plants’. Bladder saltbush and barley Mitchell-grass are decreaser plants.

Increaser plants

These are plants that are not preferentially grazed by stock and which increase in density and eventually dominate zones of high grazing pressure (replacing decreaser plants). Some bindyis, nulla nullas and sandhill wattle can be increaser plants in some situations.

Invader plants

These are plants that establish and subsequently dominate sites on which they were formerly scarce or absent (e.g. Bathurst burr and wild turnip). The invasion usually occurs after, or as a result of, soil disturbance such as vegetation clearance, fire or high grazing pressure.

Proneness to Soil Erosion

This category identifies the types and extent of soil erosion occurring or that may occur in the land system.

Other Management Problems

This column identifies management problems other than soil erosion that are associated with the land system.

Successful Rehabilitation Methods

This column identifies best options for managing the land management problems identified in the previous columns. Further information on management of these constraints is given in the Land Management section of this District Plan.

Table 2 Land Systems - Production Indicators and Constraints

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Arcoona	Undulating tableland with gilgai supporting low chenopod shrubland and perennial grasses in gilgais. The soils are deep clays with a thick cover of gibber.	6 sheep/km^2 average and 4 - 8 sheep/km^2 according to seasonal conditions.	Bladder saltbush, low bluebush, barley Mitchell-grass, neverfail, cotton-bush, bush minuria.	Prone to water erosion if gibber surface is removed. Loss of perennial vegetation near permanent waters.	Maintain stone cover on soil surface. Place waters away from fences, especially southern fences. Make use of ephemeral waters (spell paddocks with permanent waters in good seasons).	No underground water. Military exercises. Off-road vehicles and camping Erosion of graded roads. Kangaroos Emus Goats	Negotiate land management conditions through Pastoral Program Erect "No public access" signs. Do not remove stone cover. Construct banks to run water off safely. Apply for permit to shoot. Muster and truck and shoot with goal of preventing build up of numbers in the region. Co-ordinate mustering with neighbours.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Baltana	Fine clay plains with limited perennial vegetation. Good response to rainfall by short-lived chenopod forbs and grasses. Watercourses support chenopod shrubs and barley Mitchell-grass.	Seasonal grazing of plains. Watercourses have more perennial vegetation but water supplies limit grazing potential.	Cotton-bush, bladder saltbush, bush minuria, neverfail and barley Mitchell-grass.	Low	Regulate stock to seasonal conditions. Watercourses support perennial feed and may allow stocking if water is available. Other areas are most productive after at least 50 mm rain. Clay soils require wetting-up before soil moisture is high enough to support ephemeral plant growth.	Kangaroos inside Dog Fence	Apply for permit to shoot.
Breakaway	Breakaway slopes and extensive outwash plains. Bladder saltbush dominates the shaly outwash plains, with samphire and spiny saltbush. Red mallee and mulga occur on breakaways.	3 - 4 sheep/km^2 depending on season.	Bladder saltbush, spiny saltbush, cotton-bush and dead finish.	High water erosion if surface disturbed	Avoid deep grading and removal of shale pavement. Stock lightly, use as opportunity country	Kangaroos	Apply for permit to shoot.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Common-wealth	Sand plains with low open woodland. Sand plains grade into low dunes in the south. Occasional isolated stony hills (former Mailgate land system). Claypans	5 sheep/km^2 average. Varying from 2 - 8 sheep/km^2 according to season.	Pearl bluebush, satiny bluebush, ruby saltbush, woollybutt and regenerating mulga.	Wind erosion - high potential where vegetation cover on dunes has been removed.	Regulate stock numbers according to seasonal vegetational cover. Locate waters in harder country to minimise drift.	Rabbits Fire Kangaroos.	No general economic control method, rip warrens in most productive areas if desired. Regulate stock and kangaroo numbers after fire to maximise opportunities for recruitment of desirable species. Apply for permit to shoot.
Coward	Flat calcareous plains supporting a bluebush and saltbush dominated shrubland, falling away steeply to lower plain with creeks and small watercourses.	Cattle <50 head per water, 0.5 breeding cows/km^2. Sheep 3 - 4 sheep/km^2 average, 2 - 5 sheep/km^2 depending on seasonal conditions.	Watch for depletion of low bluebush and bladder saltbush and utilisation of bottle-washers. Watch for depletion of bladder saltbush and utilisation of bottle-washers.	Prone to water erosion on slopes. Prone to scalds on severely disturbed areas.	Erosion control banks, maintain stone cover on tracks. Light stocking Water ponding banks	Rabbits Kangaroos inside Dog Fence Graded roads wash on slopes	No general economic control method, rip warrens in most productive areas if desired. Apply for permit to shoot. Construct banks to run water off safely.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Ingomar	Alluvial plains and watercourses. Sandy flats supporting chenopod shrubs, mulga woodlands on dunes, coolibah and teatree swamps and watercourses.	5-7 sheep/km^2 average. Varying from 2 - 8 sheep/km^2 according to season. (Up to 10 sheep/km^2 in flooded areas.)	Regenerating mulga, dead finish, bladder saltbush and pearl bluebush.	Soil erosion not a significant problem. Dunes may drift where vegetation density is low.	Regulate stock numbers according to seasonal vegetation cover	Kangaroos	Apply for permit to shoot.
Kingoonya	Calcareous plains supporting open mulga and western myall woodlands and pearl bluebush shrubland.	5 - 6 sheep/km^2 in average seasons. 2 - 8/km^2 according to season.	Pearl bluebush, satiny bluebush, bladder saltbush, ruby saltbush, mulga (browse line and regeneration).	Wind - moderate if bush density is reduced. Water – minimal Scalding - this country is moderately prone to scalding if vegetation density is reduced and areas become bare.	Regulate stock numbers according to seasonal vegetation cover to maintain perennial bush density.	Fire Kangaroos	Regulate stock and kangaroo numbers after fire to maximise opportunity for recruitment of desired plants. Apply for permit to shoot.
Mount Eba	Very flat buckshot covers plains supporting patchy mulga scrub, *Aristida* grassland and chenopod shrubland. Low hills and rises of the Stuart Range supporting chenopod low shrublands.	Set stock at rate of 5 - 6 sheep/km^2.	Ruby saltbush, bindyi, bladder saltbush, woollybutt, neverfail, dead finish; browse-line and regeneration of mulga.	Minimal	Regulate stock numbers according to seasonal vegetation cover, particularly to maintain perennial bush density in chenopod shrublands.	Kangaroos	Apply for permit to shoot.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Oodna datta	Undulating treeless plain with gilgai and numerous creeks, watercourses and flood plains.	Cattle: 0.6-1.2 head/km^2. Sheep: 4 - 8 sheep per km^2. Creeks provide quality feed after rain increasing the carrying capacity of this land system.	Bladder saltbush, barley Mitchell-grasses, old man saltbush, removal of grasses, light grazing only of Oodnadatta saltbush on tablelands. Cotton-bush and barley Mitchell-grass. Cotton-bush, bladder saltbush, Oodnadatta saltbush.	Water erosion (gullying) if gibber pavement removed, especially on graded roads	Avoid deep grading and removal of gibber pavement; placement of water control banks on steep roads.	Loss of perennial bush around permanent waters. Rabbits Kangaroos inside Dog Fence	Make use of ephemeral waters (gilgai, waterholes) by shutting off permanent waters and pushing stock out. Cut numbers at onset of dry conditions. No general control method, rip warrens in most productive areas if desired. Apply for permit to shoot.
Paisley	The Stuart Range tableland consisting of flat topped uplands with gilgai. Low chenopod shrubland and perennial grasses vegetate the gilgais.	2 to 8/km^2 depending on seasons. Reasonably stable stock condition.	Bladder saltbush, bluebush.	Wind erosion - low Water erosion - low, except high if stone cover is removed. Scalding - medium where vegetation and stone have been removed.	Regulate stock to seasonal conditions and vegetation cover. Stable numbers can be carried through if good water is available.	Loss of bush around waters. Rabbits, low numbers Kangaroos	Shut off waters and allow areas to revegetate. Apply for permit to shoot.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Roxby	Deep sands on dunes support white cypress pine woodlands, with mulga woodlands on smaller dunes and in swales. Chenopod shrublands occur on calcareous interdune flats.	4 - 7 sheep/km^2 average up to 8 sheep/km^2 depending on season.	Bladder saltbush, low bluebush, ruby saltbush, bullock bush, mulga grass, tall kerosene grass and mulga (browse line). Decrease of the generally unpalatable tall kerosene grass from dunes is a sign of overgrazing.	Dunes: Prone to wind erosion where there is limited vegetation cover. Swales: Prone to water erosion if surface is disturbed or vegetation removed.	Avoid heavy stocking. Avoid locating water points on dunes (careful selection). Destock in dry times.	Rabbits Fire Kangaroos Off-road vehicles and camping	No general economic control method, rip warrens in most productive areas if desired. Regulate stock and kangaroo numbers after fire to maximise opportunity for recruitment of desired plants. Apply for permit to shoot. Erect "No public access" signs.
Vivian	Low dunes with both shallow sandy and calcareous loam swales; sandplains. Mulga woodlands dominate the sandy units and chenopod shrubland the calcareous earths.	5 - 6 sheep/km^2 average. Varying from 3 - 8 sheep/km^2 according to season.	Bluebush (obvious grazing) Mulga (browse line)	Wind - high when vegetation cover removed. Water - minimal Scalding- minimal	Regulate stock numbers according to vegetation cover.	Rabbits Fire Kangaroos	No general economic control method, rip warrens in most productive areas if desired. Regulate stock and kangaroo numbers after fire to maximise opportunity for recruitment of desired plants. Apply for permit to shoot.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Wattiwar - iganna	Parallel dunes supporting sandhill wattle and sandhill cane-grass; broad swales with chenopod low shrublands or grasslands.	4 - 7 sheep/km^2 average up to 8 sheep/km^2 depending on season.	Bladder saltbush, low bluebush, ruby saltbush, bullock bush, mulga grass, tall kerosene grass and mulga (browse line). Decrease of the generally unpalatable tall kerosene grass from dunes is a sign of overgrazing.	Dunes: Prone to wind erosion where there is limited vegetation cover. Swales: Prone to water erosion if surface is disturbed or vegetation removed.	Avoid heavy stocking. Avoid locating water points on dunes (careful selection). Destock in dry times.	Rabbits Fire Off-road vehicles and camping	No general economic control method, rip warrens in most productive areas if desired. Regulate stock and kangaroo numbers after fire to maximise opportunity for recruitment of desired plants. Erect "No public access" signs.
Waula-lumbo	Parallel dunes supporting white cypress pine and mallee woodland. Granite outcrops.	5-6 sheep/km^2 average, varying from 2 - 7 sheep/km^2 according to season.	Ruby saltbush, bladder saltbush and regenerating mulga.	Degradation due to seasonal factors especially close to salt lakes with water erosion. Considerable movement of some dunes due to wind.	Adjust stock to suit season	Kangaroos Fire.	Apply for permit to shoot. Regulate stock and kangaroo numbers after fire to maximise opportunity for recruitment of desirable plants.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Wilgena	Mulga scrub on skeletal stony sandy loams is the dominant unit in this land system. Patches of chenopod and *Eremophila* shrubland are also present.	Average carrying capacity is 4 - 6 sheep/km^2 and ranges from 2 - 8 sheep/km^2 depending on season.	Bladder saltbush, pearl bluebush and ruby saltbush; browse line and regeneration of mulga.	Minimal except on tracks with removal of stone cover.	Regulate stock numbers according to seasonal vegetational cover. If denuded of vegetation, may need longer to revegetate due to lack of ephemeral/annual species.	Kangaroos	Apply for permit to shoot.
Wirrida	Dunefields associated with salt lakes, claypans and cane-grass swamps, supporting salt tolerant chenopods.	Cattle: 0.7 head per km^2; in clover seasons this can be increased to 0.7-8 per km^2. Sheep: 2 - 5 per km^2 according to season.	Bladder saltbush, pearl bluebush and bottle-washers close to lakes and in swales; mulga (browse line and regeneration), spiny saltbush and ruby saltbush on dunes.	Wind erosion - of dunes if vegetation is removed.	Close watch on stocking rates: first land system to destock because area and shape of lakes and claypans funnels stock movements and concentrates grazing pressure.	Rabbits Fire Kangaroos	No general economic control method, rip warrens in most productive areas if desired. Regulate stock and kangaroo numbers after fire to maximise opportunity for recruitment of desired plants. Apply for permit to shoot.

Land System	Land unit description	Indicative carrying capacity	Indicator species	Proneness to soil erosion - wind water, scalding	Successful management methods	Other management problems	Suggested rehabilitation methods
Wynbring	Dunes and deep sandy swales supporting mulga and mallee woodland.	4 - 5 sheep/km^2 average. Varying from 2 - 7 sheep/km^2 according to season.	Woollybutt and satiny bluebush.	Wind erosion - high potential where vegetation cover on dunes has been removed.	Surface water supplies limit stock grazing to good seasons. Can carry up to 7 sheep/km^2 while grass lasts.	Rabbits Fire Kangaroos.	No general economic control method, rip warrens in most productive areas if desired. Regulate stock and kangaroo numbers after fire to maximise opportunity for recruitment of desired plants. Apply for permit to shoot.

RABBITS

A survey of landholders by the Kingoonya SCB identified rabbits as the major environmental concern of pastoralists in the District.

Rabbits were first reported in damaging numbers in the Kingoonya area in about 1890. Several plagues occurred from then until the mid 1950s whenever good seasons prompted the rabbits to breed rapidly for an extended period.

The advent of myxomatosis in the 1950s caused a major decline in rabbit populations and it appears to have prevented subsequent large-scale plagues. However, its effectiveness has now waned.

The impacts of rabbits can be summarised as follows:

- even low numbers of rabbits suppress regeneration of perennials and can contribute to the replacement of a perennial plant community with an annual or ephemeral plant community or to an increase in the density of unpalatable plants;

- grazing by rabbits, particularly when warrens are numerous, denudes an area and leads to increased erosion, especially in sandy country;

- twelve rabbits graze the equivalent of one dry sheep equivalent (DSE) and compete directly with livestock and native animals for available feed. Localised destocking may become necessary where rabbits have grazed heavily;

- rabbits provide a food source for dingoes, cats and foxes enabling these animals to reach high numbers which then impact on native wildlife and livestock.

Warrens provide refuge for some animal species during hot seasons, as did the warrens of locally extinct burrowing marsupials. These benefits are far outweighed by the costs to the environment of rabbits.

Rabbits occur throughout the District. The populations vary from $<10/km^2$ in some land systems such as Arcoona and Wilgena to $>750/km^2$ in land systems in the north-east of the District and adjacent to lakes and swamps, e.g. Roxby and Wirrida.

Control

Rabbits are difficult and expensive to control. The trial on Billa Kalina Station by the Kingoonya Rabbit Control Group has indicated that rabbit control may not be justified on a purely economic basis over a property as a whole. The low productivity of the land per unit area and the need for continual maintenance of areas in which warrens have been ripped makes rabbit control an ongoing expense.

Any rabbit control programme therefore needs to be planned to maximise benefits by targeting areas of high use and/or productivity and by designing a programme of manageable size.

Warren destruction is the key to rabbit control because rabbits rarely breed away from a warren. Control is most effectively carried out when numbers are low. Warren destruction is the most effective form of rabbit control and is recommended in "harder" more productive country. In

sandy country control is more difficult because warren-reopening rates are higher.

Work should be done in summer or during a dry spell when rabbit numbers are low to take advantage of:

- dry, friable soil (which readily collapses into the warren);
- low rabbit numbers (less likelihood of warrens being re-opened);
- heat (rabbits without the shelter of their warrens tend to be in poorer condition because they have no refuge from heat and dehydration and are more vulnerable to predation).

It is important to rip any open warren that could shelter rabbits. Warrens should be ripped to a depth of at least 70 cm and a spacing of no more than 50 cm. Ripping should extend three metres beyond the visible edge of the warren to ensure the destruction of the entire warren structure.

Cross ripping is essential unless winged boots are used on the ripping tines to minimise reopening.

Warrens that have been re-opened must be re-ripped or fumigated to ensure the effectiveness of the ripping programme. The complete destruction of all warrens is vital for effective long-term rabbit control.

Research into the biological control of rabbits has resulted in new strains of myxomatosis, better use of current strains in conjunction with vectors such as the Spanish rabbit flea, which was released in the District in 1993, and Rabbit Calicivirus Disease (RCD). Continuing research into new biological control methods is essential to the ongoing control of rabbits.

RCD spread through the District during 1996 and resulted in massive reductions in the District's rabbit population. Rabbit counts carried out in association with the Billa Kalina exclosures recorded numbers dropping from a high of 630 rabbits/km^2 to zero following the spread of RCD. Rabbit numbers have since increased.

Preliminary research has started on fertility control by modifying the myxoma virus to spread an antigen to fertilisation. The Board supports these research efforts and will co-operate with any fieldwork required while encouraging mechanical control of rabbits where feasible.

Rabbits have been eradicated from the fenced 60km^2 Arid Recovery Reserve (see below under *Conservation*).

The Kingoonya Rabbit Control Group Exclosures

All rabbit warrens were ripped in two areas of one square kilometre on Billa Kalina Station in 1992 (Greenfield n.d.). Four sets of exclosures were constructed to monitor the effects of the ripping programme on local rabbit populations. One set of exclosures was constructed on sandy soil and one on clay soil, with two other sets on similar soils in unripped areas to act as controls. To ensure that all vegetation monitoring of the exclosures would be carried out in the same way, a manual was produced that described the monitoring programme (Badman and Fatchen 1993).

Data analysis following the first four and a half years of monitoring showed that changes in the vegetation of exclosures or control sites, when compared against their previous data, were due

almost entirely to changed seasonal conditions (Badman 1998, 2000a, 2002). The findings of a survey in August 2000 supported these earlier conclusions (Badman 2000b).

Low rabbit-numbers over the whole area throughout much of the monitoring period, caused by RCD as well as by to the initial ripping programme, almost certainly influenced the results of this study. The effects of RCD effectively removed the differences between ripped and control areas. Cattle stocking rates were low throughout the monitoring period. Kangaroo grazing was recorded more frequently in August 2000 than at any other time during the monitoring and contributed significantly to total grazing pressure at that time.

There were similar trends between the exclosures and control sites, although some trends had begun to emerge by August 2000 (the last time the exclosures were monitored) that were not evident in April 1997. However, similar divergences from the general trend had occurred at other times during the monitoring, but did not continue until subsequent monitoring events. The most recent trends were not consistent at all sites and did not consistently favour the exclosures over the control sites. In some cases the rabbit-proof exclosure had the highest cover or species richness values, or had shown the greatest improvement, while at other sites it was the stock-proof exclosure or even the control site that recorded the best performance. Trends were also not consistent between sandy or clay sites or between single- or cross-ripping treatments. Subsequent monitoring will be required to confirm whether or not the emerging trends are maintained in the longer term.

Total perennial cover increased more at some control sites than in exclosures, while in others the best results were recorded in the rabbit-proof exclosure. At other sites the control and rabbit-proof exclosure showed similar results. Cover of *Atriplex vesicaria* increased most in the stock proof exclosure at three sites, suggesting that cattle grazing in the past had adversely affected this species. Why it did not react in the same way in the rabbit-proof exclosure, where cattle are also excluded, is not known. In contrast, *Maireana astrotricha* achieved its best results in the rabbit-proof exclosure at one site, with similar trends in both exclosures and control sites at another. *Gunniopsis quadrifida* had its largest cover increase at a control site. Species richness values also provided ambiguous results, having highest values at a control site, in the rabbit-proof exclosure at two sites and in the stock-proof exclosure at the remaining site.

The findings of this study support the long-held belief of Board members and local pastoralists that three-year programmes have little value in assessing the effects of changed grazing regimes on the vegetation of arid ecosystems. This study needs to be continued for at least another half century, with monitoring at approximately five-yearly intervals, to obtain meaningful results. All fencing will be maintained in its present excellent condition.

OTHER FERAL ANIMALS

Goats and camels occur in the district and are to some extent a problem. Camels occur in the sandy country of the west and south-west; some migrate into the District from the Maralinga Tjarutja Aboriginal Lands and cause frequent damage to the Dog Fence. The problem appeared to become worse during the very hot summer of 2000-2001, when many feral camels are known to have died through lack of water. Goats occur in the south of the District, where their numbers fluctuate in response to seasonal conditions. Foxes kill young lambs and native fauna. Cats also destroy native fauna.

Dingoes are still an intermittent problem inside the Dog Fence. This is particularly so following very heavy rainfall when the fence is often washed away, or gullies are washed beneath it, allowing access to dingoes. The transfer of Dog Fence maintenance to a local board and employment of a local contractor to maintain the fence has gone some way towards resolving the problem.

Management and control

Management strategies for brumbies, goats and camels involve shooting, trapping and/or mustering. These small populations mean that control is a feasible but necessarily ongoing task. Opportunities for financial returns are limited.

Land managers are encouraged to control feral cat and fox numbers in order to assist with the maintenance of the district's ecosystems and biodiversity. The effectiveness of control of these animals has been demonstrated at the Arid Recovery Project at Olympic Dam, with benefits to biodiversity and the re-introduction of several formerly locally extinct mammal species (see section on *Conservation* for more information on this project).

KANGAROOS

The survey of District land managers (KSCB 1996) identified kangaroos as a land management concern.

Artificial watering points and the Dog Fence have provided conditions that have allowed the kangaroo population to increase far beyond its former natural level. Permanent water and the Dog Fence have also reduced the necessity for, and ability of, kangaroos to migrate. The population still moves about the District but is more stable.

Kangaroos are now able to use more of the country on a continuous basis. They increase the grazing pressure, compete for food and water and damage fences.

Recent work (Newsome et al. 2001) has suggested that two different ecological environments occur on different sides of the Dog Fence. Badman (2002.) found that plant species richness (the number of plants per survey site) was almost double at identically sized sites in similar land systems outside the Dog Fence where there were few kangaroos.

The Department of Environment and Heritage (DEH) and its predecessors have monitored red kangaroo and western grey kangaroo numbers in the Kingoonya SCD since 1978.

Aerial survey figures supplied by the DEH indicate a mean red kangaroo density of 5.0/km^2 during that time. Western grey kangaroos occur in low densities after a run of good seasons (Table 3). This species prefers areas of denser scrub such as occur along creek lines, a habitat

that is scarce in the District. Because of this scarcity of suitable habitat, it is very difficult to estimate absolute numbers for western grey kangaroos from aerial survey data and their abundance is therefore best expressed in terms of density per km^2, as is done in Table 3.

Euro numbers have increased at several locations within the District since the first District Plan was published. The reasons for this are not known. However overall numbers are still low.

Management objectives proposed under the South Australian Kangaroo Management Program are:

Red Kangaroos:

Objective 1: To harvest red kangaroos as a sustainable resource.

Action: A sustainable use harvest quota of 15% of the estimated population on each property will be issued each year based on survey results of the previous year. Permits are to be issued in whole at the beginning of each year.

This approach seeks to achieve the prevention of a build up of very high numbers of kangaroos, facilitate the development of a kangaroo harvesting industry capable of sustaining the required harvest and where possible enable an economic return to landholders from kangaroo harvesting.

Objective 2: To avoid excessive increases in red kangaroo numbers and concentration of excessively large numbers of this species on dwindling food and water resources during the onset of drought.

Action: Encourage the use of the 15% sustainable harvest across the whole of the Soil Conservation District on an annual basis. This should avoid rapid increases in numbers under most conditions.

Additional kangaroo harvesting quota may be sought in years where kangaroo densities are above average and the 15% sustainable use quota is likely to be fully utilised before the end of the year. The additional quota will be allocated from the land management component of the annual South Australian kangaroo-harvesting quota.

The land management component of the South Australia kangaroo harvesting quota is available to reduce unusually high kangaroo numbers or address specific land management issues identified at a regional level.

In years where drought conditions are developing, this Soil Conservation Board, in consultation with DEH, will seek to achieve a reduction of kangaroo densities in the region. This will be done through additional kangaroo harvesting quotas or shoot and let lie permits in the case where conditions are severe and the kangaroo industry is unable to take the required numbers.

Western Grey Kangaroos

Objective 3: To prevent any major build up in the number of western grey kangaroos.

Action: This is unlikely to become a problem, but if western grey kangaroo densities of 1.0/km² or more are recorded for the district, a quota will be sought from the land management component of the kangaroo-harvesting quota.

Euros

Objective 4: To manage isolated colonies of euros occurring within the District.

Action: Harvesting of euros will occur in the District only where necessary to fulfil land management obligations.

Table 3: Red and Western Grey Kangaroo Densities and Estimated Populations

(Data for the Years 1978 to 2000 as Determined by Aerial Survey by DEH.)

YEAR	RED KANGAROOS PER KM²	NUMBER OF RED KANGAROOS	GREY KANGAROOS PER/KM²	NUMBER OF GREY KANGAROOS
1978	2.08	148 000	0.01	Trace
1979	4.11	293 000	0.01	Trace
1980	3.22	230 000	0.01	Trace
1981	6.17	441 000	0.09	Trace
1982	7.48	534 000	0.00	0
1983	2.95	211 000	0.00	0
1984	3.17	226 000	0.00	Trace
1985	6.08	434 000	0.00	0
1986	4.80	343 000	0.00	0
1987	3.43	245 000	0.00	Trace
1988	4.92	352 000	0.02	Trace
1989	4.30	307 000	0.00	Trace
1990	6.61	472 000	0.00	0
1991	4.78	341 000	0.01	Trace
1992	5.13	366 000	0.03	Trace
1993	6.83	488 000	0.16	Trace
1994	4.98	356 000	0.00	Trace
1995	8.41	600 000	0.03	Trace
1996	6.95	496 000	0.12	Trace
1997	4.14	296 000	0.12	Trace
1998	5.72	408 400	0.20	Trace
1999	5.20	371 300	0.22	Trace
2000	5.18	555 000	0.17	Trace
Average	**5.07**	**370 160**	**0.05**	**Trace**

INSECT PESTS

Infestations of an undescribed species of native whitefly (*Zaphanera* sp. n.) caused the deaths of numerous western myall trees within the District during 1999-2000 (SARDI 2000). Tree deaths were first reported around Roxby Downs, particularly on disturbed areas near the town, but are now known to have occurred right across to the western side of the District. Most deaths were of adult trees, but juveniles were also affected in some areas. This may be an infrequent natural phenomenon and may have been the cause of many old dead trees in otherwise healthy populations.

Surveys during 2000 found that the whitefly was present in high numbers on western myalls from Glendambo and Mount Vivian in the west to Andamooka in the east and from Roxby Downs in the South to Billa Kalina in the north. This coincided with the area where tree deaths were most prevalent. No other tree species were affected by the whiteflies. A newly described species of parasitic wasp was found to parasitise the pupae of the whitefly, but was generally present in numbers that were too few to control it.

The Board has initiated a monitoring programme across the District, coordinated by PIRSA in Port Augusta.

There were massive increases in locust numbers in the north of South Australia during 2000, with these insects moving south in the spring. Although control of these pests within the northern pastoral areas is generally considered uneconomic, aerial spraying was carried out on several stations in the south of the District to protect cropping lands to the south.

SCALDING

Scalds are bare areas produced by the removal of the surface soil by wind and/or water erosion. The result is exposure of the more clayey subsoil, which is, or becomes, relatively impermeable to water. Scalds are a typical erosion form of texture contrast soils in semi-arid and arid regions.

Scalds result from the removal of protective plant cover (e.g. by high grazing pressure, hail storm, or drought) followed by removal of topsoil by high intensity rainfall and/or winds. Scalds should not be confused with natural claypans, which are areas where water lays for extended periods following big rainfall events.

Scalds are difficult to revegetate due to the lack of topsoil, low permeability and often a saline surface.

Texture contrast and calcareous soils are susceptible to scalding. The land systems in which texture contrast soils occur to a significant extent are:

Kingoonya
Coward
Mount Eba
Breakaway

Land management and rehabilitation

Plant cover needs to be maintained to prevent scalds from developing on susceptible soils. Plant cover protects the soil from the erosive actions of water and wind and provides niches for the accumulation of organic matter, wind blown soil and seeds. Perennial bush species provide the best soil protection because they are still present during dry times when the soil is most vulnerable to erosion.

Scalds have a smooth, crusty and often saline surface that is unsuitable for seed lodgement and germination and for seedling establishment. A successful revegetation programme alters the environment to provide conditions suitable for seed entrapment and plant growth.

To rehabilitate scalds:

- assess the expected benefit against cost;
- control water run-off;
- reduce wind velocity at the soil surface;
- provide adequate moisture of suitable quality to allow seed germination and seedling establishment;
- select suitable sites for seed germination and growth;

- ensure a seed source is available at the site, either from mature bushes of appropriate species within 150 metres of the site and on the same level or above the site, or by direct seeding.

These needs can be met by mechanically altering the site. Furrowing and water ponding have been successful in reclaiming scalded areas. Disc pitting has been used extensively in trials, but is often not successful on scalded areas because the soil slakes and/or disperses when wet and the pits quickly fill with soil and crust over. No formal trials on scald rehabilitation have been completed in the District.

Water ponding techniques have progressed rapidly in recent years, both at Port Augusta and interstate. PIRSA can provide advice (and see Powell 2000a) and a surveying service to pastoralists considering using water ponding.

WIND EROSION

Wind erosion occurs where soil surface protection is low and soil particles are small enough to be moved by the wind.

The major cost to the land manager of wind erosion is the loss of fine soil particles and organic matter, with a corresponding loss of nutrients. The loss of this most productive part of the soil reduces the productivity of the site and increases its susceptibility to further erosion. The sand blasting effect of eroding soil may damage or destroy plants, particularly seedlings.

Soil loss by wind erosion is most likely to occur in areas where vegetation has been removed. This can occur through stock and feral animal grazing, fire and hail storm (the latter in small isolated patches).

Soils prone to drift are the sandy soils of the sand plain and sand dune land systems. The land systems in which sandy soils occur to a significant extent are:

Commonwealth
Ingomar
Roxby
Vivian
Wattiwarriganna
Waulalumbo
Wirrida

Sandy loams of the texture contrast soils are prone to wind erosion, leading to the possible development of scalds (see section on *Scalding*).

Fire is the biggest single contributing factor to wind erosion in the District. The lighter soils support mulga woodlands, which are the most susceptible vegetation community to fire in the District. Fire kills the mulga overstorey, burns the grasses and depletes the seed store. Even gentle winds will erode this type of country after a fire. The ground surface then remains bare until suitable rains provide moisture for germination and even then it is usually annual plants that begin the colonisation process. If dry years follow the fire, it can be more than a decade before perennial plants are recruited in sufficient densities to stabilise the soils, although this can happen much more quickly if suitable rainfall occurs. Management of fire-affected areas is discussed later in this plan.

The land system associated with salt lakes (Wirrida) and some parts of Roxby and Wattiwarriganna Land System have some sand dunes that are naturally unstable and shifting.

Further information on the effects of wind erosion can be found in Powell (2000b).

Land management and rehabilitation

Prevention of wind erosion is cost effective and much easier than revegetating areas after erosion has occurred.

Measures for the prevention of wind erosion include:

- maintaining or increasing the density of perennial vegetation cover;
- maintaining annual pastures to maximise grass and litter cover on sandy soils;
- avoiding locating access tracks and water points on sandy soils;
- managing fire affected areas to ensure maximum recruitment of plants and establishment of perennial plants in the longer term;
- controlling or, if possible, eradicating rabbits;
- maintaining the lichen crust on soil surfaces.

To revegetate areas where wind erosion has occurred it is necessary to restrict grazing pressure. Providing a seed source (Powell 2000c) and nutrient traps in the form of dead timber or rough soil surfaces will contribute to the re-establishment of vegetation.

WATER EROSION

Gully erosion following high intensity rainfall events is common when the protective stone cover is removed from gibber country.

Creek systems are also prone to natural erosion, especially following high intensity rainfall events.

The following gilgai and gibber land systems are prone to gully erosion:

Arcoona
Oodnadatta
Paisley.

Erosion of watercourses may occur in the Ingomar, Oodnadatta and Breakaway land systems.

Further information on the effects of water erosion can be found in Powell (2000d).

Land management and rehabilitation

Gully erosion of gilgai and gibber land systems occurs only where the stone cover has been removed or disturbed. The stone cover needs to be maintained when building tracks, which should be on the contour or on a gentle grade so that gully erosion is avoided. Water control banks may be necessary to control the flow of water along tracks.

FIRE

The occurrence of fire was identified by a survey of land managers as a high priority land management issue in the region (KSCB 1996).

Fires are a natural occurrence and are likely to occur during summer following seasons of significantly higher than average rainfall. At such times they are sustained by prolific amounts of flammable grasses such as spear grass and tall kerosene grass. Lightning strikes start most of the fires in the District though some fires have been started by vehicles and through carelessness.

When fires do occur, very large areas are often burnt and this can result in the death of almost all of the vegetation. In mulga woodland, mulga and perennial shrubs are killed by fire. In chenopod shrublands the shrubs may be killed, particularly on sandy soils where a more flammable understorey is often present than is found on clay soils. These burnt areas are then susceptible to soil erosion. Due to the erratic nature of rainfall in the District it may be several years before suitable rainfall and plant growth occur to stabilise the area, particularly on sandy soils.

Woody shrub species may establish in high densities after fire. Fortunately, these species are generally short lived and are eventually replaced by long-lived species such as mulga. Woody shrubs are more likely to become a problem if grazing pressure on the fire-affected area is not managed during the early recruitment phases. Woody shrub seedlings are not palatable to grazing animals; grazing of the more palatable species reduces competition for moisture and favours the survival of the woody species.

Most fires occur in the mulga woodlands, but some bush country has burned where there have been sufficient quantities of spear grass and/or tall kerosene grass or mulga grass. The spinifex country in the south of the District is also fire prone.

Land management and rehabilitation

Where fire has removed vegetation cover, management of the area needs to ensure that germination and seedling establishment is given the best possible opportunity. Keeping the area free of grazing pressure and disturbance will maximise revegetation following rain. Stock numbers need to be reduced at least in proportion to the area burned. In the first growing season it is likely that annual species will germinate and establish cover. Perennial species may take several growing seasons to re-establish. The species of mature seeding plants in close proximity to the site will determine which species colonise the burned area first.

WOODY SHRUB INCREASE

Increase in density of woody shrubs is a localised response to soil disturbance often related to past overgrazing. The species showing tendencies to become a woody shrub problem are broom emubush, narrow-leaved hopbush and senna.

Research interstate indicates that woody species increase where the vegetation and soils have been disturbed and/or where there is a lack of competition for soil moisture from grasses. In these situations the growth of woody shrub seedlings is not limited by competition and shrubs may establish in high densities. Some evidence is emerging from the Arid Recover Project at Roxby Downs (John Read, pers. comm.) that at least some of the woody weed species may once have been controlled to some extent by small mammals that are now locally extinct.

Woody shrub increase is not an extensive problem in the district.

Land management and rehabilitation

It is likely that the rainfall in the District is too low for woody shrub increase to become an extensive problem. To prevent an increase in woody shrubs it is necessary to maintain conservative stocking rates so that the density of palatable perennial bush species is not reduced and soil stability is maintained.

It is tempting to treat the symptoms of this problem rather than the cause. Destroying woody shrubs is not the entire solution to the problem. Soil needs to be stabilised and a good cover of more desirable vigorous deep-rooted plants is also necessary.

WEEDS

About 12% of the species known to occur within the District are naturalised taxa (110 of 885, see Appendix F). This is well below the figure of 25-30% given by Playfair et al. (1996) for areas in the south-eastern rangelands of South Australia and slightly below the figure (13%) given by Badman (1999) for the Olympic Dam area.

Frank Badman investigated this issue as part of a Master of Science qualifying thesis (Badman 1995a) and his comments on the spread of naturalised plants across the South Australian rangelands were updated in 1999 (Badman 1999). The 1995 study is the only one to use quantitative data to assess the abundance of weeds in the Kingoonya SCD. A summary of the main findings of this research is given in Appendix E. The majority of naturalised species in the District are annual species, with very few perennials established away from settlements.

Wild turnip[15] is the most abundant and widespread of the introduced species in the District. It can be a serious problem in sandy country (e.g. in Roxby and Wirrida land systems) where it may choke out native winter and spring annuals. Graetz and Tongway (1980) reported that this species accounted for 80% of the vegetation cover on some sandy areas at Olympic Dam. Badman (1995a) documented the decline of this winter-growing species and demonstrated a correlation between the decline and increased cover of perennial grasses following heavy summer rainfall in both 1989 and 1992.

[15] Scientific names of species are given in Appendix C.

This study predicted that wild turnip could again increase in abundance if the native grasses were removed by drought or grazing and heavy winter rainfall then preceded useful summer rainfall. This actually occurred in the following year, following several dry years that resulted in the removal of most of the short-lived perennial grasses.

Wild parsnip has been implicated in the death of cattle (Badman 1995b) and the deformation of calves and lambs in the Roxby Land System.

Most of the weeds that are widespread in the District have been in the area for more than 50 years (confirmed from herbarium collections or other reliable published sources, see Badman 1995a). New introductions tend to occur in areas where soil has been disturbed and run-off is concentrated, such as roadsides, borrow pits, storm water drains, sewage lagoons and rubbish dumps.

Mesquite has been a problem in the Woomera town area for many years as a result of escapes from a local botanic park. The first collection from the District in the State Herbarium of South Australia was made in 1966, although the collection label says that it came from "Kingoonya". The label on a collection made in 1980 describes it as occurring as "a thicket" and since that time it has spread into many watercourses that flow away from the town. Scattered populations have also established in roadside table drains. Ongoing control measures undertaken over the last few years under the direction of the Kingoonya SCB have greatly reduced the problem. Parkinsonia has a similar history in the Woomera area, although far less common and widespread than mesquite, with the species being first mentioned by Jessop (1989). Badman (1995a) found that species such as these that were associated with settlements and had escaped from cultivation in recent years did not spread into the surrounding rangelands in the Olympic Dam area. However, it is not certain whether this would be the case at Woomera because both the mean and median rainfall figures are considerably higher there (190mm and 175mm respectively). They are even higher than those for the stations on the western side of the district (see figures for Mulgathing and Tarcoola in Figures 3 and 4), where rainfall is generally considered to be about 20-25mm higher than on the eastern side of the district (see Figures 5 and 6).

Horehound has been present in the District since at least 1948 (Badman 1995a), but appears to be restricted to the south-eastern parts of the District and to Bulgunnia and Commonwealth Hill stations. Bathurst burr is also a problem in this area. The most recent invasions of new weed species have been along the Stuart Highway and include:

- onion weed
- evening primrose
- salvation Jane
- cut-leaf mignonette (Wirraminna)
- wall rocket (Lake Hart parking bay).

Onion weed was collected at Olympic Dam in 1990 and although it was known to have already been in the area for a few years it did not spread into the surrounding rangelands during the above average rainfall years of 1989 and 1992 (Badman 1995a). Salvation Jane has been in the district for many years, but its incidence appears to be greater now than previously. The Board is currently liaising with the Transport SA over the control of weeds along the Stuart Highway and with the Animal and Pest Plant Control Commission (APPC) over the control of weeds in general. The Board supports and is keen to be involved with the APPC in the compilation of a weeds database for the South Australian rangelands.

DROUGHT

Land management in the Kingoonya SCD needs to recognise that this is an arid environment in which the rainfall is extremely variable and unpredictable. The rainfall is lower than average in more years than it is average or above, resulting in the median rainfall figure being well below the mean, particularly in the north of the District.

Annual and ephemeral grasses and forbs are not present during dry years, when stock and other grazing animals must rely on the perennial species for forage. It is important that managers observe the condition of the vegetation and react accordingly. When stock are grazing less palatable plants it is often too late to protect the pasture because many of the most productive plants have already been removed.

The cost of not reacting early to dry seasons is high and includes:

- heavy grazing of perennial plants, reducing their ability to respond to rainfall and leading to many plant deaths;
- increase in size of the piosphere[16];
- soil disturbance and loss of soil and nutrients by wind erosion.

Pastoral enterprises need to be managed for drought at all times: it is necessary to manage for a drought not because of a drought. Managing for drought includes assessing the feed to stock ratio several times per year. It may become necessary to sell or agist stock as part of a drought management strategy.

Management strategies will depend on the type and mix of country, types of vegetation and their response to rainfall, and the types of water supplies, permanent or ephemeral, on a lease.

The use of permanent monitoring sites is useful for the routine assessment of the feed to stock situation. A record at each of several sites representing different types of country, consisting of photographs, notes about the response of the vegetation to different seasons and stock management strategies, is a useful tool in managing the productivity of the enterprise.

[16] The area of changed plant density and species composition resulting from stock grazing near water points; pio means water.

CONSERVATION

Dedicated Conservation Areas

There are no dedicated government conservation areas within the Kingoonya SCD, although the Lake Gairdner and Lake Torrens national parks, including Lake Everard and Lake Harris, form part of the southern and eastern boundaries of the District. Privately initiated conservation practices are the core of a potentially large and effective conservation strategy for pastoral lands in the District. Indeed, it is now a widely held view that long-term survival of many vertebrates will only be possible if there is active management of animal and plant diversity by landholders and managers.

This needs to be based on adequate information about each species' life requirements and its population dynamics. A manual has been developed on behalf of the Pastoral Board (Ehmann and Tynan 1997) that:

- identifies species of special conservation interest and their habitat types and provides general information about species behaviour and biology;
- provides information on best management practices to maintain or enhance wildlife diversity;
- includes information for accessing advice and wildlife management funding.

Biodiversity

There is no simple and unarguable definition of biodiversity, although true biological diversity is more than simply a list of species. It is the variety of life and includes the numbers of individuals and types of animals and plants in an area or habitat.

The sustainable management of the grazing enterprise achieves plant conservation. The maintenance of biodiversity will also maintain a viable grazing operation. Plant and animal species of the arid and semi-arid lands contribute to the biological wealth of the country and may have values yet to be discovered (Biological Diversity Advisory Committee 1992).

For lists of plant and animal species known to occur within the Kingoonya SCD refer to Appendices F and G.

Threats to Biodiversity

Five main threats to biodiversity have been identified:

- habitat loss
- introduced species
- pollution
- population growth
- over-consumption.

The human race is directly responsible for all five threats.

Habitat loss is generally recognised at the greatest threat to biodiversity. This loss is greatest in higher rainfall areas when land is cleared for farming or urban development, but can also be caused by overgrazing. Overgrazing is not restricted to introduced herbivores, kangaroos can

have an equally devastating effect when present in inappropriate numbers, as they often are in the southern rangelands because of the presence of additional permanent watering points and the exclusion of dingoes by the Dog Fence.

Introduced plants often do well in native vegetation associations and can sometimes become established faster than native species. This can happen where a suitable niche becomes available, either through drought or overgrazing. Badman (1995a) found that wild turnip is able to dominate vegetation within parts of the Kingoonya SCD when native perennial grasses are removed and winter rainfall occurs, but is displaced by these species when good summer rains precede any winter rainfall.

Pollution is not a widespread problem in the District, although the public perception of pollution from a low-level radioactive waste dump is a real problem. Localised damage to vegetation by airborne pollutants occurs in the vicinity of the Olympic Dam processing plant (Badman 2002) and results of terrestrial pollution are still visible around other older mine workings (e.g. Tarcoola and Glenloth). Accumulations of rubbish around town dumps and roadside parking bays are of growing concern.

Human population pressures can result in over-grazing and over-planting of marginal lands, threatening much of Earth's land surface with desertification. This is not a problem in the District, although the effects of population pressure on local habitats can be seen around the larger settlements. This is often in the form of multiple tracks left by off-road vehicles.

Consumption of natural resources faster than they can be replenished is not generally a problem within the District. Although it may occur following local droughts, it was a greater problem in the past and is now better managed because of the current state of environmental awareness throughout the rangelands.

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act came into operation on 16 July 2000. Its affects on the District are likely to be limited to future developments in areas that provide habitat for rare or endangered species, wetlands that provide habitat for migratory birds, and to the Olympic Dam Mine through its provisions for the mining and milling of radioactive ores. Migratory bird habitat is provided by the Arcoona lakes system, which Read and Ebdon (1998) have identified as a significant water bird habitat, and by several other ephemeral wetlands throughout the District.

The Arid Recovery Project

The Arid Recovery Project is a joint initiative between WMC Resources Ltd, National Parks SA, University of Adelaide and Friends of the Arid Recovery Project. A 60 km^2 area of land has been fenced to exclude all introduced ground-dwelling animals and to control the number of kangaroos. These have been progressively eliminated from within the fenced areas, with completion of the final 30 km^2 during 2001. The first stage was on the Olympic Dam Mine Lease and on Roxby Downs Station, with later expansions extending on to Stuarts Creek, Mulgaria and Billa Kalina stations. All but three square kilometres of the total area lies within the Kingoonya SCD.

Four species of mammal that formerly inhabited the area have been reintroduced to the exclosure: Greater Stick-nest Rat, Burrowing Bettong, Greater Bilby and Western Barred Bandicoot. In 1998 and 1999, 100 Greater Stick-nest Rats were introduced to the exclosure and these are showing a pattern of breeding up from autumn to spring, but declining during January

and February. Their numbers are now in the hundreds. It is expected that survival of young will be greater once nests become larger and better insulated. Thirty-five Burrowing Bettongs were released in late 1999 and early 2000 and these have bred almost continuously since that time. They have constructed many warrens, often opening up old rabbit warrens, some of which are thought to have been old bettong warrens. Eleven bilbies released in April 2000 have bred up to a population of at least 100 in late 2002. Bilbies have been very active in burrowing and turning over the soil. During one period, they sought out grubs in the roots of hopbushes, leading to the deaths of many juvenile plants (perhaps a natural control for woody weeds). Eleven Western Barred Bandicoots were released in 2001. These animals began to breed as soon as they were released into the exclosure.

The cover of annual plants within the reserve is now significantly greater than it is outside. This is due both to the absence of rabbits and to the control of kangaroos.

Community support has been vital in the establishment of this project, particularly that given by the local friends group. Further information can be obtained from:

Friends of the Arid Recovery Project
C/o Environmental Department
P.O. Box 150
Roxby Downs SA 5725
or at “www.aridrecovery.org.au”.

PROPERTY MANAGEMENT PLANNING

Many station managers have been successfully developing and implementing property management plans for decades. These plans have often been developed in the manager's head but not written down. Plans that are not documented are difficult to critically review, develop and discuss with family and financiers.

The documentation of plans assists with the management of a high-risk enterprise. In an environment where the producer is unable to control prices of produce, market variability is high and costs of production are increasing, there is little tolerance for sub-optimal management.

The State and Federal Governments are now promoting property management planning through the FarmBis programme. FarmBis is a partnership between the Commonwealth and South Australian Governments, supporting farmers and fishers to participate in learning activities focussing on improving business and natural resource management skills. Financial Assistance is available by way of non-repayable grants to assist participants to undertake development activities.

In April 2003, a number of significant changes to funding criteria were made by the State Planning Group as part of its mid term review of the FarmBis Program. These are outlined below:

- Farmbis training grants of up to 75% of eligible costs are now available for most eligible training activities, with the exception that training activities related to Production management will be supported at a level of 50% of eligible costs

- Basic computer training, Quality Assurance training and stand-alone Recognition of Current Competency Programs are no longer eligible for funding.

- Training must closely align to AQF level 5 of the National Agricutural and Horticultural Training Packages (or equivalent) except for Occupational Health and Safety and Business Management Training which may align to level 4 Rural Business Management competencies.

- Groups and individuals must indicate that they have planned a total of at least 2 days (this may be 4 x half days) of training, and should involve a learning needs identification process.

- Training programs that provide natural resource management, risk management, strategic planning and continuous business improvement outcomes and on-going learning opportunities are encouraged.

- Funding is not available for materials or other costs for students studying a VET funded program. No conferences or associated workshops will be supported.

- Training activities must commence within 3 months and be completed within 6 months of application approval.

- A list of potential participants must be submitted with the application.

- Grant payments will only be made for participants who have submitted a signed FarmBis Group or Individual Participant Review Form.

MINING AND EXPLORATION

Mining

There is a long history of small-scale mining in the district, with gold mining beginning around Tarcoola as early as 1893. Gold mining still continues in the Tarcoola and Glenloth areas, but on a smaller scale than in its heyday. Opal mining at the Andamooka Precious Stones Field began in the 1930s and is still continuing. In recent years there have also been a small sand mining operation on Purple Downs and a small slate quarry on Andamooka Station. Individuals, partnerships or small companies now run all of these operations.

Large-scale mining came to the district with the discovery of the Olympic Dam ore body in the 1970s. The Olympic Dam Mine is owned by WMC Resources Ltd and had an annual output of 66 000 tonnes of refined copper, 1400 tonnes of uranium oxide, 20 000 ounces of gold and 500 000 ounces of silver by the mid 1990s. A major expansion of the mine and metallurgical plant in the late 1990s increased production to 200 000 tonnes of copper, 4500 tonnes of uranium oxide, 70 000 ounces of gold and 200 000 ounces of silver. Further optimisations are expected to increase copper production by a further 50 000 tonnes per annum over the next few years.

The Challenger gold mine commenced operation in late 2002.

At the Andamooka Opal Field, rehabilitation of old mines is still not a common practice and many of the people who did the original mining have now left the area. In any case, many of the old workings are constantly being re-worked and rehabilitation is impractical. These old workings are now part of the District's cultural heritage and are one of the area's main tourist attractions.

Another potential resource within the District is the large coalfield in the Lake Phillipson area. Work commenced in early 2000 on mining 20 000 tonnes of coal from an area on Ingomar Station for use in a demonstration plant at Whyalla. If this trial is shown to be successful it could be the start of a major mining operation in the area.

Exploration

Exploration must precede any mining operation: exploration activities have covered most of the District during the last 20 years and continue to do so. In the past, exploration was a haphazard affair with little or no regulation. Large operations, such as WMC (Olympic Dam Operations) have an environmental department which controls and repairs damage to the environment caused by the company's exploration and mining activities. Modern techniques rely less on the clearance of straight lines than was the case in the past. Temporary tracks are often not graded and an effort is made to minimise the removal of vegetation. At Olympic Dam, written environmental clearances must be obtained from the operation’s Environmental Department before any form of disturbance can take place. The clearance often places conditions on the way the job is to be done. All mining companies and individuals must also adhere to government regulations and guidelines.

Disturbed areas caused by exploration and mining at Olympic Dam are now rehabilitated as soon as these activities have been completed. Other large companies have similar policies. Table 4 describes the impacts that can be expected as a result of exploration. Table 5 provides a summary of preventative and mitigation measures used by WMC at its Olympic Dam operation.

Rehabilitation

The survey of land managers identified degradation associated with mining and exploration as a land management issue in the District. There is a considerable difference between the disturbance caused by exploration and actual mining. Exploration activities cause more disturbances over a far larger area than does mining. Once a mine is established, operations are now well regulated and managed by professional environmental officers.

Methods used for the rehabilitation of old mine and exploration sites are quite simple. Rubbish is removed, small holes are filled in, steep slopes are battered off, topsoil is re-spread when available and the area is ripped. Deep ripping to a depth of about one metre has given the best results at Olympic Dam. Some areas are seeded using locally collected seed (collected within 15 kilometres of where it is to be used), although this is not necessary on small areas which are surrounded by native vegetation where enough seed blows on to the ripped areas to enable establishment of vegetation following the next good rain (see Badman (1992) for a more detailed account of mine rehabilitation techniques in this area).

The success of these simple rehabilitation techniques can be gauged from the fact that 66 sites used for quantitative analysis of the success of the rehabilitation programme at Olympic Dam prior to 1995 had been dropped from the long-term monitoring programme in the previous five years because they were deemed, on the basis of quantitative data, to be rehabilitated (ODO 1995). Best results were obtained following the exceptional rainfall events of 1989, when 19% of the 353 sites monitored in that year were found to meet the rehabilitation criteria (ODO 1990). It should be noted that not all sites monitored each year were used for analysis (ODO 1990).

Establishment of vegetation on ripped areas is entirely dependent on rainfall. Seasons favourable to establishment of perennial shrubs may occur only about once or twice in each decade (Badman 2002), although enough rain falls in most years to maintain the continued growth of established plants. The larger trees need at least two consecutive good seasons to become established. Exceptional rainfall events will not enable the establishment of mulga, western myall and white cypress pine if they are followed by a dry spell before the seedlings are well established.

Experimental work at Olympic Dam has shown that recruitment of these species is influenced more by seasonal conditions than by the effects of grazing by domestic livestock or even rabbits, although established plants can later be removed by heavy grazing.

Table 4: Impacts of Traffic on Landform Types

ACTIVITY	STONY TABLELAND	INTERDUNE CORRIDORS	DRAINAGE DEPRESSIONS	LOW STONY RISES	SAND PLAINS	DUNE FIELDS
Light foot traffic	No effect	Breakdown of surface	No effect	No effect	Little effect	Little effect
Concentrated foot traffic	No effect	Breakdown of surface skin	No effect	No effect	Slight deflation, some breaking of low shrubs reducing erosion protection	More severe deflation[17], some breaking of low shrubs reducing erosion protection
Single vehicle	No effect	Breaking of vegetation and surface skin	No effect	No effect	Some breaking of low shrubs reducing erosion protection	Some breaking of low shrubs reducing erosion protection
Multiple vehicles	Some rutting, particularly when wet. Prone to track erosion on sloping areas	Complete loss of vegetation leaving surface exposed to erosion	Some rutting when wet	Little effect	Loss of vegetation and deflation	Loss of vegetation and deflation
Minor construction traffic	Break up of surface	Loss of vegetation, break up of surface	Break up of surface	Little effect	Loss of vegetation and deflation	Loss of vegetation and deflation
Major construction traffic	Complete disturbance of surface, leading to erosion	Exposure of surfaces from which dispersion and run-off occur	Break up of surface	Break up of surface, otherwise little effect	Compete loss of vegetation, deflation and drifts	Complete loss of vegetation, deflation and drifts

Adapted from: Kinhill-Stearns Roger (1982)

[17] Deflation - the removal of fine particles of soil by wind.

Table 5: Potential Mining and Exploration Impacts and Mitigation Measures for Landform Types

LANDFORM DESCRIPTION	RANGE OF POTENTIAL IMPACTS	PREVENTATIVE MEASURES
Tableland Almost flat tableland surface with no dune ridges present	1. Interception and concentration of surface flows. 2. Erosion of dispersive soils 3. Rutting of surface by construction traffic in wet weather 4. Dust from trafficked areas	1. Keep drainage dispersed where possible 2. Direct flows through stabilised or lined drains. Avoid disturbing gibber pavement 3. Avoid use of tracks by heavy vehicles/machinery during wet weather, or provide sheeted surfaces and pavements for construction traffic 4. Either provide sheeted surfaces and pavements for traffic or water unstabilised areas
Dissection slopes Dissection slopes of the tableland, generally with no dune ridges	1. Interception of surface flows 2. Channelling of flows alongside embankments 3. Scarring and erosion of surfaces caused by difficult working conditions 4. Alteration to sediment movement pattern	1. Provide pipes, culverts etc 2. Ensure adequate drainage through embankments and stabilise soil surfaces 3. Minimise construction traffic and confine to prepared access roads 4. Keep drainage lines open, where practicable, and avoid re-routing
Drainage areas Broad concave depressional drainage areas which can contain sand ridges	1. Alteration to areas of swamplands and claypans 2. Accelerated erosion due to erection of structures within drainage channels	1. Ensure construction works in catchment areas do not affect drainage 2. Place footings outside channels where practicable, or provide adequate protection for footings
Widely spaced dunes Almost flat tableland surface with widely spaced sand ridges (up to 30% of the area of the pattern)	1. Loss of vegetation, leading to increased sand movement generally 2. Localised sand movements caused by construction of corridors through dune ridges 3. Alteration to drainage pattern within swales 4. Alteration to sediment movement towards terminal drainage points in swales 5. Creation of the hardpan surfaces 6. Loss of sand from windward side of structures	1. Avoid unnecessary removal of vegetation 2. Stabilise potential erosion areas 3. Provide adequate drainage through any barriers created across swales 4. Engineer drainage facilities to reduce ponding and associated sediment build-up 5. Retain saltbush and bluebush in swales where practicable 6. Provide stabilised or sheeted pavements in areas where deflation is likely to occur
Moderately spaced dunes Almost flat tableland surface with between 30 and 60% of the area covered by sand ridges	1. Loss of vegetation, leading to increased sand movement 2. Localised sand movement caused by construction of corridors through dune ridges 3. Creation of hardpan surfaces 4. Loss of sand from windward side of structure	1. Do not remove vegetation 2. Stabilise potential erosion areas 3. Retain saltbush and bluebush in swales; cover with sand where hardpan occurs 4. Provide stabilised or sheeted pavements in areas where deflation is likely to occur
Closely spaced dunes Almost flat tableland surface with between 60 and 80% of the area covered by sand ridges	1. Loss of vegetation, leading to increased sand movement 2. Localised sand movement caused by construction of corridors through dune ridges 3. Loss of sand from windward side of structures	1. Do not remove vegetation 2. Stabilise potential erosion areas 3. Provide stabilised or sheeted pavements in areas where deflation is likely to occur

Adapted from: Kinhill-Stearns Roger (1982)

DEFENCE OPERATIONS

Army training exercises involving the deployment of heavy vehicles such as Leopard Man Battle Tanks and Armoured Personnel Carriers, large numbers of personnel and wheeled vehicles have been carried out frequently in the district. These exercises result in extensive damage to vegetation and soils and often result in damage to station improvements such as waters and fences. Large-scale exercises are carried out once every few years and have been located on several stations in the district. Most station managers now require better OH&S and environmental management planning before agreeing to have these exercises on their leases because the damage to vegetation and soils is long term, unsightly and extensive.

Land management and rehabilitation

The Board feels that the Defence Force needs to take care in the planning and implementation of these defence exercises. The involvement of heavy vehicles and large numbers of smaller vehicles and personnel has resulted in unacceptable damage to vegetation, soils and station infrastructure. The Board feels that the Army has the same responsibility for the sustainable use of the land as the rest of the Australian community.

Future Defence Force exercises in the District need to comply with the following minimum conditions:

- agreement with the pastoral lessee, Kingoonya SCB and Pastoral Board with regard to the location of the exercise and conditions for the use of the land;
- rehabilitation of the affected areas to the satisfaction of the pastoral lessee and the Kingoonya SCB;
- monitoring and rehabilitation of affected sites;
- adherence to restrictions determined by the lessee, Kingoonya SCB and Pastoral Board for the protection of vegetation, soils and infrastructure;
- transport to and from the exercise should be along roads and tracks which are to be rehabilitated by the Defence Force after the exercise to the satisfaction of the lessee and Kingoonya SCB.

LOW LEVEL RADIOACTIVE WASTE STORAGE

Most Australians benefit either directly or indirectly from the medical, industrial and scientific use of radioactive materials, and a small amount of radioactive waste is generated from the use of these substances.

A large proportion of Australia's radioactive waste is low-level and short-lived intermediate level, and is suitable for near-surface disposal. The waste includes items such as lightly contaminated paper, plastics, glassware, soil, instrument dials, etc.

Currently, radioactive waste is stored at over 50 locations around Australia, including in hospitals, universities, industry stores and research institutions, in areas that were not designed for the long-term management of this material. About two-thirds of our low level waste, contaminated soil from the processing of uranium ores in the 1950s and 1960s, is stored in a hangar on the Woomera Prohibited Area adjacent to Evatt's Field.

The safest and most responsible way for Australia to deal with the waste that arises from the beneficial use of radioactive materials is to take it from sites where it is currently held and to put it in purpose-built facilities where it can be effectively managed and monitored.

A nationwide search for a site for the repository, which commenced in 1992, has been narrowed down to one of three possible locations in the Kingoonya SCD. These sites have been chosen because they performed best against criteria such as geology, ground water, rainfall, etc.

Consultation has been undertaken throughout the project.

Discussion papers have been released nationally and consultation at the regional level has been through the Regional Consultative Committee, a body comprising regional stakeholders, including a member from the Kingoonya SCB, information days, and through meetings with key groups. The Department of Industry, Science and Resources has organised a number of meetings with local pastoralists.

After assessment of the results of the final phase of drilling investigations of the three short-listed sites and further consultation in the region, a preferred site for the national repository was announced towards the end of 2000 at a location south of Evatt's Field.

Relevant statutory processes, including environmental assessment and licensing by the Australian Radiation Protection and Nuclear Safety Agency, is now being undertaken.

The national repository will only be established after the satisfactory completion of these processes.

There will be no release of radiation from the repository, but, to reassure pastoralists, foodstuffs from the region can be routinely checked on request and certified as safe through a long-running monitoring programme operated by the Australian Radiation Protection and Nuclear Safety Agency.

Further information can be obtained from the government web site www.isr.gov.au/radwaste or

National Radioactive Waste Repository
Coal and Mineral Industries Division
Department of Industry, Science and Resources
GPO Box 9839
Canberra ACT 2601.

IMMIGRATION RECEIVING AND PROCESSING CENTRE

An immigration receiving and processing centre was established at Woomera West in November 1999. Its occupancy rates have fluctuated as its detainees are processed: peaking at about 1400 in May 2000, but generally being less than this. The centre was for some time the largest employer in Woomera, but is now being scaled down.

OFF-ROAD VEHICLES

Damage to vegetation, soil disturbance, inappropriate rubbish disposal, damage to gates and improvements, gates left open and shooting of fauna and stock are the main problems associated with the use of many motor bikes and 4WD and other off-road vehicles.

This is not an extensive problem and is concentrated around towns. The damage to property has reduced markedly since the opening of the sealed Stuart Highway. People are less tired and frustrated by the trip and spend less time in the area.

Land management and rehabilitation

The travelling public needs to be made aware that the leasehold lands are private property and that unauthorised entry is not permitted.

ACHIEVEMENTS OF THE BOARD

The main achievements of the Board since it was formed in 1990 are:

- Construction of the Billa Kalina exclosures and regular vegetation monitoring within the exclosures.
- Mapping and ripping all rabbit warrens in two areas surrounding the Billa Kalina exclosures.
- Preparation of a comprehensive plant reference collection for the District and of smaller collections for individual pastoralists and schools within the District.
- Preparation of a portable photographic display on land condition for use at field days and other public forums.
- Property management planning.
- Facilitation of course to obtain recognition in current competency in Rural Business Management Levels 3-6.
- Initiation of the western myall (whitefly) monitoring project.
- Review of the District's land systems.
- Preparation of two District Plans.

THREE-YEAR PROGRAMME

2002 - 2004

The aims of the Kingoonya SCB and the Board's commitment to an educational and co-operative approach to the management of the District's natural resources are the basis of the following programme of activities of the Board.

The three year plan needs to be flexible in its approach to achieving the Board's goals due to the unpredictable nature of the Arid rangelands and the necessity of fitting in with seasonal activities of station properties.

Aim: Protect the land and its biodiversity through promotion of sustainable land use.

Goal: Support the long-term viability of communities and industries in the District.

Actions:

District Education Program

- Publish and promote this District Plan and the land management strategies identified within.
- Organise one field trip, in conjunction with a Soil Board meeting, per year to educate members about issues of importance within the Kingoonya District. Include inspections of mining, tourism, defence and other enterprises.
- Hold 1 open meeting with Keynote speaker per year and extend an invitation to all land holders within the district to attend.
- Provide support for local land managers to attend relevant seminars/conferences where the Board sees fit.
- Review display material on evaluation of pasture condition, land condition monitoring, forms of soil erosion and the land systems of the District, and update for Glendambo field day which is held bi-annually.

District Research Program

- Develop a district project that encompasses the following issues of importance:
  - The development of a weed register and distribution of threatening weeds.
  - Monitoring of rabbit population dynamics at the Billa Kalina trial site.
  - Monitoring of the reoccurrence and efficacy of the rabbit calici-virus across the district.
  - Map the distribution of, and suitable habitat for, the rare and endangered animal and plant species within the District.
  - Monitor the distribution of western Myall white flies and the degree of infestation and tree death.
  - Investigate use of new technologies such as remote sensing for monitoring and management purposes.
  - Update inventories of biological resources.
- Seek funding sources to finance the employment of a project officer and funds to manage this project
- Encourage the district community to participate in this project

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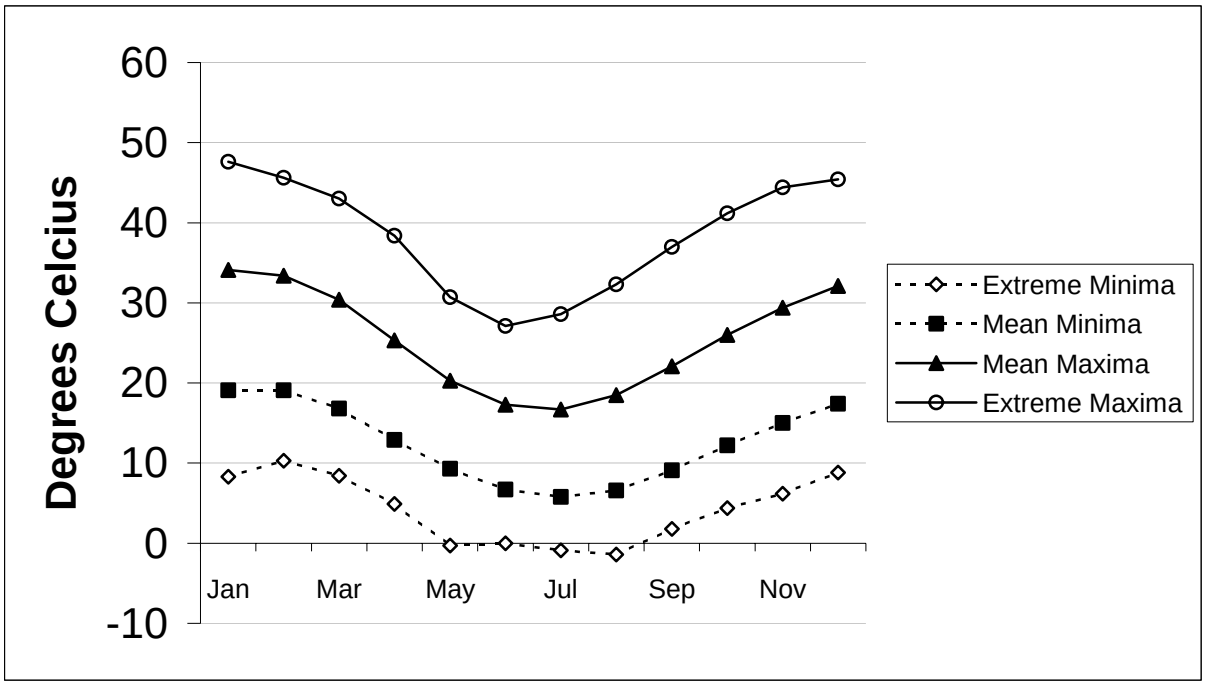
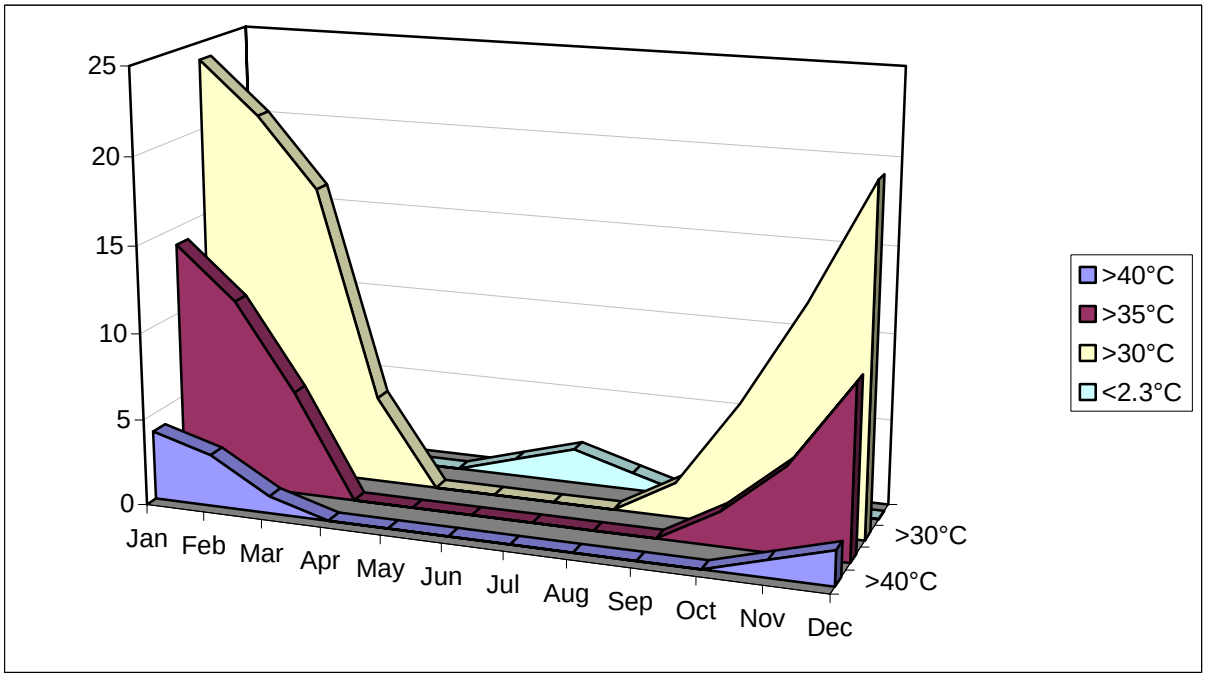
APPENDICES

APPENDIX A

A: MONTHLY TEMPERATURE DATA FOR SELECTED STATIONS[18]

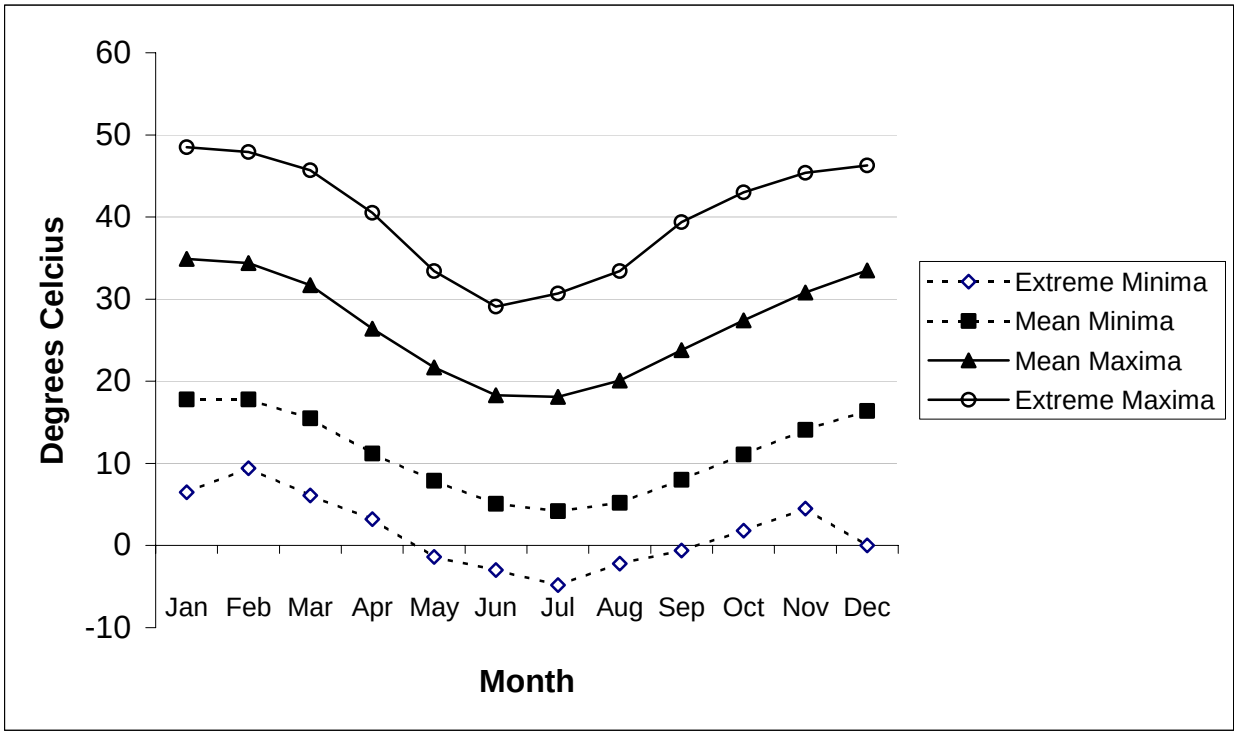
Woomera





[18] The second graph shows the ***average*** number of days per month for which temperatures either exceed 40°C, 35°C and 30°C, or fall below (or equal to) 2.2°C or 0°C. O^0C is omitted where this temperature has not been recorded.

Tarcoola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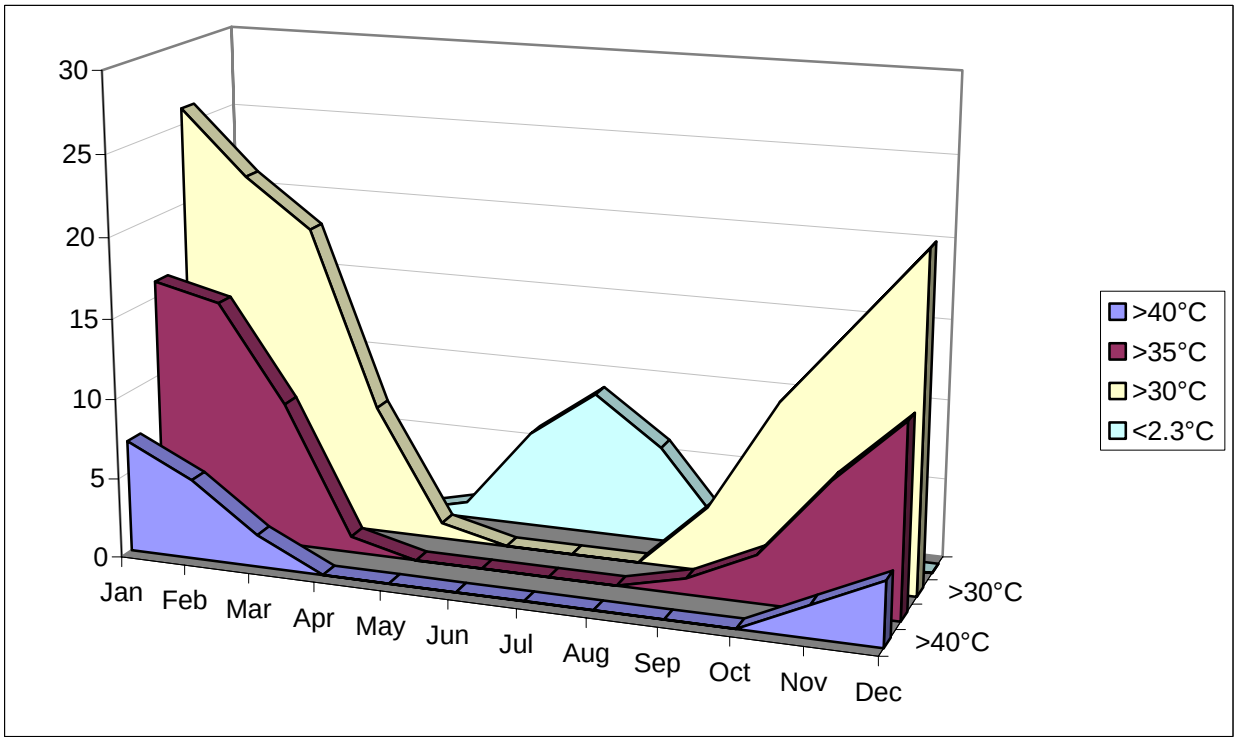
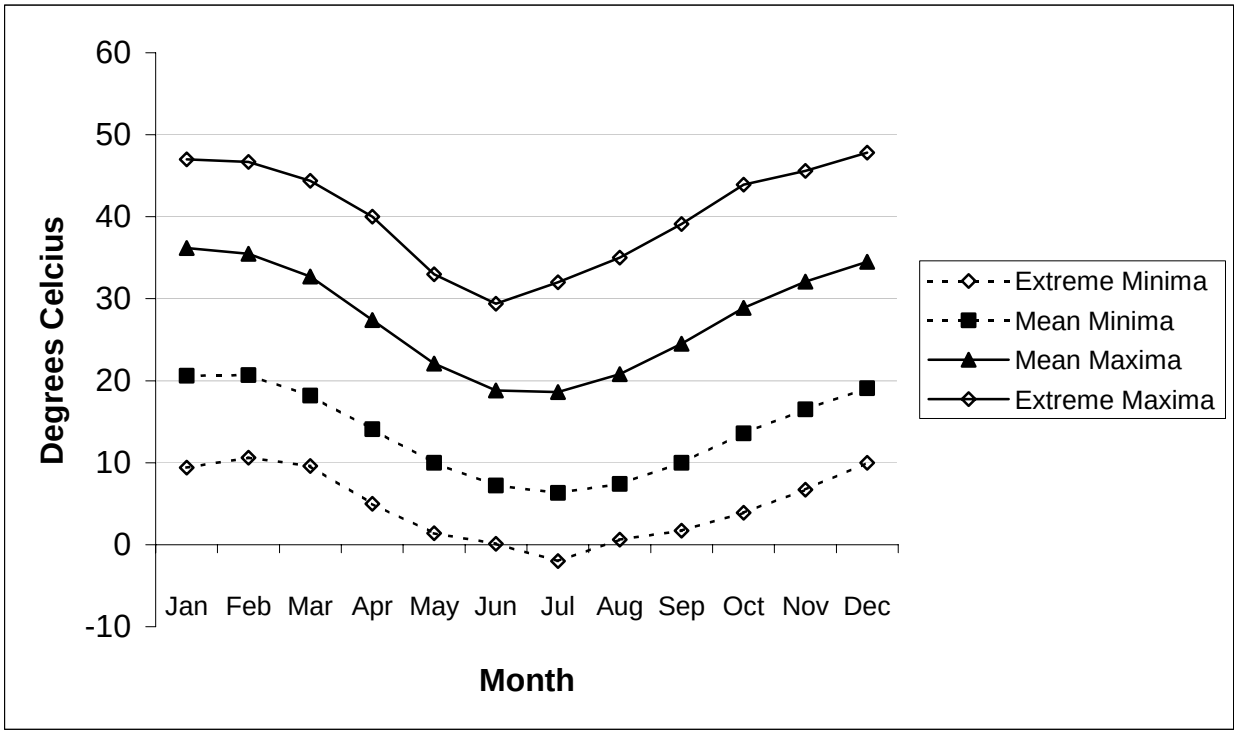
50
40
30
20
10
0
-10
Degrees Celcius
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month
Extreme Minima
Mean Minima
Mean Maxima
Extreme Maxima


30
25
20
15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
>30°C
>40°C
>40°C
>35°C
>30°C
<2.3°C

Coober Pedy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Degrees Celcius
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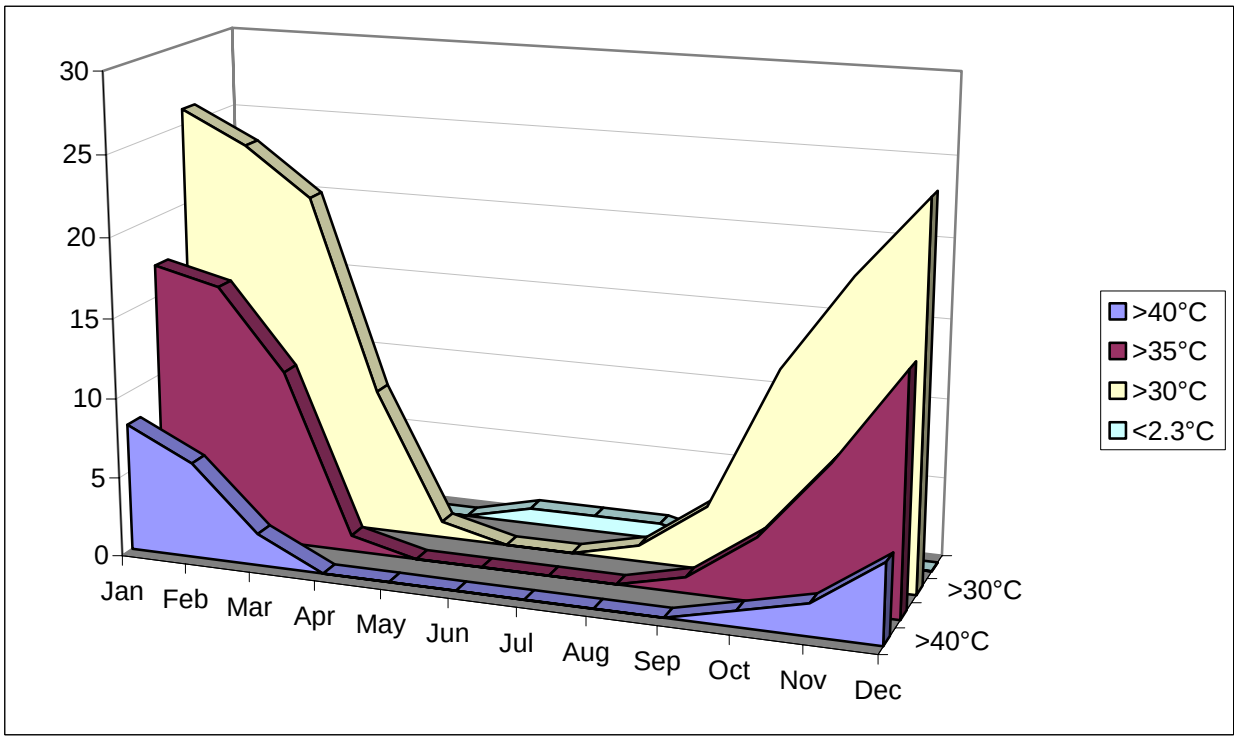
Month
Extreme Minima
Mean Minima
Mean Maxima
Extreme Maxima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25
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15
10
5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
>30°C
>40°C
>40°C
>35°C
>30°C
<2.3°C

APPENDIX B

B: LAND SYSTEM DESCRIPTIONS

In its first district plan (KSCB 1996), the Kingoonya SCB identified several areas concerning land system description and mapping that required further research and modification. Badman (2001) addressed these issues using analysis of quantitative data collected from more than 400 sites across the district. Land system descriptions from that report are given here. Badman (2001) provided a full explanation for the changes and these are not repeated here.

The number of land systems has been reduced from 33 to 17 in the interests of uniformity across the District and with adjoining districts. Less emphasis has been placed on land units in this district plan because separate management of these units is generally not practical in the South Australian rangelands, even though in many cases it might be desirable. Reference to "common" species is to those species with a projected canopy cover value of 1-5% across the whole land system (Badman 2001) while "dominant" species have a cover value >5% across the whole land system within the District.

Reference to old or former land systems in the following descriptions is to those described in the original District Plan (KSCB 1996) while current or new land systems are those described by Badman (2001). Common names of plants are generally those preferred by the Biological Survey Branch of the South Australian Department of Environment and Heritage (e.g. Brandle 1998). The names used are listed in Appendix C.

Sand Plains with Woodland Vegetation

Commonwealth Land System

The description of the Commonwealth land system remains largely unchanged, although the area covered by this land system has increased. It now includes the entire old Commonwealth, Tallaringa and Mailgate land systems and the northern part of the old Indooroopilly land system.

The Commonwealth land system is an extensive sand plain that is quite young in geological terms (Quaternary sands). It occurs in the western part of the district, between the Great Victoria Desert in the west and the Stuart Range in the east. Well-defined watercourses are largely restricted to the eastern margins, including part of the former Carringallana land system along Carringallana Creek. Some low sandy rises have formed from the same sediments and in the south-west these grade into the dunes of the Wynbring land system. Numerous claypans catch any run-off, although most rainfall quickly infiltrates the sandy soils. Soils are mostly light and often shallow, with calcrete or bedrock often close to the surface. Siliceous sands, earthy sands or sandy red earths dominate, although some hardpan soils also occur.

The Commonwealth land system occurs on Mobella, Commonwealth Hill, Mulgathing, Wilgena, North Well, Bulgunnia, Mount Vivian, Ingomar, and McDouall Peak stations. The sand plains of the Commonwealth land system often surround small areas of other land systems.

Vegetation of the sand plain is dominated by low open mulga woodland. Flat-stalk senna is common in the shrub layer, which also includes dead finish, Australian boxthorn, crimson emubush and tar bush. The latter species are widespread and may be locally common, but they are not common over the whole land system. Satiny bluebush, pearl bluebush, rosy bluebush, silver mulla mulla, ruby saltbush and spiny saltbush also occur here. Woollybutt is common in the understorey but other perennial grasses, including bandicoot grass, cotton panic-grass and

window mulga-grass, also occur. Mulga grass and bottle-washers are common in good seasons.

Commonwealth (grassy understorey)

Commonwealth (chenopod shrub understorey)

On clay and silty soils at the margins of claypans, where salinity is higher, mulga woodlands are replaced by chenopod shrublands dominated by bladder saltbush, with black bluebush, samphires and cotton-bush also common. Emubushes, sennas and silver tails are also present, together with many of the other understorey species found in nearby areas. Mulga still occurs

here, but as scattered trees rather than as open woodland.

Dunefields with Woodland Vegetation

Wynbring Land System

The Wynbring land system includes all of the old Wynbring and Mendea land systems and the southern part of the Indooroopilly land system.

This land system occurs in the south-west of the district, on the south-eastern edge of the Great Victoria Desert. It is similar to the very extensive Yellabinna dune system that occurs further to the south-west. It was formed by deposition of enormous quantities of deep red siliceous Quaternary sands over large areas of low-lying land. This material was brought into the area as stream sediments from nearby ranges and now forms large parallel east-west trending dunes up to 10 m high. Earthy sands and red earths occur in the swales. Sands are deep enough to ensure less variation between vegetation of dunes and swales than is found in similar systems in eastern parts of the district. The mallees found in this land system are generally the tallest in the district and at least four species are present.

Wynbring (typical of the south-west of the District)

No external drainage lines occur in this area. Most rainfall quickly soaks into the sandy soils, with any run-off flowing into claypans within the dune systems. Some of these pans have accumulated enough clay to hold water for short periods, but few support any swamp vegetation.

This land system occurs in the south-west and extreme south of the district, on Mobella, Mulgathing, Wilgena, North Well and Kokatha stations.

Horse mulga is dominant on dunes, with bullock bush and narrow-leaved hopbush also common. Yumbarra mallee occurs on some dunes. Cactus pea was found to be co-dominant with mallees on one dune, but was not recorded elsewhere. The understorey includes woollybutt and tall

kerosene grass, which are widespread but not common over the whole land system. Victoria Desert mallee, black oak and flat-stalk senna are common in the overstorey of swales, with silver mulla mulla and rosy bluebush common in the understorey. Woodlands of swales also include several species that are widespread but not common over the whole land system. These include quandong, false sandalwood, mulga and shrubby riceflower in the overstorey and ruby saltbush, tar bush, Australian boxthorn, bladder saltbush, pearl bluebush, grey bindyi and mulga grass in the understorey. *Rhagodia preissii* is often found growing beneath the mallees.

Another vegetation type occurs in similar terrain to the main vegetation association but is dominated by black oak woodland. Mallees, hopbushes and quandongs are not common here, while bullock bush, broom emubush, Australian boxthorn, bladder saltbush, satiny bluebush, woollybutt and mulga grass are more common. It also has greater cover of bindyi species as well as leafless cherry and velvet potato bush.

Another vegetation association occurs in the few drainage areas and is dominated by tall shrublands of flat-stalk senna, with open woodlands of western myall and black oak also common. Other common species are false sandalwood, quandong, Mueller's daisy bush, spiny saltbush and oblique-spined bindyi.

Wynbring (typical of the south-east of the District)

White cypress pine occurs only in the extreme south of the district on Kokatha Station and is a distinguishing feature of a recognisably different vegetation association, although classification of its vegetation still places it within the Wynbring land system. This vegetation association includes most of the species listed above, but woodland and shrubland vegetation often has a greater canopy cover than it does further to the north-west.

Sand Dunes and Stony Plains with Woodland and Shrubland Vegetation

Five land systems are made up of mixtures of dunes and stony country, sometimes in close proximity to land systems containing extensive dune fields. Sands moving in from the west have overlain the existing uplands and plains, creating mixtures of hard and soft country. Dunes in hilly country often lack regular patterns, with the original hills determining the shape of the overlying dunes, while dunes on plains have similar east-west linear alignments to those described for the Wynbring land system. However, the plains underlying these dune systems have different origins and this is reflected in the different vegetation of the interdune corridors.

Ingomar

The old Brumby and Phar Lap land systems have been combined to form the Ingomar land system.

Flood plains and outwash plains of the Stuart Range and other nearby uplands form the basis of the Ingomar land system. In places these plains have been overlain by mostly parallel east-west trending linear sand dunes. These become jumbled near the ranges. Wide braided watercourses, often with numerous waterholes persisting following rain, end in small claypans. Soils are alluvial sands, clays, or red or yellow duplex on plains and siliceous sands on dunes. Gilgais are uncommon.

This land system is found on Ingomar, McDouall Peake, Bulgunnia, Mount Eba and Millers Creek stations.

Chenopod plains are dominated by bladder saltbush, with cotton-bush and tangled bindyi also common. Other widespread species include neverfail, ball bindyi, common bottle-washers and low bluebush, but although these may be locally common they are not common across the whole land system. Mulga and dead finish are the most widespread of the emergent trees and shrubs.

Mulga, sennas and dead finish are common overstorey species on plains with sparse woodland vegetation, with plumbush also widespread but not common. Low bluebush, ruby saltbush and silver mulla mulla are common in the understorey. Brilliant hopbush, neverfail, mulga grass, common bottle-washers and several bindyi species are widespread in the understorey but not common across the whole land system.

Open mulga woodlands dominate dune vegetation, with horse mulga occurring on some dunes. Because many of the dunes are associated with sandy watercourses, coolabah and inland paper-bark are also common in the overstorey. Flat-stalk senna is common and narrow-leaved hopbush and plumbush are widespread. Ruby saltbush and woollybutt are the most common understorey species, with sand sida and velvet-leaved hibiscus also widespread. Swales are dominated by mulga grass and chenopod species, including ball bindyi, bladder saltbush and other bindyi species. The understorey of watercourses includes the same species as the surrounding dunes or plains.

Another vegetation association includes both large watercourses and adjoining sandy-clay plains. Coolibah woodlands are common bordering the watercourses, with dead finish and sennas also widespread. Common understorey species are cane-grass, swamp wanderrie and goat-head bindyi, with mulga grass, neverfail, ball bindyi and common bottle-washers all widespread but not common overall.

Ingomar (sand dunes and swales)

Ingomar (gibber plains and watercourses)

Roxby Land System

The old Roxby land system has been extended to the south-west to include parts of the Vivian land system around Lake Hart and south of the Wirraminna HS. Areas of former Roxby land system on the eastern side of Billa Kalina Station are now placed in the Wattiwarriganna land system.

Large areas of the eastern part of the district are included in the Roxby land system. This system comprises a large dunefield overlying older alluvial plains or ancient basement limestone. Limestone is often very close to the surface or occurs as outcrops. Red duplex soils or firm calcareous sands overlie the limestone, while siliceous sands occur on dunes and firm calcareous sands occur on rises. Alluvial silts and clays are associated with drainage channels, claypans and swamps.

Roxby (swales with chenopod shrubs)

This land system occurs on Roxby Downs, Parakylia, Billa Kalina, Andamooka, Purple Downs, Arcoona and Wirraminna stations and the Olympic Dam Mine Lease.

Mulga woodlands are dominant in the main vegetation association, with white cypress-pine also common on the larger dunes and horse mulga common on siliceous sands of both large and small dunes. Tall shrublands of sandhill wattle, narrow-leaved hopbush and bullock bush are also common on dunes. Understorey is often dominated by tall kerosene grass, with sand sida, ruby saltbush and rosy bluebush all widespread but not common throughout the whole system. Western myall and mulga woodlands are common in swales and white cypress-pine occurs in some swales with deep sandy soils. Tall shrubland of senna are widespread and low shrublands of bladder saltbush and low bluebush are common in the understorey of swales, although these are usually dominated by mulga grass. Australian boxthorn, ball bindyi, oblique-spined bindyi and desert lantern bush are widespread but not common throughout the whole system.

Other vegetation associations identified here often represent changes in abundance of particular species rather than distinct land units (Badman 2001). Small swamps are often bordered by tea tree (*Melaleuca xerophila*) low woodlands and swamp cane-grass is also common in or bordering such places. These areas are usually quite small. Claypans are also common, but very little vegetation grows on their surfaces. Halophytic species, particularly chenopods, often border them but these areas usually also support the same species as the surrounding swales.

Roxby (swales with grasses and forbs)

Vivian Land System

The Vivian land system is reduced in area through the removal of areas around Lake Hart and south of Wirraminna HS. These have been placed in the Roxby land system.

Areas in the south-east of the district are included in the Vivian land system. Scarcity of sand for dune building has resulted in the formation of a series of low parallel dunes and thin sand sheets rather than large dunes, with the older calcreted plain exposed in many places. Drainage is into claypans and salt lakes of the adjoining Wirrida land system. Soils are siliceous sands on dunes, firm sands on sandplains and red earths or red duplex soils in swales. Calcareous earths occur on some sandy clay rises.

This land system occurs on North Well, Bon Bon, Coondambo, Roxby Downs, Parakylia and Mount Vivian stations. The Vivian and Roxby land systems grade into each other on the eastern side of the Vivian land system. The separation between Vivian and Roxby land systems is not always clear, but dunes are smaller and white cypress-pine is absent from the Vivian land system.

Mulga woodlands dominate the overstorey vegetation of both dunes and swales, with horse mulga, umbrella bush and witchetty bush occurring on some dunes although they are not common across the whole land system. Woollybutt and bandicoot grass are common in the understorey. Vegetation of dunes and sand sheets also commonly includes Australian boxthorn, silver mulla mulla, rosy bluebush, mulga grass and jointed bottle-washers. Black oak or western myall open woodland sometimes occurs on swales, but mulga woodlands and dead finish and flat-stalk senna tall shrublands are more common. The understorey of swales sometimes includes pearl bluebush, bladder saltbush, neverfail and three-wing bluebush, but silver mulla mulla is usually more common. Crimson emubush is widespread but is not common over the whole area.

Vivian

Another vegetation association is also dominated by mulga but has increased cover of western myall and bullock bush, with pearl bluebush and oblique-spined bindyi both common in the understorey.

Waulalumbo Land System

The Waulalumbo land system remains unchanged, although its relationship to similar land systems in the Gawler Ranges is still unclear.

The Waulalumbo land system has similarities with land systems of the Gawler Ranges and is found only in the extreme south of this district, on Kokatha Station. It forms a transitional area between the Wilgena and Wynbring land systems. East-west trending parallel dunes occupy lowlands between granitic hills.

On the western side of the land system, larger dunes support sparse woodlands or tall shrublands of white cypress-pine, horse mulga and bullock bush. Western myall is common in swales or where the sands are shallow, while bladder saltbush, ball bindyi, ruby saltbush, rosy bluebush, oblique-spined bindyi and spear-grasses are all common in the swale understorey. Vegetation of low dunes and sandsheets is dominated by flat-stalk senna, with sparse mulga woodland and Australian boxthorn also common. Understorey is similar to that of swales between the larger dunes.

Red mallee and white cypress-pine woodlands occur on siliceous dune sands towards the centre and on the eastern side of the land system. Horse mulga, mulga, umbrella bush, bullock bush and narrow-leaved hopbush are also common. The dune understorey is dominated by spear-grasses and cannonball bindyi. Western myall, mulga and black oak woodland occur on sandy red earths over alluvial sandy clays of swales, with bullock bush, broom emubush, narrow-leaved hopbush and daisy bush also common (McDonald 1992).

Waulalumbo

Mulga scrub dominates on skeletal or loamy soils over granite and rhyodacite on hills, with dead finish, granite wattle, green emubush, crimson emubush, bladder saltbush, three-wing bluebush and silver mulla mulla also occurring. The few hills with calcrete support pearl bluebush. Low chenopods characteristic of calcareous plains occur where the sand cover is thin or where hill outwash sediments are exposed in the swales. Porcupine grass (*Triodia* sp.) forms the main understorey species on some stony hillsides, especially in areas with rocky outcrops (McDonald 1992).

Wattiwarriganna Land System

Neither McDonald (1992) nor KSCB (1996) included this land system within the Kingoonya SCD. Badman (1999) considered the sand dune country on the eastern side of Billa Kalina to belong to the Stuarts Creek land system (MSCB 1997), which was thought to have characteristics mid way between those of the Roxby and Wattiwarriganna land systems. Further work (Badman 2001) has shown that these two land systems are too similar to warrant individual land system status. The area of former Emu land system in the south-eastern corner of Billa Kalina, with broad swales and long parallel dunes, is also included in this land system.

The Wattiwarriganna Land System is formed from a series of large parallel sand ridges overlying an older gibber plain, with swales usually containing a gibber pavement. Dunes are generally from 100 m to 500 m apart and up to 10 m in height. The quartzite and silcrete gibbers are gravel rather than scree size because they have been sorted as they travelled further from their source. Numerous claypans, swamps and large watercourses occur throughout this land system. Dunes usually have deep red sandy soils, although dunes within the Kingoonya SCD and the Stuart's Creek land system of the Marree SCD (MSCB 1996) are generally paler. Dunes in this land system in the Marla-Oodnadatta SCD are often softer and are more likely to have mobile crests than those on Billa Kalina Station. Sandy or clay-loam soils occur in the swales, which are generally flat, but may contain low sandy or calcareous clay rises. Swamps have brown clay, or cracking grey or brown clay, or yellow or red sandy-loam soils.

Wattiwarriganna (dunes with sandhill wattle dominant)

Sandhill wattle is the most common tall shrub on dunes, while mulga, horse mulga, narrow-leaved hopbush, silver needlewood and sandhill cane-grass also occur. White cypress-pine may occur as scattered trees where this land system is close to the Roxby land system. Bluebush pea and sand sage are also common. Kerosene grass is common in the understorey on dunes.

Wattiwarriganna (dunes with sandhill cane-grass dominant)

Bladder saltbush is usually the dominant species on swales supporting chenopod low shrubland, with Sturt's pigface, cotton-bush, salt bindyi, neverfail and mulga grass, also common. Mulga grass is often the most common species on swales when few shrubs are present, although Sturt's pigface and neverfail also occur here.

Large sandy watercourses and numerous swamps occur in the Wattiwarriganna Land System, although the largest creeks are outside the Kingoonya SCD. Creeks are often lined with coolibahs, while lignum and nitre goosefoot are common in the shrub layer. Goat-head bindyi, tangled bindyi, neverfail and mulga grass are common in the understorey. Swamp cane-grass is common at some swamps and claypans. Red gum occurs in this land system in the Marla-Oodnadatta SCD, but not in the Kingoonya SCD. Swamps have similar understorey vegetation to watercourses but usually lack associated riparian woodlands.

Drainage Areas with Woodland and Shrubland Vegetation

Wirrida Land System

The Wirrida land system includes the old Labyrinth, Phillipson, Gairdner and Torrens land systems as well as some other adjacent areas.

Larger lakes and claypans have formed at the end of drainage lines from the Stuart Range, or are a series of linear depressions in ancient river channels left over from a much wetter period than the present. Vegetation includes both salt tolerant species and those that can stand periods of inundation. Dunes of Quaternary siliceous sands have formed around salt lakes, swamps and claypans from materials that were transported as sediments into the drainage sump. Prevailing winds have carried these sediments on to the nearby plains, with the prevailing trend of dunes being parallel to the lakeshores. The largest dunes are generally found on the downwind or eastern side of these lakes and claypans. Soils of lakes and interdune areas are of gypsiferous, saline sands, silts and clays. Low limestone and gypsum cliffs border some lakes and swamps. This limestone often forms a shelf around the larger lakes, allowing sand to accumulate and form dunes at the lake's edge.

This land system occurs on all properties west of the Stuart Highway, and on Millers Creek and Billa Kalina stations. It is absent from the south-eastern corner of the district except on the margins of some salt lakes.

Although sparse mulga woodlands and senna tall shrublands are found throughout, no tree or tall shrub species dominates the vegetation of the whole land system. This probably reflects the continuing influence on vegetation of the dispersal of salts from lake surfaces. The only shrub species that can be regarded as common across the whole land system are Australian boxthorn and rosy bluebush. Other widespread species on dunes are ruby saltbush, bullock bush, narrow-leaved hopbush and sandhill wattle, but these are never common in a land system context. The understorey of dunes includes grasses and bindyis. Grasses include the perennial woollybutt, but shorter-lived species such as mulga grass and bottle-washers are more common. Swales and lake margins or floodouts often have low shrublands of bladder saltbush and oblique-spined bindyi, with these species dominating the vegetation in some areas. Black oak occurs on some swales and although it is sometimes the main tree species present it is not common overall.

Wirrida (salt lakes with chenopod low shrubland)

Wirrida (tea tree tall shrublands)

Tea trees and paper-barks border some lakes and swamps. *Melaleuca xerophila* is present in the south and west and inland paper-bark in the north and north-east. Understorey vegetation is similar to that of other areas in this land system.

Mallees sometimes occur on gypsiferous rises near salt lakes in the south of the district. In such areas, bullock bush, narrow-leaved hopbush and silver needlewood also occur in the canopy,

with woollybutt, silver mulla mulla and rosy bluebush in the understorey. Flat-stalk senna also occurs here. Western myall, black oak and umbrella wattle occur on lower areas, with bladder saltbush and bottle-washers in the understorey.

Another vegetation association is dominated by low bluebush and black bluebush on calcareous rises. Mulga, dead finish, sandhill wattle, narrow-leaved hopbush, low bluebush, cotton-bush and bladder saltbush are also present. Neverfail and mulga grass occur in the understorey. Yet another vegetation association has an overstorey dominated by inland paper-bark on sandy rises, with nitre goosefoot also common and with some coolibah present. Woollybutt is common in the understorey and grey bindyi sometimes occurs here.

Plains with Woodland and Shrubland Vegetation

Extensive plains with hard calcareous soils but little stone cover occur across much of the district. Two of these land systems support woodland or tall shrubland vegetation, while the other has low chenopod shrubland.

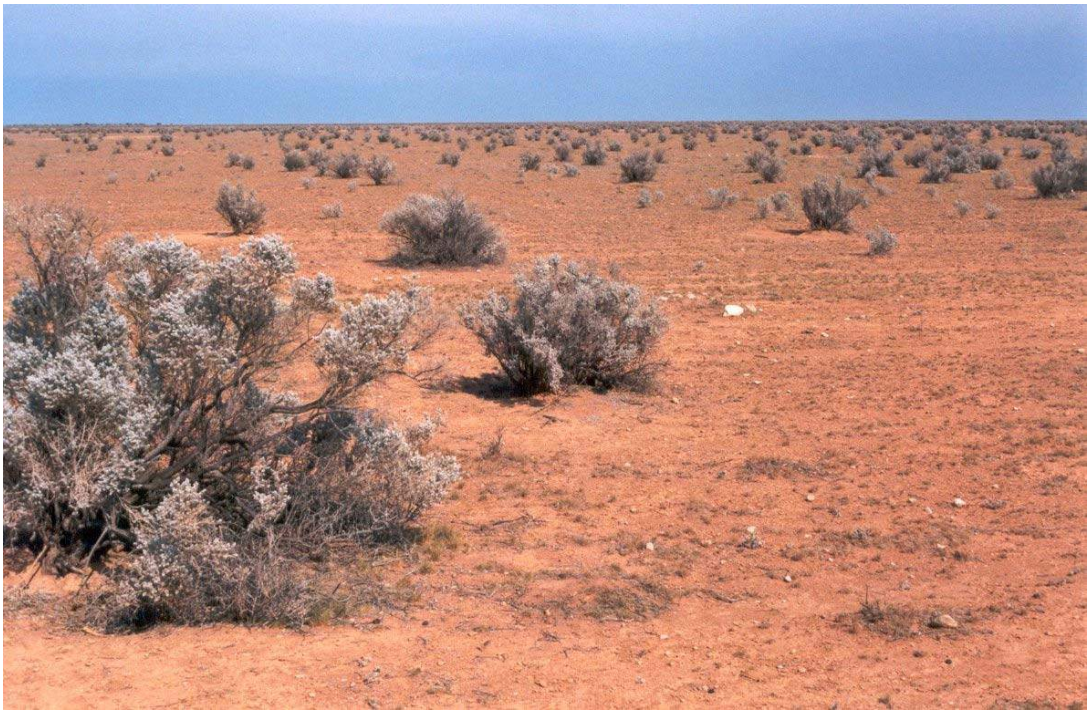
Coward Land System

The Coward land system remains unchanged.

The Coward land system occupies areas in the north-east of the district on Millers Creek and Billa Kalina stations, particularly north of the Millers Creek drainage line. Soils originate from an ancient lake in which dolomites and limestones were deposited and are therefore highly alkaline and rich in lime. These plains have limited topographic relief, with run-on areas and watercourses being only marginally lower than the surrounding plains. Plain surfaces are well exposed and are being encroached on by sands in the west and south. Soils are predominantly sandy loams and earths, alluvial sands, red duplexes and brown clays.

Vegetation on the plains is a chenopod low shrubland dominated by low bluebush, with pearl bluebush and bladder saltbush also common. Small-spine bindyi and jointed bottle-washers are common in the understorey. Shrubby twinleaf occurs widely in this land system and twiggy sida and pin sida are also widespread in the understorey but not common overall. Emergent taller vegetation includes dead finish, elegant wattle, native apricot and bullock bush, which may occur in small groves but are never particularly common in a land system context. Chenopod shrublands are sometimes quite open, although never as sparse as those generally occurring in the Baltana land system. This is possibly due to the lowest rainfall in the district and the poor water retention of the soils.

Watercourses support shrublands of sennas (particularly fine-leaf desert senna), spotted emubush, elegant wattle, dead finish and Australian boxthorn. Tall verbine is common following rainfall. Mulga, plumbush, black bluebush, showy groundsel and native apricot also occur in some areas.



Coward

Kingoonya Land System

The Kingoonya land system includes areas previously ascribed to the Gina, Glendambo and Yarna land systems.

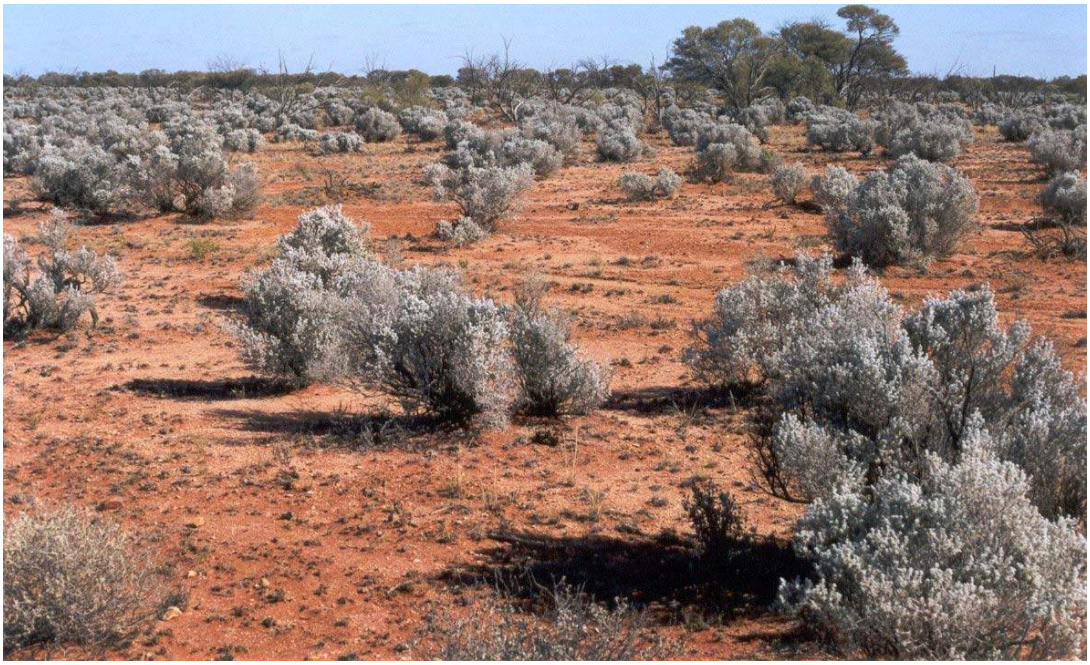
The Kingoonya land system is one of the largest land systems in the Kingoonya SCD. It consists of calcareous plains, sometimes with pebble cover or outcropping limestone, but usually without gibbers or large rocks. Hills are absent from this land system, although it often borders hilly country. Soils consist of calcareous sandy loams, calcareous earths, sandy earths, earthy sands or red duplex soils on plains. Deep earthy sands and shallow siliceous sands occur on sand spreads. Rises have calcareous sand soils, while sandy red earth soils occur on run-on flats.

This land system is widespread in the western half of the district and occurs on all properties west of or traversed by the Stuart Highway and on Mount Vivian, Parakylia, Millers Creek and Billa Kalina to the east.

Open mulga woodland dominates over most of this land system, with pearl bluebush dominant in the understorey. In the vegetation association that occurs over a wide area in the west of the district, crimson emubush is common in the mid-storey, with satiny bluebush, silver mulla mulla and oblique-spined bindyi common in the understorey. Sennas, dead finish, Australian boxthorn and ruby saltbush are widespread. Black oak woodlands are sometimes present but this species is uncommon overall.

In the eastern mulga woodlands, dead finish is common in the overstorey, with ball bindyi, low bluebush, three-winged bluebush, silver mulla mulla, oblique-spined bindyi and mulga grass common in the understorey. Sennas, ruby saltbush, satiny bluebush, plains nightshade and bladder saltbush are widespread in this unit but are not common overall.

Kingoonya (mulga woodlands with mainly forbs and grasses in understorey)



Kingoonya (mulga woodland with bluebush understorey)

Western myall woodland occurs in some areas and this species is sometimes dominant, with sennas (including Gawler Ranges senna), Australian boxthorn, broom emubush and bullock bush widely distributed throughout the overstorey. Black oak is sometimes present. Pearl bluebush is dominant and bladder saltbush and oblique-spined bindyi are common in the understorey. This vegetation association has affinities with the Wirrida land system. This has nothing to do with its proximity to salt lakes, but is more likely to be due to the calcareous nature of its soils. This soil type is also the reason for the dominance of western myalls.

Kingoonya (western myall and mulga woodland with bluebush understorey)

Mount Eba Land System

The Mount Eba land system is a combination of the Buckshot and Lookout land systems.

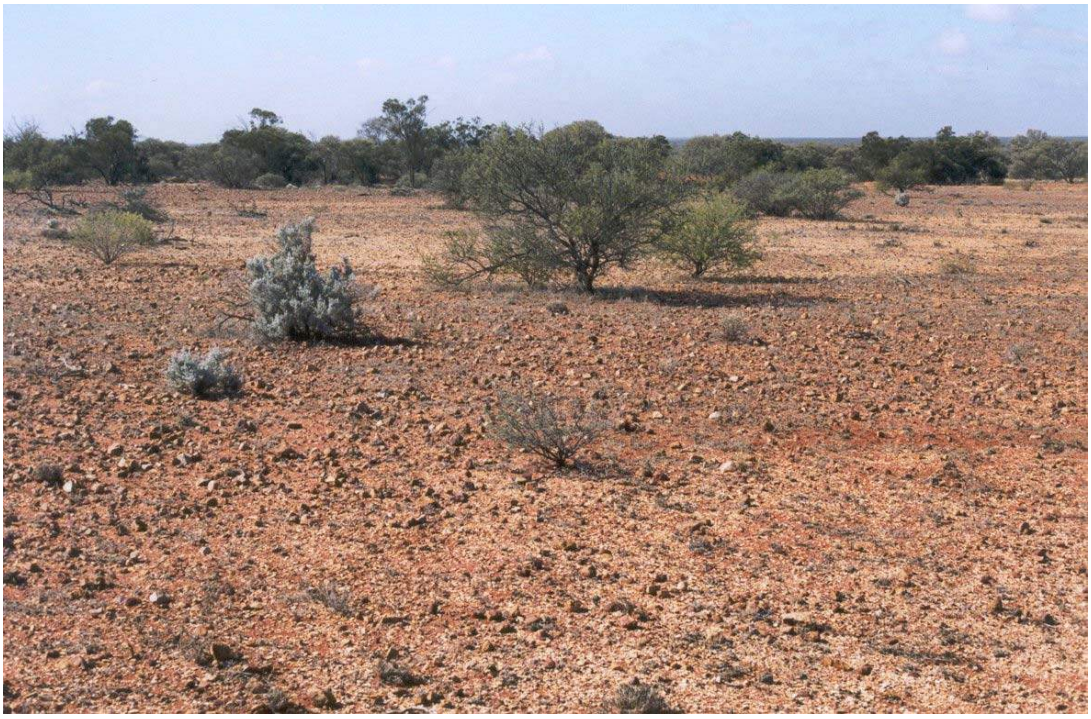
This land system occurs in the central part of the district to the west of the Stuart Range. Erosion of underlying bedrock, particularly Bulldog Shale, has created a system of low silcrete-capped hills with adjacent plains. Calcareous loams and earths occur with silicified shales on plains and calcareous loams occur with silicified shales on rises. Usually non-calcareous sandy clay, red earth or desert loam plains have a cover of buckshot gravel. In areas with buckshot gravel, most vegetation occurs in groves or corridors in softer areas that benefit from run-off from the buckshot flats. These areas may even act as minor watercourses.

The Mount Eba land system occurs on McDouall Peak, Bulgunnia, Mount Eba, North Well, Wilgena, Bon Bon, Mount Vivian and Millers Creek stations.

Open or sparse mulga woodland is common across the whole land system and dead finish is also common. Low bluebush, silver mulla mulla, tangled bindyi and mulga grass are common in the understorey. Sennas (mainly silver senna), ball bindyi, three-winged bluebush, rock sida, round-leaf emubush, ruby saltbush, pearl bluebush and plum bush are all widespread here but are not common overall. Sparse western myall woodland occasionally occurs, with a chenopod understorey similar to that described above.

Mulga woodlands are often dominant where run-on areas are larger and soils are sandier. Plum bush, sennas (especially silver senna), crimson emubush and Australian boxthorn are all widespread. Pearl bluebush, satiny bluebush, silver mulla mulla, oblique-spined bindyi and woollybutt are common and ball bindyi, ruby saltbush, tangled bindyi, satiny bluebush, three-winged bluebush and pin sida are widespread but less common in the understorey.

Mount Eba (buckshot gravel)



Mount Eba (larger stone cover, but not buckshot)

Uplands with Shrubland Vegetation

Upland land systems within the Kingoonya SCD are associated with the Stuart Range, northern Gawler Ranges, Arcoona Tableland and the low hills and rises north and west of Kingoonya and Tarcoola. The Wilgena land system does not have gilgais whereas they are a distinct feature of the Arcoona, Oodnadatta and Paisley land systems.

The classification of perennial vegetation data placed the majority of Arcoona sites in one group and the majority of Breakaway sites in another. Oodnadatta sites fell mainly into two groups, one of which indicates that parts of this land system have distinct similarities with the Arcoona land system. Sites in the Paisley land system have similarities with the Breakaway land system and the Arcoona land system. Sites in the Wilgena land system fall within two groups that have affinities with vegetation from across the whole of the western side of the district (Badman 2001).

There are many residual hills, with underlying Bulldog Shale often exposed, in these land systems. Soils are variable but include sandy loams and earths, calcareous loams, desert loams, shallow sands, stony loams, red duplex, red earths, brown clays, skeletal loams, alluvial soils and brown cracking clays.

Arcoona Land System

The Arcoona land system remains unchanged.

The gently undulating tableland of the Arcoona land system dominates the south-east of the district on Arcoona, Bosworth, Andamooka, Purple Downs, Roxby Downs, Coondambo (Parakylia South block) and Wirraminna stations. A few low hills and escarpments are included within this system. Soils include stony red duplex and stony brown clay soils of the tablelands, stony clay soils over quartzite on hills, skeletal loams on escarpments and alluvial soils along watercourses.

Arcoona (typical chenopod low shrublands)

Chenopod low shrublands dominate throughout this land system, with some trees along watercourses and tall shrublands on isolated dunes. Bladder saltbush dominates the vegetation, with glassworts also common. Salt bindyi, bush minuria, bristly-sea heath, tangled bindyi, ball bindyi and neverfail are widespread, with barley Mitchell-grass, ray grass and plover daisies

moderately common in some areas but not common across the whole land system.

Isolated dunes, often with associated calcareous rises, have sparse woodland or tall shrubland vegetation where no single species dominates. Mulga, sandhill wattle and dead finish are common in this unit. The understorey commonly includes tall kerosene grass and mulga grass. Pearl bluebush, black bluebush, Tate's bindyi and shrubby twinleaf are common on calcareous rises.

Arcoona (area with more barley Mitchell-grass)

Baltana Land System

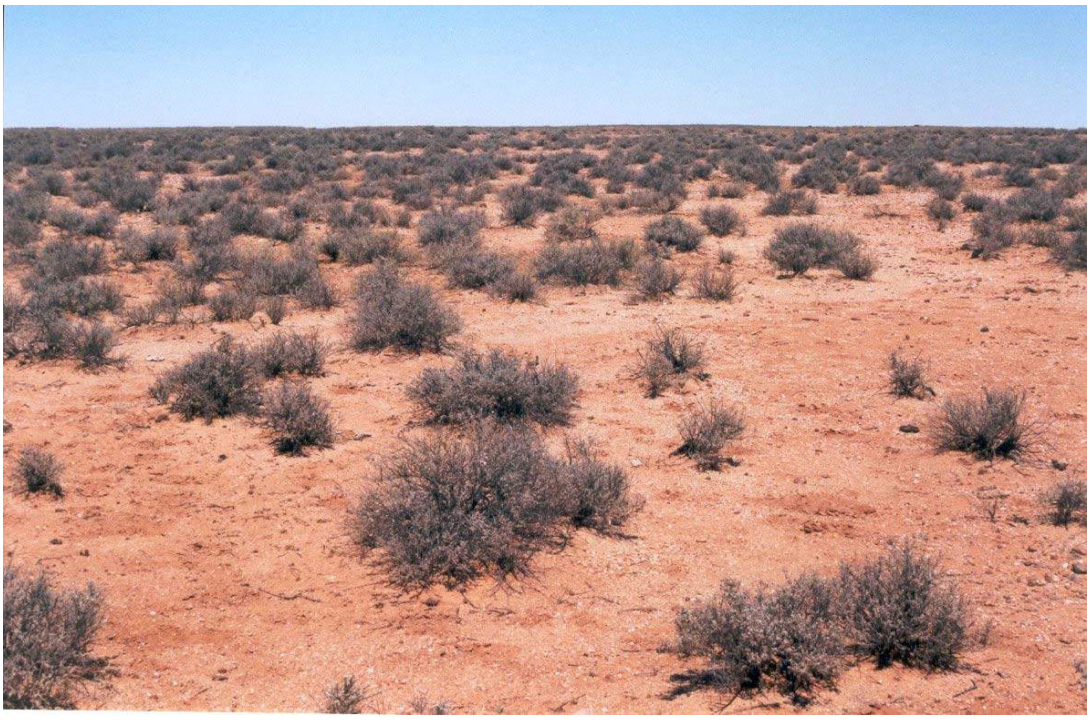
The Baltana land system remains unchanged.

The Baltana land system has formed where erosion of the silcrete capping has exposed the softer underlying Bulldog Shale. This has mixed with alluvium from the Stuart Range and has resulted in the formation of extensive undulating plains with numerous gilgais and some areas of sandsheet. It has distinct similarities with the nearby Oodnadatta Land System. Soils, which include silts, sands and grey clays, are covered with a lag of silcrete and quartzite gibbers.

This land system occurs in the Kingoonya SCD only on Ingomar and McDouall Peake stations.

No perennial species truly dominate the vegetation on plains and there are often large bare areas, which support ephemeral species following rain, between patches of perennial vegetation. Barley Mitchell-grass, glassworts (*Sclerostegia* sp(p).) and tangled bindyi are the most common species on the plains. Other species that may be common or even dominate over small areas include bladder saltbush, Oodnadatta saltbush, ball bindyi, neverfail, woolly bluebush, thyme sea-heath, black-seeded samphire and twiggy sida. Cotton-bush, twin-horned copperburr and bush minuria are widespread but not particularly common.

Baltana (typical with few shrubs)



Baltana (mainly samphire shrubs)

Vegetation associated with broad watercourses commonly has an overstorey of elegant wattle, while river cooba is also sometimes common. Bladder saltbush is dominant in the understorey and cotton-bush, low bluebush, swamp cane-grass and neverfail are all common here. Grey bindyi, salt bindyi, tangled bindyi, mulga grass and common bottle-washers are common in the understorey.

Soils of eroding watercourses contain large amounts of shales and gypsum and support very little vegetation. Any vegetation that does grow here usually consists of mainly ephemeral species.

Sandsheets have formed in some areas from residual yellow sands deposited on the underlying gibber plain. These areas support low open shrublands with Sturt's pigface prominent in the vegetation. Elegant wattle and bladder saltbush also occur here.

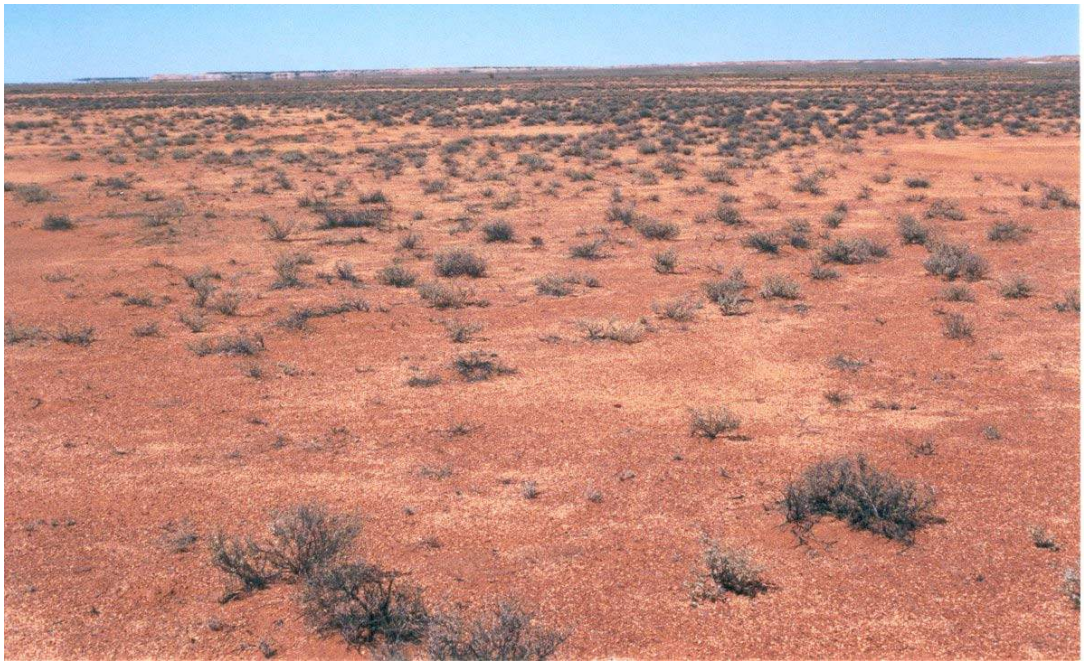
Breakaway Land System

The Breakaway land system is equivalent to the Painted land system of KSCB (1996). The name has been changed in order to standardise names between the Kingoonya and Marla-Oodnadatta SCDs. The Breakaway land system covers a greater area than the Painted land system and better describes the land system over the whole area in which it occurs.

Breakaway (hills and footslopes with low chenopod shrublands)

This land system has formed from an eroding basement of principally Bulldog Shale, with a capping of residual silcrete. Eroding shales and silcretes have resulted in mixtures of silcrete gibber, grey shales and other variously coloured silicified and soft shales. The various colours result from the amount of leaching of iron from the shales, with red coloured shales containing more iron and paler ones containing less. The Breakaway land system occurs in the north-east of the district, in the area known as the Painted Hills, but is more common in the Marla-Oodnadatta SCD to the north. It occurs in the Kingoonya SCD on Millers Creek, McDouall Peak, Mount Eba and Ingomar stations.

Little or no vegetation grows on the eroding shales of the slopes and footslopes or in shallow skeletal soils of hilltops. Vegetation becomes denser and sometimes includes areas of woodland where sediments have been deposited and nutrients have collected in pockets at the base of hills and along watercourses.



Breakaway (shaly footslopes with sparser low shrubland vegetation)

Bladder saltbush is the dominant species on the outwash plains of this land system, with black-seeded samphire and spiny saltbush also common. Native apricot, dead finish and umbrella bush are widely distributed across the outwash plains, usually as isolated plants or in small groves and often associated with drainage lines. Kidney-fruit saltbush, cotton-bush, groundsel and mulga grass are all widely distributed in the understorey but are not common overall.

Sparse low woodlands of red mallee occur on the hills, with mulga also present. Bastard mulga is common on breakaway slopes to the north, but is uncommon in this land system in the Kingoonya SCD. Three-wing bluebush occurs in the understorey, with black bluebush, silver mulla mulla and sennas also present. The soils in this unit may be too shallow to allow more than sparse establishment of low bluebush. Where mulga woodlands are common, the vegetation is similar to woodlands on the western side of the district. The understorey here commonly includes silver mulla mulla, ruby saltbush, grey bindyi and mulga grass.

In areas where vegetation is closely allied to that of the Arcoona Tableland, Sturt's pigface, bush minuria, tangled bindyi, salt bindyi and barley Mitchell-grass are common, but bladder saltbush still dominates the low shrublands. Areas in this vegetation association in the Breakaway land system also commonly include Oodnadatta saltbush, a species that is more characteristic of the Oodnadatta land system. However, this species is also common here in areas where bladder saltbush is common rather than dominant. Spinach bindyi, barley Mitchell-grass and neverfail are common in the understorey.

Oodnadatta Land System

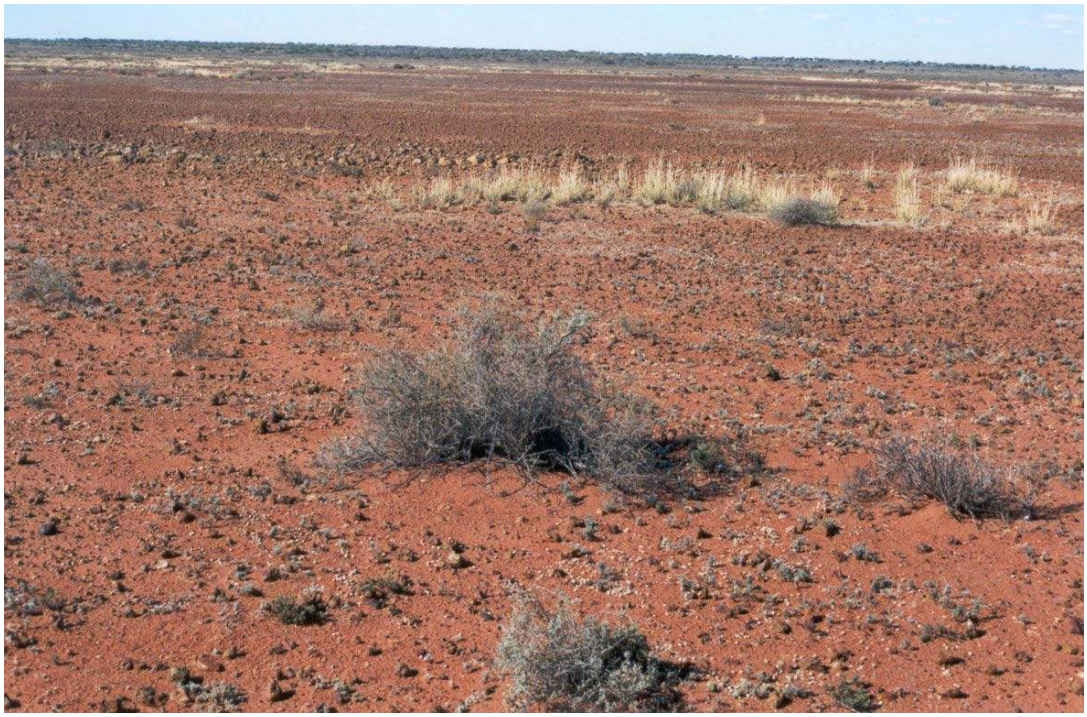
This land system includes the Mudla, Emu and Margaret land systems, as well as a small area of what was formerly described as Christie on Billa Kalina Station (KSCB 1996, Badman 1999). "Oodnadatta" is the name used by the Marla-Oodnadatta SCB (M-OSCB 1997) for this land system. The Oodnadatta land system is one of the largest systems in that district and covers a much greater area there than it does in the Kingoonya district. The name "Oodnadatta" is therefore given precedence.

Oodnadatta (typical area with Oodnadatta saltbush)

The Oodnadatta land system occurs on Billa Kalina, Mount Eba and Millers Creek stations in the north-east of the district. It is made up of extensive undulating plains with a lag of silcrete and quartzite gibbers and with numerous well-developed gilgais. The densest vegetation occurs in the gilgais and the stony shelves between them are often bare or covered only with a few bindyis or by sparse samphire. Chenopod shrublands are dominant, with trees generally restricted to watercourses. Trees and tall shrubs are usually absent because of limited water storage, underlying salinity and excessive gypsum that is not leached out because of poor water penetration of the overlying soil. Large watercourses support riparian woodlands and the largest have no gibber cover.

Soils are generally red-brown gypseous to slightly calcareous pebbly silts and clays. Shallow clays and desert loam soils overly Bulldog Shale, with quartzite cobbles and boulders and silcrete gravels also present. Soils of the tableland are saline and dispersive, with much of the soil salinity thought to have arisen through vertical leakage at the margins of the Great Artesian Basin (e.g. Woods 1990), which underlies much of this land system. Saline gravely alluvial sands and silts occur in watercourses, with alluvial silts, yellow duplex and heavier clay soils on flood plains

The northern area on Billa Kalina Station that was previously described as the Emu land system has low sandstone ridges, with occasional siltstones and claystones and calcrete capping. These are outcrops of ancient beach ridges and are flat rather than undulating, as is the case elsewhere in the land system. Silcrete gravels are common on the lower slopes of ridges, with the underlying Bulldog Shale often exposed in the narrow valleys. The ridges sometimes appear mesa-like, with steep margins and some sand drift on their lower slopes. Gilgais do not occur on the ridges.



Oodnadatta (area with more barley Mitchell-grass and no Oodnadatta saltbush)

The main land unit is dominated by low shrublands of Oodnadatta saltbush, with bladder saltbush, grey samphire, ball bindyi, short-wing bindyi, tangled bindyi and barley Mitchell-grass also common. Desert glasswort, salt bindyi, bottletree spurge, bush minuria, pale plover-daisy, cotton-bush, woolly bluebush, neverfail and spreading scurf-pea are also widespread but are not common overall. Most species are more common and attain their largest size in gilgais where they receive water subsidies from the surrounding plain.

Areas where Oodnadatta saltbush is not present or occurs only infrequently are dominated by bladder saltbush, with low bluebush, satiny bluebush and black bluebush also common. Barley Mitchell-grass, bush minuria, short-wing bindyi, salt bindyi, ray grass and common bottle-washers are common in the understorey. Pin sida, jointed bottle-washers, neverfail, spiny saltbush, mulga grass and tangled bindyi are widespread in the understorey but are not common overall.

Coolibah woodlands and river cooba tall shrublands dominate large watercourses, with old man saltbush dominant on the floodplains. Golden goosefoot (Queensland bluebush), spotted emubush, cotton-bush and cane-grass are common. Splendid flat-sedge is common in the understorey on creek banks. The floodplain understorey commonly includes tall verbine (tall scurf-pea), ruby saltbush, thyme sea-heath, daisy bush, goathead bindyi, barley Mitchell-grass, neverfail, swamp wanderrie and common nardoo. Red gum is present in the upper reaches of some creeks and can be locally common in such places. However, it does not occur along lower parts of the creeks where soil salinity is higher. Gidgee is common in this land system in the Oodnadatta area, but occurs along only one stony creek on Billa Kalina Station in the Kingoonya SCD.

The area known as “The Mulgas” is quite distinct from other parts of this land system. Sandy-loam soils of this unit are covered by sandstone and milky quartz pebbles, rather than red gibbers, except where a thin veneer of sand covers them. Sparse mulga woodlands are common

here, occurring mainly on the sandier areas, with dead finish also present. A small isolated grove of western myalls also occurs here and narrow-leaved hopbush is present on deeper sands at the edge of the unit. Low bluebush dominates the understorey, particularly on stony rises, while bladder saltbush, black bluebush and mulga grass are also common. There is an almost complete lack of samphires within this unit.

Oodnadatta (coolibah creeklines)

Numerous mound springs occur in this land system. These were described in detail by Badman (1999). Springs vary from active with visible flows to extinct and include the whole range between the two extremes. Mound springs often support dense grasslands of common reed when they are not subject to grazing. Prolonged grazing removes the common reed and the more resilient but much smaller boredrain sedge replaces it.

Paisley Land System

The Paisley land system remains unchanged.

Paisley land system describes the western outwash plains of the Stuart Range and extends from north-west of Coober Pedy through to central and southern parts of the Kingoonya SCD. Bulldog Shale commonly underlies the heavy clay soils, with infrequent silcrete outcrops. Gilgais are generally well developed. Silicified bands in the Bulldog Shale are the source of opals in the Coober Pedy area. Chenopod low shrubland dominates on all units except watercourses.

This land system occurs on Ingomar, McDouall Peak, Millers Creek, Mount Eba, Mount Vivian, Bon Bon, Coondambo and Wirraminna stations.

Paisley (area with mainly barley Mitchell-grass)

Paisley (areas similar to the Arcoona Tableland)

The main vegetation association has low shrubland vegetation dominated by bladder saltbush, with low bluebush, cotton-bush, black bluebush and spiny saltbush all common. Satiny bluebush is widespread but not particularly common. Emergent species include native apricot, dead finish, mulga, elegant wattle and plumbush but none of these is common and only the first two are widespread. Silver mulla mulla, velvet potato bush and barley Mitchell-grass are all common in the understorey. Tangled bindyi, spinach bindyi, ball bindyi, large-spine bindyi,

kidney-fruited saltbush and jointed bottle-washers are widespread in the understorey but are not particularly common overall.

The second most common vegetation association also has low shrubland vegetation dominated by bladder saltbush. Low bluebush, cotton-bush and three-wing bluebush are also common. Pearl bluebush, sponge-fruit bluebush and woolly bluebush are all widespread but not particularly common. Western myall, dead finish, native apricot and plumbush occur as emergent species, but are generally neither common nor widespread. Trees and tall shrubs are less common here than in the previous vegetation association, although some clumps of silver senna occur. Ball bindyi and neverfail are common in the understorey. Also in the understorey, thyme sea-heath, short-winged bindyi, oblique-spined bindyi, tangled bindyi, long-spine bindyi, salt bindyi, kidney-fruit saltbush and common bottle-washers are widespread but not common.

Occasionally the vegetation is dominated by three-wing bluebush rather than bladder saltbush, giving the vegetation greater similarities to that of land systems further to the west.

Wilgena Land System

The Wilgena land system is a combination of the Christie and Ebunbanie land systems.

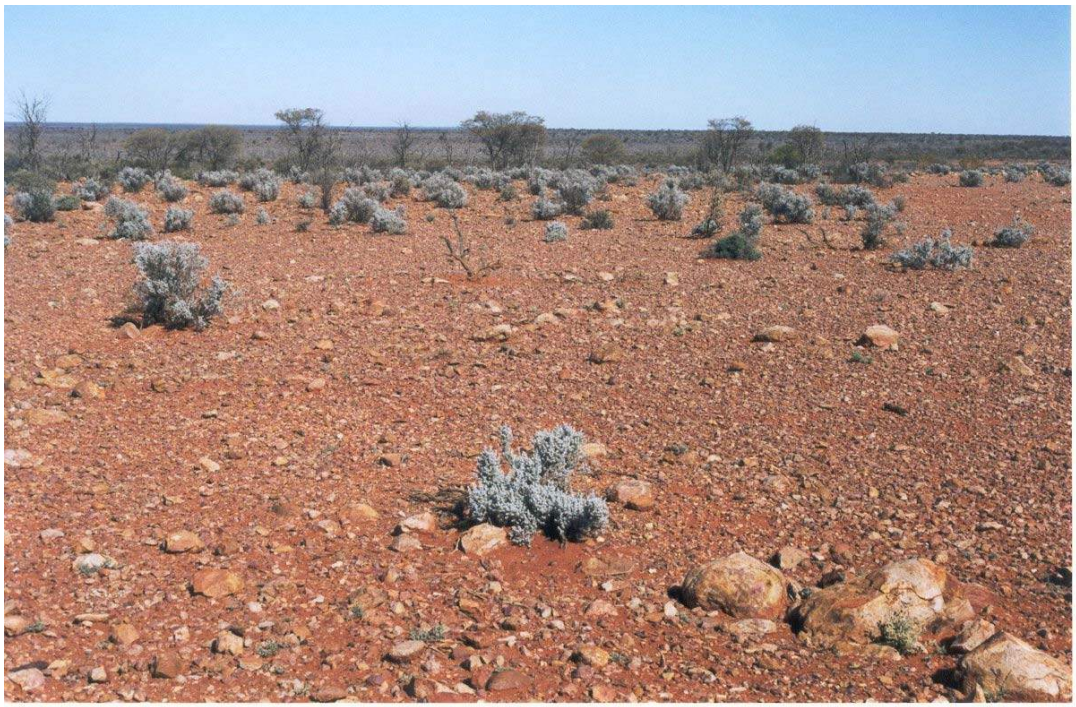
This land system is formed from a combination of ancient granitic and gneissic rocks as well as quartz bedrock and silcrete, with silcrete boulders often present on hilltops. It is widespread in western and southern parts of the district. The granites and gneisses are from the same formations as the Gawler Ranges to the south. Unlike other upland systems in the district, open mulga woodlands are common, although chenopod shrubland still dominates in the understorey. Skeletal and stony loam soils occur on hilltops and stony red duplex and brown clay soils on the plains. Shallow stony sandy loams and stony earthy sands occur on outwash slopes and valley plains have sandy earth soils. The presence of granite or silcrete divides this land system into two distinct land units, although their vegetation is often similar.

This land system occurs on Mobella, Commonwealth Hill, Mulgathing, Bulgunnia, Wilgena, North Well, Kokatha and Coondambo stations.

The granite land unit does not have any truly dominant species in the overstorey, although sparse mulga woodland is commonly found here. Round-leaf emubush is common, while dead finish, sennas, granite wattle, crimson emubush and Australian boxthorn are widespread but generally only moderately common or uncommon across the whole land unit. Pearl bluebush is dominant in the understorey and bladder saltbush, five-winged bluebush and silver mulla mulla are common. Velvet potato bush, ruby saltbush, grey bindyi and ball bindyi are widespread but not always common in the understorey. Hard spinifex occurs here and although sometimes locally common it is not common in the land unit as a whole.

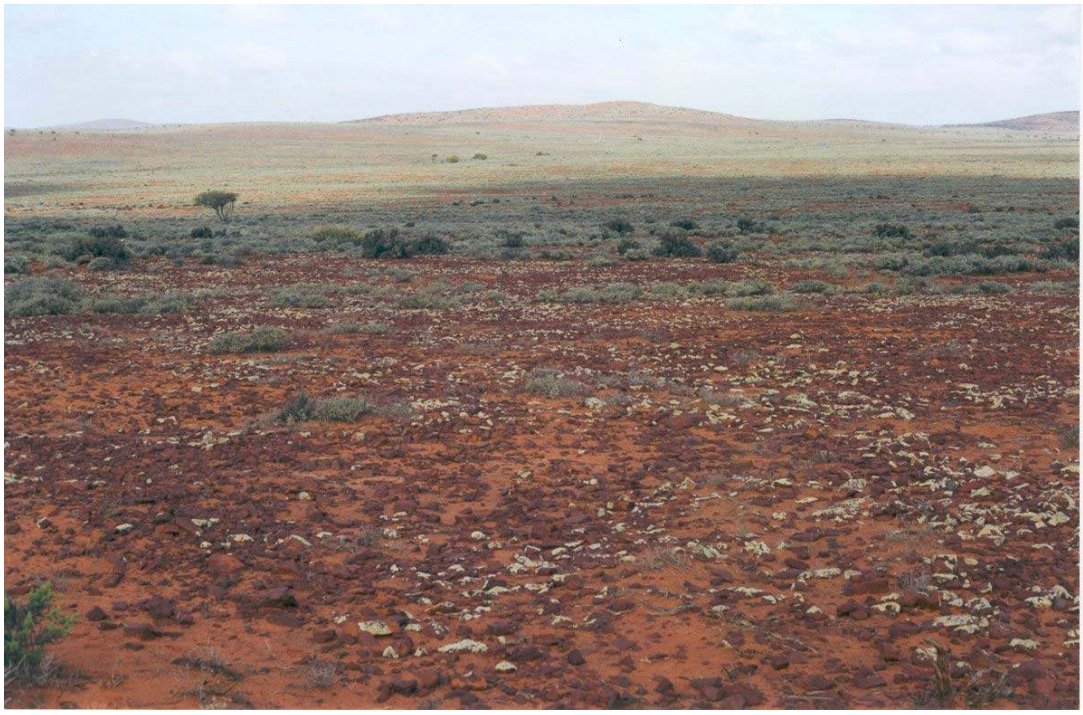
The silcrete land unit also has no truly dominant species in the overstorey, but again mulga woodlands are common, with crimson emubush and silver senna common in the shrub layer. Dead finish and Australian boxthorn are widespread in the shrub layer, but are not particularly common. Pearl bluebush is again dominant, with five-winged bluebush and silver mulla mulla also common in the understorey. Ruby saltbush, grey bindyi, rock sida and ball bindyi are widespread in the understorey, although never particularly common.

Wilgena (granite hills with granite wattle shrubland)



Wilgena (silcrete hills)

A vegetation association similar to the main Arcoona Tableland association has low shrublands dominated by bladder saltbush. Black-seeded samphire is also common. There are a few emergent mulgas, round-leaf emubushes and dead finish shrubs, but these are never common and the low shrublands are always dominant. Low bluebush, ball bindyi, five-winged bluebush, bush minuria, glasswort, tangled bindyi and neverfail occur in the understorey, but are not particularly common.



Wilgena (areas similar to the Arcoona Tableland)

APPENDIX C

C: LIST OF PLANT SPECIES REFERRED TO IN THE TEXT: COMMON NAME-SCIENTIFIC NAME

Scientific names follow Jessop (1993)

Common Name	Species
Australian boxthorn	*Lycium australe*
ball bindyi	*Dissocarpus paradoxus*
bandicoot grass	*Monachather paradoxa*
barley Mitchell-grass	*Astrebla pectinata*
bastard mulga	*Acacia stowardii*
Bathurst burr	*Xanthium spinosum*
beaked red mallee	*Eucalyptus socialis*
bindyi	*Sclerolaena spp.*
bitter saltbush	*Atriplex stipitata*
black bluebush	*Maireana pyramidata*
black oak	*Casuarina pauper*
black-seeded samphire	*Halosarcia pergranulata*
bladder saltbush	*Atriplex vesicaria*
bluebush	*Maireana sedifolia*
bluebush pea	*Crotalaria eremaea* ssp. *strehlowii*
boredrain sedge	*Cyperus laevigatus*
bottletree spurge	*Euphorbia stevenii*
bottle-washers	*Enneapogon spp.*
brilliant hop-bush	*Dodonaea microzyga*
bristly love-grass	*Eragrostis setifolia*
broom emubush	*Eremophila scoparia*
Broughton willow	*Acacia salicina*
bullock bush	*Alectryon oleifolius*
bush minuria	*Minuria cunninghamii*
button grass	*Dactyloctenium radulans*
cactus pea	*Bossiaea walkeri*
cane-grass	*Eragrostis australasica*
common bottle-washers	*Enneapogon avenaceus*
common nardoo	*Marsilea drummondii*
common reed	*Phragmites australis*
coolibah	*Eucalyptus coolabah*
cotton-bush	*Maireana aphylla*
crimson emubush	*Eremophila latrobei*
cut-leaf mignonette	*Reseda lutea*
curly wire-grass	*Aristida contorta*
daisy bush	*Minuria rigida*
dead finish	*Acacia tetragonophylla*
desert glasswort	*Neobassia proceriflora*
desert lantern-bush	*Abutilon otocarpum*
desert red mallee	*Eucalyptus oleosa*
elegant wattle	*Acacia victoriae*
erect mallee bluebush	*Maireana pentatropis*
evening primrose	*Oenothera stricta*
false sandalwood	*Myoporum platycarpum*
fine-leaf desert senna	*Senna artemisioides* ssp. *filifolia*

flat-stalk senna	*Senna artemisioides* ssp. *petiolaris*
Gawler Ranges senna	*Senna cardiosperma* ssp. *gawlerensis*
gidgee	*Acacia cambagei*
glasswort	*Sclerostegia* sp.
goathead bindyi	*Sclerolaena bicornis*
golden goosefoot	*Chenopodium auricomum*
granite wattle	*Acacia tarculensis*
green emubush	*Eremophila serrulata*
grey bindyi	*Sclerolaena diacantha*
grey samphire	*Halosarcia halocnemoides*
groundsel	*Senecio cunninghamii*
hard spinifex	*Triodia basedowii*
harlequin emubush	*Eremophila duttonii*
horehound	*Marrubium vulgare*
horse mulga	*Acacia ramulosa*
inland paper-bark	*Melaleuca glomerata*
inland red mallee	*Eucalyptus eucentrica*
jointed bottle-washers	*Enneapogon cylindricus*
kidney-fruit saltbush	*Atriplex quinii*
kopi mallee	*Eucalyptus gypsophila*
leafless cherry	*Exocarpos aphyllus*
leafy bottle-washers	*Enneapogon polyphyllus*
lignum	*Muehlenbeckia florulenta*
long-spine bindyi	*Sclerolaena longicuspis*
low bluebush	*Maireana astrotricha*
mallee cypress-pine	*Callitris verrucosa*
shrubby riceflower	
mesquite	*Prosopis juliflora*
Mueller's daisy-bush	*Olearia muelleri*
mulga	*Acacia aneura*
mulga grass	*Aristida contorta*
narrow plover-daisy	*Ixiolaena leptolepis*
narrow-leaved hop-bush	*Dodonaea viscosa* ssp. *angustissima*
narrow-leaved red mallee	*Eucalyptus leptophylla*
native apricot	*Pittosporum phylliraeoides*
needle wattle	*Acacia rigens*
neverfail	*Eragrostis setifolia*
nitre goosefoot	*Chenopodium nitrariaceum*
nitre-bush	*Nitraria billardierei*
northern myall	*Acacia calcicola*
oblique-spined bindyi	*Sclerolaena obliquicuspis*
old-man saltbush	*Atriplex nummularia* ssp. *nummularia*
onion weed	*Asphodelus fistulosus*
Oodnadatta saltbush	*Atriplex nummularia* ssp. *omissa*
pale plover-daisy	*Ixiolaena chloroleuca*
parkinsonia	*Parkinsonia aculeata*
pearl bluebush	*Maireana sedifolia*
pepper-tree	*Schinus areira*
pin sida	*Sida fibulifera*
pinbush wattle	*Acacia burkittii*
plains nightshade	*Solanum quadriloculatum*
plover daisy	*Ixiolaena* sp.
plumbush	*Santalum lanceolatum*
quandong	*Santalum acuminatum*

Queensland bluebush	*Chenopodium auricomum*
ray grass	*Sporobolus actinocladus*
redgum	*Eucalyptus camaldulensis*
river cooba	*Acacia stenophylla*
rosy bluebush	*Maireana eriocladа*
round-leaf emubush	*Eremophila rotundifolia*
ruby saltbush	*Enchylaena tomentosa*
salt bindyi	*Sclerolaena ventricosa*
salvation Jane	*Echium plantagineum*
sand sida	*Sida ammophila*
sand spurge	*Phyllanthus fuernrohrii*
sandhill cane-grass	*Zygochloa paradoxa*
sandhill wattle	*Acacia ligulata*
satiny bluebush	*Maireana georgei*
short-winged bindyi	*Sclerolaena brachyptera*
showy groundsel	*Senecio magnificus*
shrubby riceflower	*Pimelea microcephala*
shrubby twinleaf	*Zygophyllum aurantiacum*
silver mulla mulla	*Ptilotus obovatus*
silver needlewood	*Hakea leucoptera*
silver senna	*Senna artemisioides* nothossp. *artemisioides*
small-spine bindyi	*Sclerolaena uniflora*
spear-grass	*Stipa* spp.
spinach bindyi	*Sclerolaena lanicuspis*
spinifex	*Triodia* sp.
spiny goosefoot	*Rhagodia ulicina*
spiny saltbush	*Rhagodia spinescens*
splendid flat-sedge	*Cyperus exaltatus*
spotted-emubush	*Eremophila maculata*
spreading scurf-pea	*Cullen patens*
starbush	*Gunniopsis quadrifida*
steel bush	*Acacia tarculensis*
Sturt’s pigface	*Gunniopsis quadrifida*
swamp wanderrie	*Eriachne ovata*
tall kerosene grass	*Aristida holathera*
tall scurf-pea	*Cullen australasicum*
tall verbine	*Cullen australasicum*
tangled bindyi	*Sclerolaena cuneata*
tangled bindyi	*Sclerolaena divaricata*
tangled bindyi	*Sclerolaena intricata*
tar bush	*Eremophila glabra*
Tarcoola wattle	*Acacia tarculensis*
Tate’s bindyi	*Sclerolaena tatei*
tea-tree	*Melaleuca spp.*
Three-wing bluebush	*Maireana triptera*
thyme sea-heath	*Frankenia serpyllifolia*
tomato bush	*Solanum coactiliferum*
twiggy sida	*Sida intricata*
twin-horned copperburr	*Dissocarpus biflorus*
twin leaf	*Zygophyllum spp.*
umbrella bush	*Acacia ligulata*
umbrella wattle	*Acacia oswaldii*
velvet potato bush	*Solanum ellipticum*
velvet-leaf hibiscus	*Hibiscus krichauffianus*

Victoria Desert mallee	*Eucalyptus concinna*
wall rocket	*Diplotaxis muralis*
western myall	*Acacia papyrocarpa*
white cypress-pine	*Callitris glaucophylla*
white mallee	*Eucalyptus gracilis*
wild parsnip	*Trachymene glaucifolia*
wild turnip	*Brassica tournefortii*
window mulga grass	*Thyridolepis mitchelliana*
witchetty bush	*Acacia kempeana*
woolly bluebush	*Maireana eriantha*
woollybutt	*Eragrostis eriopoda*
Yumbarra mallee	*Eucalyptus yumbarrana*

APPENDIX D

D: LONG TERM MANAGEMENT OF THE CHENOPOD SHRUBLANDS: A 46 YEAR PERSPECTIVE

John Maconochie and Brendan Lay
Pastoral Management DEH SA (Current Address, Pastoral Program, PIRSA)

Supported by the INTERNATIONAL WOOL SECRETARIAT

INTRODUCTION

In 1945, Fred Jessup, a soil conservation officer for the South Australian Department of Agriculture, embarked on a largely descriptive survey of the North - West of the state, from Woomera to Oodnadatta (Jessup, 1951), the area now covered by the Kingoonya Soil Conservation District. His primary aim was to map the soil, geology and plant associations of the region. During the survey he recognised the three main species of the chenopod shrubland on which sheep are particularly dependent, *Maireana sedifolia* (pearl bluebush), *Maireana astrotricha* (low bluebush), and *Atriplex vesicaria* (bladder saltbush). These perennial species are now regarded as the primary stock feed in summer and prolonged dry periods.

In 1970-72 Brendan Lay re-evaluated Jessup's survey examining the plant communities and the changes that had occurred in the intervening 23 year period (Lay, 1972 and 1979). In 1994, approximately 23 years after Lay's study and with funding from the International Wool Secretariat, the survey was again re-evaluated by John Maconochie to determine the changes that have occurred in the plant populations over the last 46 years (Maconochie and Lay, 1996). This report is a summary of the findings in Maconochie and Lay (1996).

Of the 22 pastoral runs in the Kingoonya district, the survey covers six stations totalling an area of 27 230 square kilometres or 40 % of the District. **Figure 1** shows the study area and the routes relocated in 1994. The three surveys together are unique in that they comprise the longest running study of broad scale changes in chenopod shrublands in Australia (46 years).

John Maconochie's survey involved following the same routes taken by Jessup and Lay on six stations in the district. The routes were derived from the field note books held by the Pastoral Management Branch, Department of Environment and Natural Resources, South Australia. Lay's notebooks were more detailed than Jessup's and were therefore used as the guide. Comparable observations from both observer's notebooks were used to compare and evaluate the changes that have occurred in the district.

Table 1 details the total distance covered by Maconochie and the proportion of comparable traverse extracted from the notes. Due to the limited coverage of the Jessup study on many stations, additional traverses were undertaken by Lay and now provide a more detailed study of the district. The study is described in two parts; the 46 year period comprised of 9428 sampling units (**Data Set I**), and the larger 23 year period comprised of 27033 sampling units (**Data Set II).**

Table 1. Survey distance and the proportion and length of comparable traverse.

Station	Total Traverse km	Lay (1972)		Jessup (1948)	
Bulgunnia	700	570	81 %	380	54 %
Commonwealth Hill	1140	920	80 %	280	25 %
Mobella	960	870	90 %	60	6 %
Mulgathing	780	700	90 %	420	54 %
North Well	780	730	94 %	200	26 %
Wilgena	780	680	87 %	210	27 %
Survey Total :	5140 km	4470 km	86 %	1550 km	30 %

SURVEYED CHENOPOD SPECIES

Three chenopod species were used in this study (*Maireana sedifolia*, *M. astrotricha* and *Atriplex vesicaria*). All are desirable pasture species; they are drought tolerant and able to shed many of their leaves and lie in a dormant state until the next rains. As well as being important food reserves for extended dry summer periods, these plants also help to stabilise soil, reduce erosion and they compete with less desirable species. It is generally recognised that care should be taken with regard to the utilisation of these plants if long-term stability of the whole pasture is to be maintained. Overstocking can result in the loss of these important components and lead to long-term degradation. **Table 2** adapted from Graetz and Wilson (1984), describes the range of sensitivities and life spans that occurs across the three species.

Table 2: Sensitivity and life span of the three chenopod species studied

Most sensitive	*Atriplex vesicaria*	Short-lived (10 – 30 years)
↓	*Maireana astrotricha*	↓
		(100+ years)
Least sensitive	*Maireana sedifolia*	Long-lived (150+ years)

Species Characteristics:

Pearl bluebush (*Maireana sedifolia*) **:** A distinct pearly-blue shrub growing to 1 metre, it is one of the longest lived chenopods with a lifespan greater than 150 years. It provides summer feed but is also susceptible to moderate to heavy grazing. Seeding of this plant can occur at any time but usually follows extensive rainfall events. Documented regeneration has been rare in the district but regeneration was observed in the 1994 survey.

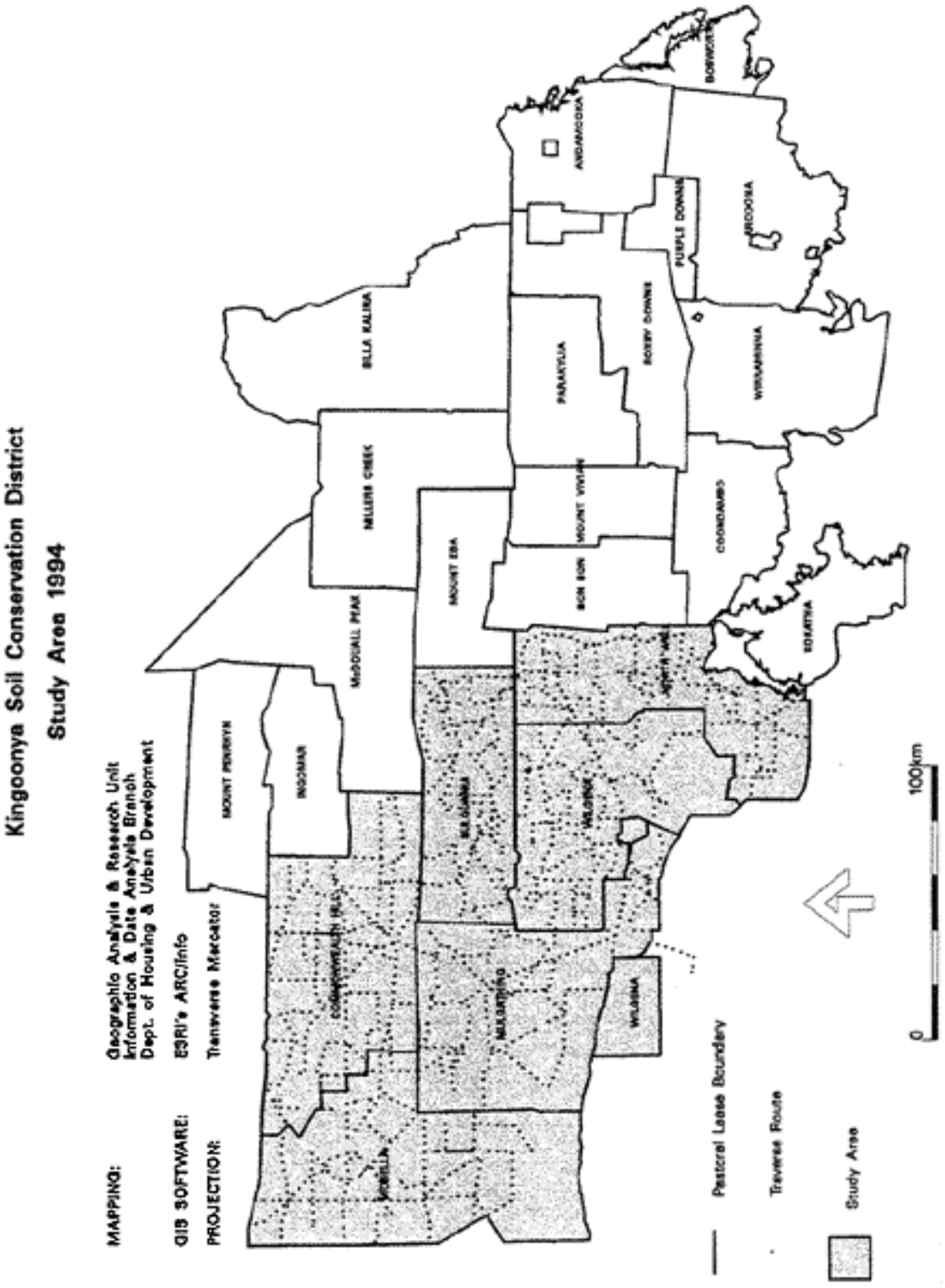


Figure 1. Location of Study Area in the Kingoonya Soil Conservation District.

Low bluebush (*Maireana astrotricha*) **:** A low bluish-grey bush, it can grow to a height of 1m. Also nutritious, it provides feed during the summer months but is susceptible to heavy or continuous grazing. A relatively slow grower, it seeds in favourable seasonal conditions but seed numbers are small.

Bladder saltbush (*Atriplex vesicaria*) **:** A silvery-grey-greenish plant, it grows to about 70 cm high and has a lifespan of 10 - 30 years. Saltbush has the ability to defoliate in drought and approximately 80% of the roots lie in the top 30 cm of soil. It provides nutritious feed but is susceptible to grazing and cannot be relied on in times of drought. Sheep prefer the female plants at fruiting time and hence reduce overall seed set. Seeding usually occurs over the spring and summer but the species may seed at any time depending on seasonal conditions. Dormancy mechanisms have been reported with seeds having a longevity of several years.

JESSUP DENSITY RATING SYSTEM

The rating system devised by Jessup is shown in **Table 3**. Density stages for the three species are based on a unit area with the limits originally defined by using the wheel marks of a vehicle as the external boundary (approximately 5 feet or 1.5 metres). Jessup drove for a distance of one tenth of a mile (160m) across a bush stand, thus outlining an area of approximately 245 m^2. Densities are determined by the number of bushes of each species whose bases are on or between the wheel marks. This method has been used consistently in all three surveys.

The numerical limits for each stage differed according to the principal vegetation types. When describing the limits, Jessup referred to two principal vegetation types; *Maireana sedifolia* dominant and *Atriplex vesicaria / Maireana astrotricha* dominant. The limits assigned for each density stage and vegetation type are defined in **Table 3**.

SURVEY RESULTS

In general the district has shown an improvement in the density of these chenopod communities over the last 23 years. This is in contrast to the results of Lay in 1972 which showed a large decrease in the density of the chenopod component. **Figures 1** and **3** describe the change in density over both the last 23 year period (**Data Set II**) and the 46 year period (**Data Set I**). The variation in the two periods should not be compared directly. The 46 year period is comprised of a smaller data set and thus a smaller area than the 23 year period.

Analysis of the first 23 years reveals a decrease in the density of the chenopod component across all stations surveyed. This decrease is believed to be the result of underdeveloped stations running high stock numbers on few water points during the first 23 years. In the last 23 years station development and improved management would appear to have resulted in a gradual improvement in the condition of the country.

Table 3. Jessup's Density Rating System in miles and the kilometre conversion used by Maconochie.

	No. of bushes/245 m2 (0.1 miles)		No of bushes/140 m2 (0.1 km)	
Density Stage	***Atriplex vesicaria/ Maireana astrotricha***	***Maireana sedifolia***	*Atriplex vesicaria/ Maireana astrotricha*	*Maireana sedifolia*
1	160 and over	46 and over	More than 90	More than 26
2	135 - 159	35 - 45	76 - 90	20 - 26
3	55 - 134	15 - 34	31 - 75	9 - 19
4	15 - 54	5 - 14	9 - 30	3 - 8
5	1 - 14	1 - 4	1 - 8	1 - 2
6	0	0	0	0

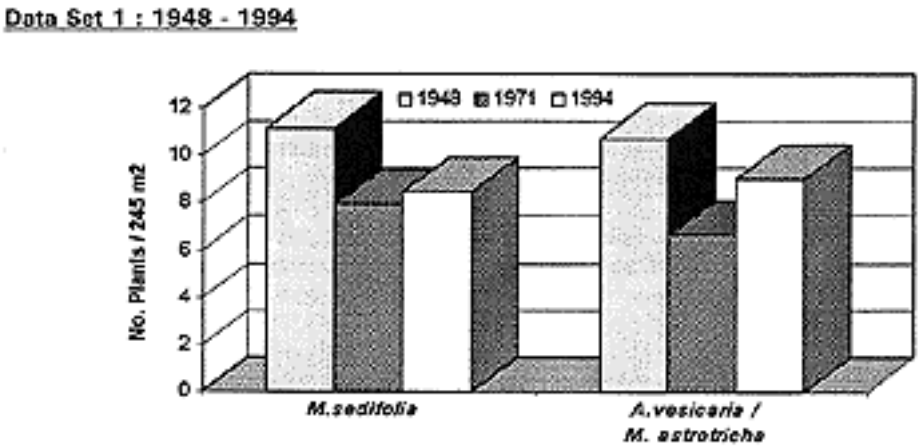


Fig. 2. Average plant density of the chenopod species for the 46 year period (1948 - 1994).

Results from the last 23 years have shown a significant improvement in the density of chenopod stands across the surveyed area. Overall, large number of paddock subdivisions in the last twenty years and improved management has helped to relieve the pressure of stock on the chenopod component.

The recuperation of the chenopod shrublands over the last 23 years has been slow and it will require many more decades before the these stands recover to the densities which occurred in 1948 and the early days of settlement. **Plates 1** and **2** provide evidence of the slow recovery

of pearl bluebush even under light or no grazing pressure. **Plates 3** and **4** show the effects of reduced stocking pressure on fence lines.

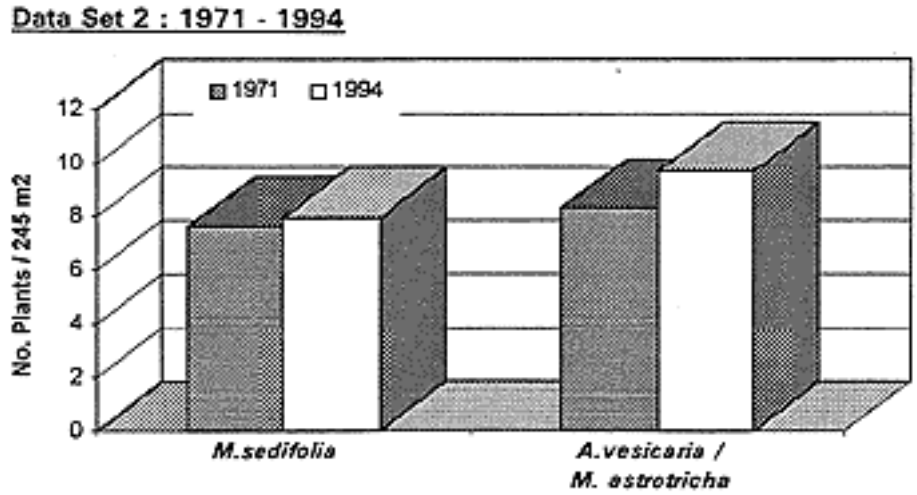


Fig. 3. Average plant density of the chenopod species for the 23 year period (1971 - 1994).

SPECIES COMPOSITION

Jessup's initial survey described the three species as dominants in two "associations", *M. sedifolia* and *M. astrotricha* / *A. vesicaria*. **Figure 4** shows the changes in the distribution and composition of these chenopod pasture compositions over the last 46 years.

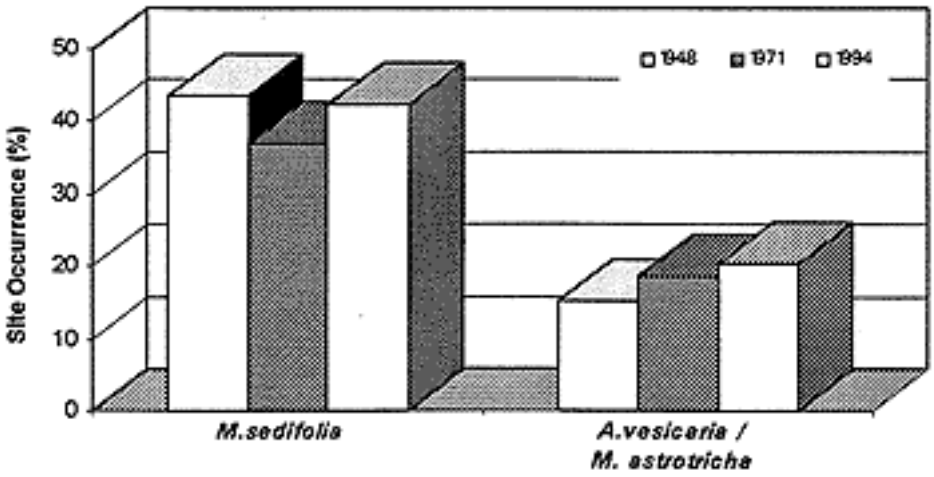


Fig. 4. Occurrence of the chenopod species for the 46 year period (1948 - 1994).

Pearl bluebush has recovered in the last twenty three years across the district but is still below that observed by Jessup. Regeneration of pearl bluebush was evident in the 1948-94 period across the whole survey area with 16% of stands showing regeneration. The increase in bladder saltbush and low bluebush can be attributed to the incorporation of bladder saltbush in stands previously dominated by low bluebush and the pearl bluebush stands now dominated by bladder saltbush and low bluebush.

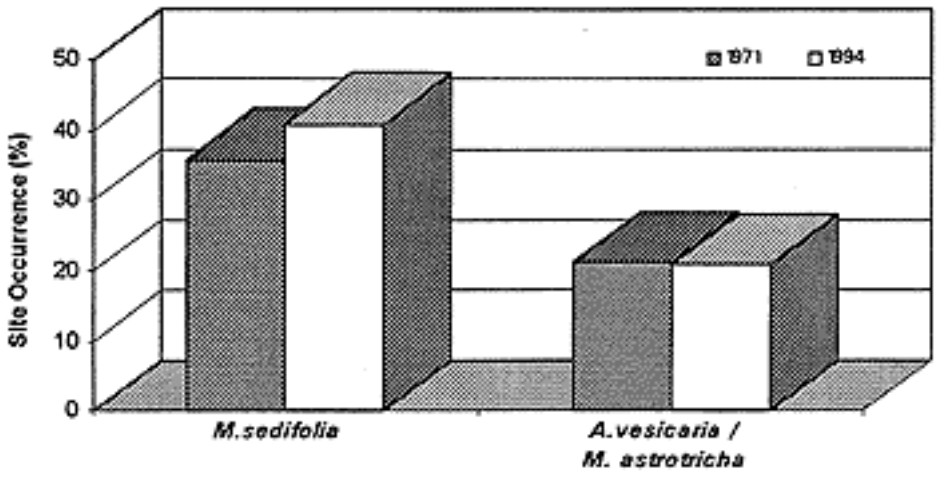


Fig. 5. Occurrence of the chenopod species for the 23 year period (1971 - 1994).

The last 23 years has seen an increase in the density of pearl bluebush and a stabilisation of stands of bladder saltbush and low bluebush (**Figure 5**). Regeneration of these species has been observed across the district; pearl bluebush was the most prevalent with 15% of the stands observed having young seedlings. As regeneration of pearl bluebush is rare, careful management of these stands is required to promote establishment of mature plants and hence the long term stability of the land.

CHENOPOD REGENERATION

Table 5 details the results of regeneration for *Maireana sedifolia* (pearl bluebush). Regeneration of pearl bluebush in the chenopod shrublands of Australia is rare and is usually associated with heavy abnormal rainfall events (Osborne *et al*., 1935; Ratcliffe, 1936; Jessup, 1951; Graetz and Wilson, 1984).

Both data sets reveal a significant improvement in the incidence of regeneration of pearl bluebush. The regeneration of this species is characterised by infrequent episodic processes, with a once-in-twenty year (or greater) recruitment pattern (Wotton, 1993). With this in mind, only two episodic heavy rainfall events have occurred in the last 23 years (1973-4 and 1989) which may have led to flowering and regeneration events. **Table 5** reveals that similar widespread regeneration of pearl bluebush is apparent in both Data Sets and that regeneration

is extensive (15%) across the surveyed stations of the larger data set (1971-1994).

Table 5. Observed regeneration of *Maireana sedifolia* (pearl bluebush).

	Regeneration of *Maireana sedifolia* (as % of observed stands)	
1994 SURVEY	**Data set I** (1948 - 1994)	**Data Set II**(1971 - 1994)
	16	15

From photopoints set up on the 1971 survey and associated regeneration studies of this species in the study area, it is evident that the record rainfall years of 1973-74 have enabled the regeneration and establishment of pearl bluebush across the district. Subsequent heavy rainfall events, especially 1989, have resulted in further cohorts establishing in some localities.

Regenerating stands will require careful management strategies if plant densities are to recover to those that were recorded in 1948. Spelling of those paddocks containing a large proportion of regenerating stands during good seasons, should be encouraged for successful establishment of mature plants and further regeneration opportunities.

Distribution patterns of pearl bluebush stands studied by Wotton (1989) suggest that the size of each bush and the distance to the nearest neighbour is a result of competition and density-dependent growth. Thus large, dense and healthy stands will not show a high proportion of regeneration due to the competitive effects of the neighbouring plants; seeding and recruitment may occur but competition from mature plants will restrict the establishment of these young seedlings.

TOPFEED SPECIES

Table 6 details the results of the 1971 and 1994 surveys of the two overstorey species studied during the survey.

Table 6. Distribution and regeneration of overstorey species.

TOPFEED SPECIES	**SURVEY DISTRIBUTION AND REGENERATION**			
	Survey Distribution (Observed %)		**Regeneration (%)**	
	1971	**1994**	**1971**	**1994**
Acacia aneura (Mulga)	99	99	14	52
Acacia papyrocarpa (Western Myall)	20.1	18.5	2.7	14

***Acacia aneura* (Mulga)**

The distribution of mulga is widespread, occurring across all six stations. Much of the district is dominated by mulga woodlands with a grass or chenopod understorey.

The health of the mulga woodlands in the study area is good and they have responded well to the heavy rainfall events of the last 23 years. The resilience of this woodland is evident today, in stark contrast to the situation in 1971 when the surveyed area was characterised by large areas of dead standing trees, with little significant regeneration of this species (Lay, 1972). The prevalence of regeneration in areas burnt in 1974-75 may support the view of Foran (1984) that the mulga woodlands can recover to their former state following infrequent fires.

Extensive regeneration of mulga was recorded across all stations in the study area. However, greatest regeneration appears to occur in sand plains or areas subject to inundation where no fires have been recorded over this time. The response to the rains of 1973-74 and 1989 has been widespread and supports the view of Preece (1971) that mulga requires large, consecutive summer and winter rainfalls for successful reproduction.

A general senescence of mulga was observed across most stations but the dominating effect of regeneration will enable healthy stands to continue. Fire scars on the lighter sandy country are evident in many areas (**Plates 5** and **6** page 134), fuel loads being much higher as this country is mainly dominated by a grass understorey.

***Acacia papyrocarpa* (Western myall)**

The western myall woodlands occur mainly in the central and eastern part of the study area. The distribution of this species has well defined limits, usually restricted to chenopod shrublands on shallow soils or soils underlain by calcrete. This accounts for the almost complete absence of western myall in the north and west of the study area with the exception of a large and extremely old specimen in the north-west corner of Mobella station, this specimen is listed on the significant tree register of the National Trust of SA.

Regeneration of western myall has been extremely encouraging with 14% of all sampling intervals in which adults occurred recording western myall regeneration in 1994. Ireland (1992) suggests that recruitment events for western myall are very rare; the results of this survey give a positive outlook for the species (C. Ireland *pers. comm.*).

Rabbit populations are low and it is believed that this may contribute to the recruitment of the western myall (C. Ireland *pers. comm.*); Lange and Graham (1993) attributed the lack of western myall recruitment at Middleback Station, well south of the study area, to the grazing of rabbits.

SURVEY FINDINGS

The findings of this survey of six stations in the Kingoonya District are of significance to the chenopod shrublands of South Australia. It is generally felt in the wider community that the arid zone is under substantial pastoral pressure and is in a state of degradation. This survey has provided evidence contrary to this belief for the Kingoonya District and provides testimony to the sustainability of the current management practices in the district.

It is considered that enlightened management practices and reduced rabbit populations, coupled with the regeneration and recovery opportunities provided by the favourable seasons, have positively influenced the survival and regeneration of both chenopod shrubs and *Acacia* overstorey over the last 23 years.

Fire is one of the greatest concerns facing managers in the Kingoonya Soil Conservation District. The chenopod shrublands have been shown to be susceptible to fire. This is clearly evident in the north western portion of the district where the scars from the 1974-5 fires are still evident today. Regeneration of chenopods in areas devastated by fire is very slow with much of the scarred country still not having responded to good rains in the past decade.

Badly burnt areas would benefit from stock reduction and feral animal control until a good vegetative response to rains is observed. Re-stocking of this land following rains may result in a less than favourable regeneration response and lead to long term degradation if stock numbers are heavy. In practice, grazing of this country post fire can take place safely providing stock are removed before ephemeral forage is either used or disappears. In the case of the perennial chenopods, establishment and new growth are highly susceptible to grazing, and given their very slow growth rates can be permanently removed from the area if stock are left for too long.

The improvements observed on a number of stations have shown that paddock size and the number and positioning of water points have significantly affected the density of these chenopod shrubs. The subdivision of larger paddocks into smaller more manageable

paddocks has resulted in the relieving of concentrated grazing pressure on the surrounding chenopod species.

Paddock size and positioning of water points are very important factors in the survival of chenopods. Centrally located waters carrying no more than 300 - 500 stock have been shown to reduce the overall pressure on the land whilst maintaining a favourable density of the palatable chenopod shrublands relatively close to the watering point. Salinity levels of stock water must also be taken into consideration when determining stock numbers on a water. Highly saline water will result in a greater proportion of grazing time being spent close to the water point in summer. This in turn leads to a greater impact on the perennial component near water and a reduction in the long term biomass component. Bladder saltbush and pearl bluebush have been shown to respond favourably to light to moderate grazing pressures but higher levels inevitably lead to pasture degradation in the longer term.

The major feral animal pest identified by land managers in the Kingoonya Soil Conservation District is the rabbit. Problems associated with rabbits are more prevalent in the eastern part of this area. The surveyed area in recent years has been almost completely free of major rabbit infestations which has resulted in a highly favourable regeneration rates for the species studied. Hence in the area surveyed, low rabbit numbers have resulted in negligible impact of this pest on shrub populations.

RECOMMENDATIONS FOR THE MANAGEMENT OF CHENOPOD SHRUBLANDS.

Successful management of the chenopod rangelands relies on an understanding of the vegetation and its response to seasonal variation. Management of rangeland areas should concentrate on improving the establishment of desirable species. Management objectives should not be determined by the health of the stock but rather the health of the vegetation. Poor stock condition therefore reflects unsustainable management of the land. As such, managers should understand the health of the land and react accordingly so that land and consequently stock condition will not be adversely affected.

Seasonal variation in weather patterns play an important role in the management of stock numbers and hence the pressure placed on the perennial vegetation. Stocking levels must reflect seasonal conditions when considering impacts on the perennial vegetation; annual growth is usually preferred by stock and hence will relieve pressure on the saltbush and bluebush species.

The management of the chenopod component must be looked at in conjunction with the whole vegetation community. **The species studied are generally relied upon as drought reserves and should be managed as such**. The deterioration in condition of these species is an indicator of overall decline in the general vegetation. This is associated with a grazing shift from annual and perennial grasses to the chenopod component and any noticeable impacts on these stands should prompt a reduction in stocking pressure.

The figure of 300 - 350 sheep per water, or 3.5 - 4.5 sheep/km^2 assuming a 5 km grazing radius, is a conservative figure but has been shown to be a useful guide for stock management. Country that responds well to seasonal conditions can support stocking rates that exceed this figure for a short period of time. The onus is on the manager to “read the country” and reduce stocking in response to the health of the vegetation rather than stock condition. This becomes

of vital importance in times of drought. Day to day observations of the condition of the country, most importantly the condition of the perennial component, should be carried out and stock management adjusted accordingly.

The following recommendations are given in regards to management of vegetation and stock from a manager's perspective. Determination of stock numbers for individual paddocks should take into account the following factors, in approximate order of importance.

1. Water quality and quantity

The age and type of stock to be carried on water is limited by the water quality. Wethers are more resilient to high saline levels and can be carried on the poorer waters. Dry ewes, lactating ewes and lambs are progressively less tolerant to saline water and should be carried on the better waters.

2. Water position

The position of the water in relation to fences determines the effective grazing range of stock. In general, centrally placed waters provide the least impediment to maximum grazing range of stock. Water placement should also take into consideration the maintenance and preservation of near ungrazed areas for the conservation of biodiversity. In open areas where prevailing wind effects occur, avoid placing waters on or near southern fencelines.

3. Perennial vegetation

The status of the perennial component of the pastures is one of the most important factors in management decisions. This component determines the long term productivity and drought resilience of the country. In good seasons, the annual component provides the majority of nutritious feed and the perennial component is relieved. As summer approaches and the annuals are reduced, dietary preference is directed to the perennial component. In times of drought the perennial plants are the primary source of feed and care should be taken to preserve these species.

4. Paddock size and shape

A combination of size, shape and the position of the water point are important factors in effective paddock utilization. With large paddocks, the productivity of the whole paddock is reduced as utilisation is restricted to the watered area. When subdividing paddocks, the location of reliable water points and the direction of the prevailing winds and hence the grazed area, should be used to determine the position of any new subdivision or replacement fencing. As with water position, subdivisions should also consider the maintenance and preservation of near ungrazed areas for the conservation of biodiversity.

This survey has provided a significant insight to the long term effects of stocking, drought and fire on the perennial chenopod vegetation of the district. Management of this land should aim to promote the retention and regeneration of these desirable species.

ACKNOWLEDGEMENTS

We would like to thank the International Wool Secretariat for the support of such a unique project in the chenopod shrublands of South Australia, Carolyn Ireland (Member of the Pastoral Board of South Australia) for her constructive comments, the many volunteers who assisted with field surveys, the members of the Kingoonya SCB, and the managers of all the stations surveyed whose co-operation and hospitality was greatly appreciated.

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Plate 1. Photopoint 81 Mulgathing Station 1971. An east - west cross fence comparison. Maireana sedifolia stage 6 on LHS and stage 3 on RHS.

Plate 2. Photopoint 81 Mulgathing Station 1994. Evidence of the slow recovery of Maireana sedifolia, the LHS has had light or no stocking in the last 23 years.

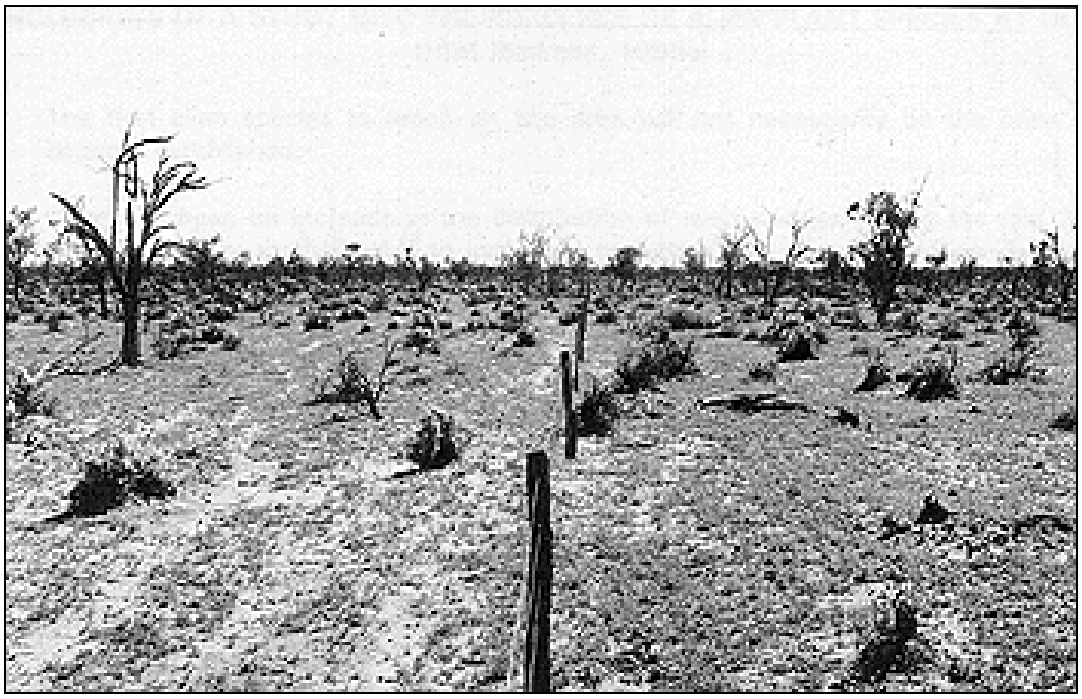

Plate 3. Photopoint 4 Commonwealth Hill 1971. This is a north-south fence comparison, the LHS is the southern paddock. This photo is approximately 1 km from a bore that services the southern paddock.

Plate 4. Photopoint 4. Commonwealth Hill 1994. Reduced stocking has lifted the pressure on the northern fenceline and recovery of Maireana sedifolia, has been good.

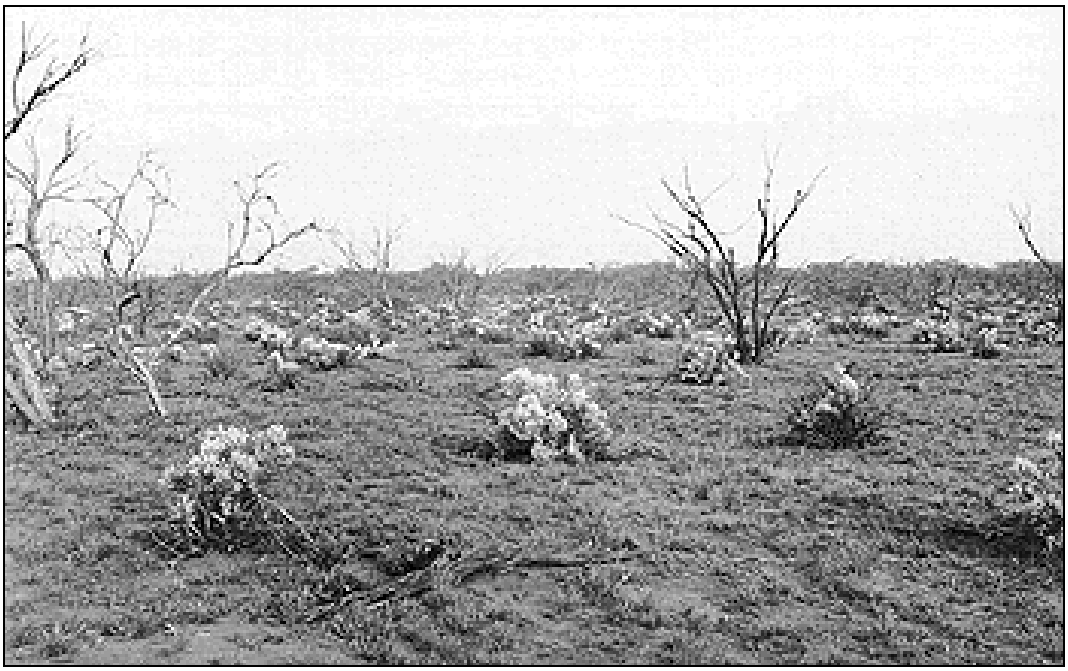

Plate 5. Photopoint 75 Mobella 1971. This photo is on the western side of the station in an area which was affected by the 1974-75 fires.

Plate 6. Photopoint 75 Mobella 1994. The mulga woodland has been almost completely removed as a result of the fire. Maireana sedifolia has survived the fire.

APPENDIX E

E: CONCLUSIONS OF A STUDY INTO THE INCIDENCE OF ALIEN PLANT SPECIES AT OLYMPIC DAM

Source: Badman (1995a)

- The first alien species to reach an arid area will not necessarily be the ones that will become established;
- there has been an increase in the distribution of alien species since 1975, but this may be partially due to increased collecting and recording effort on the part of biologists;
- there is evidence to suggest that the increase in occurrence of alien species may now be levelling off or decreasing following the adoption of more conservative land management practices, although new species are still entering the district;
- the alien flora of the Olympic Dam area can be divided into two distinct suites; those that were present before exploration activities began and those restricted to damp habitats around the township of Roxby Downs;
- all the common alien species were already present in the area before the commencement of exploration and mining activities at Olympic Dam;
- the "town-area" species are not spreading out into the surrounding countryside, despite two wet years which should have made this possible if it were going to happen. None of these "town- weeds" has been recorded at any of the monitoring sites set up to record such events and they appear not to be persisting in rehabilitated areas;
- the same patterns in the incidence of alien species have occurred on all areas (mining and exploration, town, undisturbed and pastoral) irrespective of current land use;
- alien species were out-competed by native species, particularly grasses, following the exceptional rainfall events of the first half of 1989 and in 1992. There was an actual decrease in the incidence of alien species in both years;
- summer rainfall produces native grasses which then prevent the establishment of alien species by occupying niches which the aliens might otherwise have occupied;
- a high incidence of alien species follows fire in this area, but this is not maintained once the high nutrient levels left by the fire are exhausted, especially if summer rainfall allows the establishment of native grasses;
- a decrease in the incidence of alien species following control of rabbits inside the town rabbit-proof fence coincided with an increase in total vegetation cover;
- the recording of several alien species in the area for the first time may be a result of more intensive monitoring, including the presence of on-site biologists, rather than Olympic Dam being different from other towns in the area;
- control of short-lived alien species is not feasible at present other than by way of improved land management techniques.

APPENDIX F

F: LIST OF PLANTS KNOWN TO OCCUR IN THE KINGOONYA SCD

* denotes introduced species
Sources: F.J. Badman published and unpublished data, Brandle (1998), Rangeland Program survey data.

ACANTHACEAE

Rostellularia adscendens ssp. adscendens var. pogonanthera	pink tongues, red trumpet

ADIANTACEAE

Cheilanthes lasiophylla	woolly cloak-fern
Cheilanthes sieberi ssp. pseudovellea	
Cheilanthes sieberi ssp. sieberi	narrow rock-fern, mulga fern

AIZOACEAE

Carpobrotus sp.	pigface
Disphyma crassifolium ssp. clavellatum	round-leaf pigface, rounded noon-flower
Glinus lotoides	hairy carpet-weed
Gunniopsis calva	
Gunniopsis kochii	Koch's pigface
Gunniopsis papillata	twin-leaf pigface
Gunniopsis quadrifida	Sturt's pigface
Gunniopsis septifraga	green pigface
Gunniopsis zygophylloides	twin-leaf pigface
**Mesembryanthemum crystallinum*	common iceplant, iceplant
**Mesembryanthemum nodiflorum*	slender iceplant, small iceplant
Sarcozona praecox	sarcozona
Tetragonia eremaea	desert spinach, annual spinach
Tetragonia tetragonioides	New Zealand spinach, Warragul cabbage
Trianthema triquetra	red spinach, small hogweed
Zaleya galericulata	hogweed

AMARANTHACEAE

Alternanthera angustifolia	narrow-leaf joyweed
Alternanthera denticulate	lesser joyweed
Alternanthera nodiflora	common joyweed
Amaranthus grandiflorus	large-flower amaranth
Amaranthus mitchellii	Boggabri weed
Hemichroa diandra	mallee hemichroa
Hemichroa mesembryanthema	pigface hemichroa
Ptilotus exaltatus var. exaltatus	pink mulla mulla, tall mulla mulla
Ptilotus gaudichaudii var. gaudichaudii	paper fox-tail, yellow ptilotus
Ptilotus nobilis var. nobilis	yellow-tails, regal fox-tail
Ptilotus obovatus var. obovatus	silver mulla mulla, silver-tails
Ptilotus parvifolius var. parvifolius	small-leaf mulla mulla, shrubby mulla mulla
Ptilotus polystachyus var. polystachyus forma polystachyus	long-tails, bottle-washers
Ptilotus polystachyus var. polystachyus forma rubriflorus	red long-tails, red pussytail
Ptilotus sessilifolius var. sessilifolius	crimson-tails, crimson fox-tail

AMARYLLIDACEAE

Calostemma luteum	yellow garland-lily
Crinum flaccidum	Murray lily, Darling lily

ANACARDIACEAE

**Schinus areira*	pepper-tree

ASCLEPIADACEAE

Rhyncharrhena linearis	climbing purple-star, purple pentatrope
Sarcostemma viminale ssp. australe	caustic bush, caustic vine

ASPLENIACEAE

Pleurosorus rutifolius	blanket fern

BORAGINACEAE

**Echium plantagineum*	Salvation Jane, Paterson's curse
Embadium stagnense	Arcoona slipper-plant, Arcoona embadium
Embadium uncinatum	Gawler Ranges slipper-plant, Gawler Ranges embadium
**Heliotropium amplexicaule*	blue heliotrope, clasping heliotrope
**Heliotropium curassavicum*	smooth heliotrope
**Heliotropium europaeum*	common heliotrope, potato weed
**Heliotropium supinum*	creeping heliotrope, prostrate potato weed
Heliotropium tenuifolium	bushy heliotrope, creeping heliotrope
Heliotropium undulatum	
Omphalolappula concava	burr stickseed
Plagiobothrys plurisepaleus	white rochelia, white forget-me-not
Trichodesma zeylanicum	camel bush, cattle bush

CACTACEAE

**Opuntia erinacea var. utahensis*	grizzly bear cactus

CAMPANULACEAE

Isotoma petraea	rock isotome
Wahlenbergia communis	tufted bluebell
Wahlenbergia gracilenta	annual bluebell
Wahlenbergia tumidifructa	swollen-fruit bluebell, balloon bluebell

CAPPARACEAE

Cleome viscosa	tickweed

CARYOPHYLLACEAE

**Gypsophila tubulosa*	annual chalkwort
**Sagina apetala*	annual pearlwort, common pearlwort
Scleranthus pungens	prickly knawel
**Spergularia diandra*	lesser sand-spurrey, small sand-spurrey
**Spergularia marina*	salt sand-spurrey

CASUARINACEAE

Casuarina pauper	black oak, belah

CENTROLEPIDACEAE

Centrolepis eremica	dryland centrolepis
Centrolepis polygyna	wiry centrolepis

CHENOPODIACEAE

Atriplex acutibractea ssp. acutibractea	pointed saltbush
Atriplex acutiloba	
Atriplex angulata	fan saltbush, angular saltbush
Atriplex crassipes var. crassipes	
Atriplex cryptocarpa	
Atriplex eardleyae	Eardley's saltbush, small saltbush
Atriplex fissivalvis	gibber saltbush
Atriplex holocarpa	pop saltbush
Atriplex incrassata	
Atriplex kochiana	Koch's saltbush
Atriplex leptocarpa	slender-fruit saltbush
Atriplex limbata	spreading saltbush
Atriplex lindleyi ssp. conduplicata	baldoo
Atriplex lindleyi ssp. lindleyi	baldoo
Atriplex lindleyi ssp. quadripartita	baldoo
Atriplex macropterocarpa	
Atriplex morrisii	
Atriplex nessorhina	Donald Duck saltbush
Atriplex nummularia ssp. nummularia	old-man saltbush
Atriplex nummularia ssp. omissa	Oodnadatta saltbush
Atriplex quadrivalvata var. quadrivalvata	
Atriplex quadrivalvata var. sessilifolia	
Atriplex quinii	kidney-fruit saltbush
Atriplex spongiosa	pop saltbush
Atriplex stipitata	bitter saltbush, kidney saltbush
Atriplex suberecta	lagoon saltbush, sprawling saltbush
Atriplex velutinella	sandhill saltbush
Atriplex vesicaria	bladder saltbush
**Chenopodium album*	fat hen, blue weed
Chenopodium auricomum	golden goosefoot, Queensland bluebush
Chenopodium cristatum	crested goosefoot
Chenopodium curvispicatum	cottony goosefoot, white goosefoot
Chenopodium desertorum ssp. anidiophyllum	mallee goosefoot
Chenopodium desertorum ssp. desertorum	frosted goosefoot, desert goosefoot
Chenopodium gaudichaudianum	scrambling goosefoot
Chenopodium melanocarpum	black-fruit goosefoot, black crumbweed
**Chenopodium murale*	nettle-leaf goosefoot, sowbane
Chenopodium pumilio	clammy goosefoot, small crumbweed
Chenopodium truncatum	
Dissocarpus biflorus var. biflorus	two-horn saltbush, twin-flower saltbush
Dissocarpus biflorus var. villosus	woolly two-horn saltbush, woolly twin-flower saltbush
Dissocarpus paradoxus	ball bindyi, hard-head saltbush

Chenopodiaceae (cont.)	
Dysphania glomulifera	globular crumbweed, red crumbweed
Dysphania platycarpa	flat-fruit crumbweed
Einadia nutans ssp. eremaea	dryland climbing saltbush
Einadia nutans ssp. nutans	climbing saltbush, nodding saltbush
Enchylaena tomentosa var. glabra	smooth ruby saltbush
Enchylaena tomentosa var. tomentosa	ruby saltbush, barrier saltbush
Eriochiton sclerolaenoides	woolly-fruit bluebush
Halosarcia halocnemoides ssp. halocnemoides	grey samphire, grey glasswort
Halosarcia halocnemoides ssp. longispicata	grey samphire, grey glasswort
Halosarcia indica ssp. bidens	brown-head samphire
Halosarcia indica ssp. leiostachya	brown-head samphire, brown-head glasswort
Halosarcia lylei	wiry samphire, casuarina samphire
Halosarcia pergranulata ssp. divaricata	black-seed samphire, black-seed glasswort
Halosarcia pergranulata ssp. elongata	black-seed samphire, black-seed glasswort
Halosarcia pergranulata ssp. pergranulata	black-seed samphire, black-seed glasswort
Halosarcia pruinosa	bluish samphire, bluish glasswort
Maireana aphylla	cotton-bush, leafless bluebush
Maireana appressa	pale-fruit bluebush, grey bluebush
Maireana astrotricha	low bluebush, grey bluebush
Maireana brevifolia	short-leaf bluebush, small-leaf bluebush
Maireana campanulata	bell-fruit bluebush
Maireana cannonii	Cannon's bluebush
Maireana carnosa	cottony bluebush
Maireana ciliata	hairy fissure-plant, hairy bluebush
Maireana coronata	crown fissure-plant, crown fissure-weed
Maireana eriantha	woolly bluebush
Maireana erioclada	rosy bluebush, fleshy bluebush
Maireana excavata	bottle fissure-plant, bottle bluebush
Maireana georgei	satiny bluebush, slit-wing bluebush
Maireana integra	entire-wing bluebush
Maireana lobiflora	lobed bluebush
Maireana microcarpa	swamp bluebush, small-fruit bluebush
Maireana oppositifolia	salt bluebush, heathy bluebush
Maireana ovata	
Maireana pentagona	slender fissure-plant, hairy bluebush
Maireana pentatropis	erect mallee bluebush, erect bluebush
Maireana planifolia	flat-leaf bluebush, low bluebush
Maireana pyramidata	black bluebush, shrubby bluebush
Maireana schistocarpa	split-fruit bluebush
Maireana scleroptera	hard-wing bluebush
Maireana sedifolia	bluebush, pearl bluebush
Maireana spongiocarpa	spongy-fruit bluebush
Maireana trichoptera	hairy-fruit bluebush, spike bluebush
Maireana triptera	three-wing bluebush
Maireana turbinata	top-fruit bluebush, satiny bluebush
Maireana villosa	silky bluebush, common bluebush
Malacocera albolanata	woolly soft-horns
Malacocera biflora	two-flower soft-horns
Malacocera gracilis	slender soft-horns
Malacocera tricornis	goat-head soft-horns, three-horned saltbush
Neobassia proceriflora	desert glasswort, soda bush
Osteocarpum acropterum var. acropterum	tuberculate bonefruit, water weed
Osteocarpum dipterocarpum	two-wing bonefruit

Chenopodiaceae (cont.)	
Osteocarpum salsuginosum	inland bonefruit, bonefruit
Rhagodia eremaea	desert saltbush, mukul-mukulpa
Rhagodia parabolica	mealy saltbush, fragrant saltbush
Rhagodia preissii ssp. preissii	mallee saltbush, green saltbush
Rhagodia spinescens	spiny saltbush, thorny saltbush
Rhagodia ulicina	intricate saltbush, spiny saltbush
Salsola kali	buckbush, tumbleweed
Sarcocornia blackiana	thick-head samphire, thick-head glasswort
Sclerolaena articulata	jointed bindyi, jointed poverty-bush
Sclerolaena bicornis	goat-head bindyi, goat-head burr
Sclerolaena blackiana	Black's bindyi, Black's copperburr
Sclerolaena brachyptera	short-wing bindyi, short-wing copperburr
Sclerolaena constricta	
Sclerolaena convexula	tall bindyi, tall copperburr
Sclerolaena cuneata	tangled bindyi, poverty-bush
Sclerolaena decurrens	green bindyi, green copperburr
Sclerolaena diacantha	grey bindyi, horned bindyi
Sclerolaena divaricata	tangled bindyi, poverty-bush
Sclerolaena eriacantha	silky bindyi, silky copperburr
Sclerolaena glabra	smooth bindyi
Sclerolaena holtiana	Holt's bindyi, grey bindyi
Sclerolaena intricata	tangled bindyi, poverty-bush
Sclerolaena lanicuspis	spinach bindyi, woolly bindyi
Sclerolaena limbata	pearl bindyi, pearl copperburr
Sclerolaena longicuspis	long-spine bindyi, long-spine poverty-bush
Sclerolaena obliquicuspis	oblique-spined bindyi, limestone copperburr
Sclerolaena parallelicuspis	western bindyi, western copperburr
Sclerolaena parviflora	small-flower bindyi, mallee bindyi
Sclerolaena patenticuspis	spear-fruit bindyi, spear-fruit copperburr
Sclerolaena symoniana	Symon's bindyi
Sclerolaena tatei	Tate's bindyi
Sclerolaena uniflora	small-spine bindyi, grey bindyi
Sclerolaena ventricosa	salt bindyi, salt copperbush
Sclerostegia disarticulata	
Sclerostegia tenuis	slender samphire, slender glasswort
CHLOANTHACEAE	
Dicrastylis beveridgei var. beveridgei	sand-sage
Dicrastylis beveridgei var. lanata	woolly sand-sage
Dicrastylis lewellinii	purple sand-sage
Spartothamnella teucriiflora	bead bush, red-berried stick-plant
COMPOSITAE	
Actinobole uliginosum	flannel cudweed, cotton weed
Anemocarpa podolepidium	rock everlasting
Angianthus brachypappus	spreading angianthus, spreading cup-flower
Angianthus glabratus	smooth angianthus, smooth cup-flower
Angianthus tomentosus	hairy angianthus, hairy cup-flower
**Aster subulatus*	aster-weed, wild aster
Brachycome campylocarpa	large white daisy
Brachycome ciliaris var. ciliaris	variable daisy, fringed daisy
Brachycome ciliaris var. lanuginosa	woolly variable daisy, woolly fringed daisy

Compositae (cont.)	
Brachycome dichromosomatica var. dichromosomatica	large hard-head daisy, purple hard-head daisy
Brachycome eriogona	
Brachycome iberidifolia	Swan River daisy
Brachycome lineariloba	hard-head daisy, dwarf daisy
Brachycome tesquorum	shrubby desert daisy
Brachycome trachycarpa	smooth daisy, inland daisy
Calocephalus knappii	Knapp's beauty-heads
Calocephalus platycephalus	western beauty-heads, flattened beauty-heads
Calocephalus sonderi	pale beauty-heads, yellow poverty weed
Calotis cymbacantha	showy burr-daisy
Calotis erinacea	tangled burr-daisy
Calotis hispidula	hairy burr-daisy, bogan flea
Calotis kempei	Kemp's burr-daisy
Calotis multicaulis	woolly-headed burr-daisy
Calotis plumulifera	woolly-headed burr-daisy
Calotis porphyroglossa	channel burr-daisy
**Carthamus lanatus*	saffron thistle, woolly star-thistle
**Carthamus tinctorius*	safflower
**Centaurea melitensis*	Malta thistle, Maltese cockspur
Centipeda cunninghamii	common sneezeweed
Centipeda thespidioides	desert sneezeweed
Cephalipterum drummondii	pompom head
Ceratogyne obionoides	wingwort
Chrysocephalum apiculatum	common everlasting, small yellow button
Chrysocephalum pterochaetum	shrub everlasting, perennial sunray
Chrysocephalum semicalvum ssp. semicalvum	scented button-bush, hill button-bush
Chthonocephalus pseudevax	ground-heads
**Conyza bonariensis*	flax-leaf fleabane, tall fleabane
Cratystylis conocephala	bluebush daisy, greybush
Dichromochlamys dentatifolius	
Dimorphocoma minutula	
Elachanthus pusillus	elachanth
Epaltes australis	spreading nut-heads
Eriochlamys behrii	woolly mantle
Euchiton sphaericus	annual cudweed, Japanese cudweed
Glossogyne tannensis	native cobbler's-pegs
Gnaphalium diamantinense	Diamantina cudweed
Gnephosis arachnoidea	spidery button-flower
Gnephosis eriocarpa	native camomile
Gnephosis tenuissima	dwarf golden-tip, dwarf cup-flower
**Hedypnois rhagadioloides*	Cretan weed, Cretan hedypnois
**Helianthus annuus*	sunflower, common sunflower
Hyalosperma semisterile	orange sunray
Hyalosperma stoveae	dwarf sunray
**Hypochaeris glabra*	smooth cat's ear
Isoetopsis graminifolia	grass cushion, grass buttons
Ixiochlamys cuneifolia	Silverton daisy
Ixiochlamys nana	small fuzzweed
Ixiolaena chloroleuca	pale plover-daisy
Ixiolaena leptolepis	narrow plover-daisy, stalked plover-daisy
Ixiolaena tomentosa	woolly plover-daisy, woolly ixiolaena
Kippistia suaedifolia	fleshy kippistia, fleshy minuria

Compositae (cont.)	
**Lactuca saligna*	willow-leaf lettuce, wild lettuce
**Lactuca serriola*	prickly lettuce, compass plant
Lawrencella davenportii	Davenport daisy, sticky everlasting
Lemooria burkittii	wires-and-wool
Leptorhynchos baileyi	Bailey's buttons
Leucochrysum fitzgibbonii	Fitzgibbon's daisy, glandular sunray
Leucochrysum molle	hoary sunray, soft sunray
Leucochrysum stipitatum	salt-spoon daisy, woolly sunray
Microseris lanceolata	yam daisy, native yam
Millotia macrocarpa	large-fruit millotia
Millotia myosotidifolia	broad-leaf millotia
Millotia perpusilla	tiny bow-flower
Minuria annua	annual minuria
Minuria cunninghamii	bush minuria
Minuria denticulata	woolly minuria
Minuria integerrima	smooth minuria
Minuria leptophylla	minnie daisy
Minuria multiseta	
Minuria rigida	
Myriocephalus pluriflorus	inland woolly-heads
Myriocephalus rudallii	small poached-egg daisy
Olearia muelleri	Mueller's daisy-bush
Olearia stuartii	Stuart's daisy-bush
Olearia subspicata	spiked daisy-bush, shrubby daisy-bush
**Osteospermum clandestinum*	tripteris, stinking Roger
**Osteospermum fruticosum*	
Othonna gregorii	fleshy groundsel
**Pentzia incana*	African sheep bush
Picris angustifolia ssp. angustifolia	coast picris, hawkweed picris
Pluchea rubelliflora	
Podolepis canescens	grey copper-wire daisy, bright podolepis
Podolepis capillaris	wiry podolepis, invisible plant
Podolepis davisiana	button podolepis
Podolepis rugata var. rugata	pleated copper-wire daisy, pleated podolepis
Polycalymma stuartii	poached-egg daisy, poached eggs
Pseudognaphalium luteoalbum	Jersey cudweed, cudweed
Pterocaulon sphacelatum	apple-bush, fruit-salad plant
Pycnosorus eremaeus	golden billy-buttons, yellow drumsticks
Pycnosorus pleiocephalus	soft billy-buttons
Rhodanthe charsleyae	
Rhodanthe chlorocephala ssp. rosea	western sunray
Rhodanthe citrina	pale immortelle
Rhodanthe floribunda	white everlasting, white paper-daisy
Rhodanthe microglossa	clustered everlasting, clustered sunray
Rhodanthe moschata	musk daisy, musk sunray
Rhodanthe polygalifolia	milkwort everlasting, brilliant sunray
Rhodanthe pygmaea	pigmy daisy, pigmy sunray
Rhodanthe stricta	slender everlasting, urn paper-daisy
Rhodanthe stuartiana	clay everlasting, clay sunray
Rhodanthe uniflora	woolly daisy, woolly sunray
Rutidosis helichrysoides	grey wrinklewort
Schoenia cassiniana	pink everlasting, schoenia
Schoenia ramosissima	dainty everlasting

Compositae (cont.)	
Senecio cunninghamii var. serratus	inland shrubby groundsel, shrubby groundsel
Senecio glossanthus	annual groundsel, slender groundsel
Senecio lautus	variable groundsel, elegant yellow-top
Senecio magnificus	showy groundsel, tall yellow-top
**Sonchus oleraceus*	common sow-thistle, milk thistle
**Sonchus tenerrimus*	clammy sow-thistle
Streptoglossa adscendens	desert daisy
Streptoglossa liatroides	Wertaloona daisy
Trichanthodium skirrophorum	woolly yellow-heads, woolly gnephosis
Vittadinia australasica var. australasica	sticky New Holland daisy, New Holland daisy
Vittadinia cervicularis var. cervicularis	waisted New Holland daisy, annual New Holland daisy
Vittadinia condyloides	club-hair New Holland daisy
Vittadinia dissecta var. hirta	dissected New Holland daisy, common New Holland daisy
Vittadinia eremaea	desert New Holland daisy
Vittadinia gracilis	woolly New Holland daisy
Vittadinia pterochaeta	rough New Holland daisy, fuzzweed
Vittadinia sulcata	furrowed New Holland daisy
Waitzia acuminata var. acuminata	orange immortelle
**Xanthium spinosum*	Bathurst burr, spiny cocklebur
CONVOLVULACEAE	
Convolvulus erubescens	Australian bindweed, pink bindweed
Convolvulus microsepalus	small-flower bindweed
Convolvulus remotus	grassy bindweed
Cressa cretica	rosinweed
Cuscuta victoriana	
Ipomoea racemigera	inland bell-vine
CRASSULACEAE	
Crassula colorata var. acuminata	dense crassula, dense stonecrop
Crassula colorata var. colorata	dense crassula, dense stonecrop
Crassula sieberiana ssp. tetramera	Australian stonecrop, common crassula
CRUCIFERAE	
**Alyssum linifolium*	flax-leaf alyssum
Arabidella glaucescens	
Arabidella nasturtium	yellow cress
Arabidella trisecta	shrubby cress, native stock
Blennodia canescens	native stock, wild stock
Blennodia pterosperma	wild stock
**Brassica tournefortii*	wild turnip, Mediterranean turnip
**Cardamine hirsuta*	hairy bitter-cress, hairy wood-cress
**Carrichtera annua*	Ward's weed
Cuphonotus humistratus	mother-of-misery
**Diplotaxis muralis*	wall rocket
Harmsiodoxa puberula	scented cress
**Hymenolobus procumbens*	oval purse
Lepidium muelleri-ferdinandi	Mueller's peppercress
Lepidium oxytrichum	green peppercress
Lepidium papillosum	warty peppercress

Cruciferae (cont.)	
Lepidium phlebopetalum	veined peppercress
Lepidium sagittulatum	fine-leaf peppercress
Menkea australis	fairy spectacles
Menkea crassa	fat spectacles
Menkea sphaerocarpa	
Phlegmatospermum cochlearinum	downy cress
**Rapistrum rugosum ssp. rugosum*	turnip weed, short-fruited wild turnip
**Sisymbrium erysimoides*	smooth mustard
**Sisymbrium irio*	London mustard, London rocket
**Sisymbrium orientale*	Indian hedge mustard, wild mustard
Stenopetalum anfractum	inland thread-petal
Stenopetalum lineare	narrow thread-petal
Stenopetalum sphaerocarpum	round-fruit thread-petal, pea thread-petal
Stenopetalum velutinum	velvet thread-petal

CUCURBITACEAE

**Citrullus colocynthis*	colocynth, bitter apple
**Citrullus lanatus*	bitter melon, wild melon
**Cucumis myriocarpus*	paddy melon, gooseberry cucumber
Mukia micrantha	desert cucumber, mallee cucumber

CUPRESSACEAE

Callitris glaucophylla	white cypress-pine, northern cypress-pine
Callitris verrucosa	scrub cypress pine, warty cypress pine

CYPERACEAE

Bulbostylis barbata	
Cyperus alterniflorus "Oodnadatta form"	umbrella flat-sedge
Cyperus bulbosus	bulbous flat-sedge, bush onion
Cyperus difformis	variable flat-sedge, dirty Dora
Cyperus exaltatus	splendid flat-sedge, tall flat-sedge
Cyperus gilesii	Giles' flat-sedge
Cyperus gymnocaulos	spiny flat-sedge, spiny sedge
Cyperus involucratus	
Cyperus iria	
Cyperus laevigatus	bore-drain sedge
Cyperus rigidellus	dwarf flat-sedge
Cyperus rotundus	nut-grass
Cyperus squarrosus	bearded flat-sedge
Cyperus victoriensis	yelka
Eleocharis pallens	pale spike-rush, pale spike-sedge
Fimbristylis dichotoma	common fringe-rush, eight-days grass
Isolepis australiensis	southern club-rush, southern club-sedge
Isolepis congrua	slender club-rush, slender club-sedge
Isolepis fluitans	floating club-rush
Schoenoplectus dissachanthus	inland club-rush, blunt club-rush

ELATINACEAE

Bergia perennis ssp. exigua	perennial water-fire
Bergia trimera	three-part water-fire, small water-fire

EUPHORBIACEAE

Beyeria opaca	dark turpentine bush, smooth wallaby-bush
Euphorbia "Marree"(F.J.Badman 776)	
Euphorbia australis	hairy caustic weed, caustic weed
Euphorbia drummondii	caustic weed, flat spurge
Euphorbia stevenii	bottletree spurge, bottletree caustic
Euphorbia tannensis ssp. eremophila	desert spurge, bottle tree caustic
Euphorbia wheeleri	Wheeler's spurge
Phyllanthus fuernrohrii	sand spurge
Phyllanthus lacunarius	lagoon spurge, Caraweena clover
Phyllanthus maderaspatensis var. angustifolius	
Sauropus trachyspermus	rough-seed spurge, slender spurge

FRANKENIACEAE

Frankenia cinerea	
Frankenia foliosa	leafy sea-heath
Frankenia plicata	
Frankenia serpyllifolia	thyme sea-heath, clustered sea-heath
Frankenia sessilis	small-leaf sea-heath

GENTIANACEAE

**Centaurium spicatum*	spike centaury

GERANIACEAE

Erodium angustilobum	
**Erodium aureum*	
**Erodium cicutarium*	cut-leaf heron's-bill, cut-leaf stork's-bill
Erodium crinitum	blue heron's-bill, blue stork's-bill
Erodium cygnorum ssp. cygnorum	blue heron's-bill, blue geranium
Erodium cygnorum ssp. glandulosum	clammy heron's-bill

GOODENIACEAE

Brunonia australis	blue pincushion
Goodenia berardiana	split-end goodenia, twin-head goodenia
Goodenia calcarata	streaked goodenia
Goodenia cycloptera	serrated goodenia
Goodenia fascicularis	silky goodenia, mallee goodenia
Goodenia gibbosa	
Goodenia havilandii	hill goodenia
Goodenia lunata	stiff goodenia, hairy goodenia
Goodenia modesta	
Goodenia occidentalis	
Goodenia pinnatifida	cut-leaf goodenia, scrambled eggs
Goodenia pusilliflora	small-flower goodenia
Scaevola collaris	
Scaevola collina	hill fanflower
Scaevola spinescens	spiny fanflower, prickly fanflower

GRAMINEAE

Agrostis avenacea var. avenacea	common blown-grass, fairy grass
Agrostis avenacea var. perennis	perennial blown-grass, blown grass
**Alopecurus geniculatus*	marsh fox-tail
Aristida anthoxanthoides	yellow three-awn, pale wire-grass
Aristida capillifolia	needle-leaf three-awn
Aristida contorta	curly wire-grass, mulga grass
Aristida holathera var. holathera	tall kerosene grass
Aristida latifolia	feather-top wire-grass
Aristida nitidula	brush three-awn, small brush wire-grass
Astrebla pectinata	barley Mitchell-grass
**Avena barbata*	bearded oat
**Avena fatua*	wild oat, black oat
**Avena sativa*	cultivated oat
Bromus arenarius	sand brome
**Bromus diandrus*	great brome, Kingston grass
**Cenchrus ciliaris*	buffel grass, black buffel grass
**Chloris gayana*	Rhodes grass
Chloris pectinata	comb windmill grass, comb chloris
Chloris truncata	windmill grass
**Chloris virgata*	feather-top Rhodes grass, feather windmill grass
**Critesion murinum ssp. glaucum*	blue barley-grass, northern barley-grass
Cymbopogon ambiguus	lemon-grass, scented grass
**Cynodon dactylon*	couch, Bermuda grass
Dactyloctenium radulans	button-grass, finger grass
Danthonia caespitosa	common wallaby-grass, white-top
Dichanthium sericeum ssp. humilius	annual silky blue-grass, dwarf blue-grass
Dichanthium sericeum ssp. sericeum	silky blue-grass, Queensland blue-grass
Digitaria brownii	cotton panic-grass, cotton grass
Digitaria ciliaris	summer grass, crab grass
Digitaria coenicola	spider grass, finger panic-grass
**Digitaria sanguinalis*	crab grass, summer grass
Diplachne fusca	brown beetle-grass, pale beetle-grass
**Echinochloa crus-galli*	common barnyard grass, cockspur grass
Echinochloa inundata	channel millet
**Echinochloa utilis*	Japanese millet
Enneapogon avenaceus	common bottle-washers, oat nineawn
Enneapogon caerulescens var. caerulescens	blue bottle-washers, blue nineawn
Enneapogon cylindricus	jointed bottle-washers, jointed nineawn
Enneapogon intermedius	tall bottle-washers, intermediate nineawn
Enneapogon nigricans	black-head grass, black nineawn
Enneapogon polyphyllus	leafy bottle-washers, limestone bottle-washers
Enteropogon acicularis	umbrella grass, curly windmill grass
Enteropogon ramosus	umbrella grass, curly windmill grass
Eragrostis australasica	cane-grass, swamp cane-grass
**Eragrostis barrelieri*	pitted love-grass
Eragrostis basedowii	neat love-grass
**Eragrostis cilianensis*	stink grass, stinking love-grass
Eragrostis dielsii var. dielsii	mulka, mallee love-grass
Eragrostis elongata	clustered love-grass, close-headed love-grass
Eragrostis eriopoda	woollybutt, naked woollybutt
Eragrostis falcata	sickle love-grass
Eragrostis kennedyae	small-flower love-grass

Gramineae (cont.)

Eragrostis laniflora	hairy-flower woollybutt, woollybutt
Eragrostis lanipes	woollybutt, hairy-flower woollybutt
Eragrostis leptocarpa	drooping love-grass, slender love-grass
Eragrostis parviflora	weeping love-grass, soft love-grass
**Eragrostis pergracilis*	small love-grass
Eragrostis setifolia	bristly love-grass, narrow-leaf neverfail
Eragrostis tenellula	delicate love-grass
Eragrostis xerophila	knotty-butt neverfail, neverfail
Eriachne helmsii	woollybutt wanderrie, buck wanderrie grass
Eriachne mucronata	mountain wanderrie, mountain wanderrie grass
Eriachne ovata	swamp wanderrie
Eriochloa australiensis	Australian cupgrass
Eriochloa pseudoacrotricha	perennial cupgrass, early spring grass
Eulalia aurea	silky brown-top, sugar-grass
**Holcus lanatus*	Yorkshire fog
**Hordeum vulgare ssp. distichon*	two-rowed barley
Iseilema membranaceum	small Flinders-grass
Iseilema vaginiflorum	red Flinders-grass
Leptochloa digitata	umbrella cane-grass
**Lolium perenne*	perennial ryegrass
**Lolium rigidum*	Wimmera ryegrass, annual ryegrass
**Lolium x hubbardii*	
Monachather paradoxa	bandicoot grass
Neurachne munroi	window mulga-grass, slender-headed mulga-grass
Panicum decompositum var. decompositum	native millet, Australian millet
Panicum effusum var. effusum	hairy panic
Panicum laevinode	
**Panicum miliaceum*	broom millet, common millet
Paractaenum novae-hollandiae ssp. reversum	barbed-wire grass, reverse grass
Paractaenum refractum	bristle-brush grass
Paspalidium basicladum	
Paspalidium clementii	Clement's paspalidium
Paspalidium constrictum	knotty-butt paspalidium, box grass
Paspalidium jubiflorum	Warrego summer-grass
**Paspalum dilatatum*	paspalum
**Pennisetum clandestinum*	kikuyu, kikuyu grass
**Pennisetum setaceum*	fountain grass
**Phalaris canariensis*	canary-grass
Phragmites australis	common reed, bamboo reed
**Poa annua*	winter grass, annual meadow-grass
**Polypogon monspeliensis*	annual beard-grass
**Rostraria pumila*	tiny bristle-grass
**Schismus barbatus*	Arabian grass, mulga grass
Setaria dielsii	Diel's pigeon-grass
**Setaria italica*	fox-tail millet, Italian millet
**Sorghum halepense*	Johnson grass, Aleppo grass
**Sorghum x almum*	Columbus grass, almum grass
Sporobolus actinocladus	ray grass
Sporobolus caroli	yakka grass
Sporobolus mitchellii	rat-tail couch, short rat-tail grass
Stipa acrociliata	graceful spear-grass
Stipa elegantissima	feather spear-grass, elegant spear-grass
Stipa nitida	Balcarra spear-grass, Balcarra grass

Gramineae (cont.)	
Stipa nodosa	tall spear-grass, knotty spear-grass
Stipa nullanulla	club spear-grass
Stipa platychaeta	flat-awn spear-grass
Stipa plumigera	
Stipa scabra ssp. scabra	rough spear-grass
Themeda triandra	kangaroo grass
Thyridolepis mitchelliana	window mulga-grass, mulga-grass
Thyridolepis multiculmis	
Tragus australianus	small burr-grass, bur grass
Triodia basedowii	hard spinifex, lobed spinifex
Triodia irritans	spinifex, porcupine grass
Tripogon loliiformis	five-minute grass, rye beetle-grass
Triraphis mollis	purple plume grass, purple needle-grass
**Triticum aestivum*	wheat
Urochloa praetervisa	large arm-grass
**Vulpia myuros*	fescue
Zygochloa paradoxa	sandhill cane-grass
GYROSTEMONACEAE	
Codonocarpus cotinifolius	desert poplar, poplar bell-fruit
Gyrostemon ramulosus	bushy wheel-fruit, Chinese bush
HALORAGACEAE	
Haloragis aspera	rough raspwort
Haloragis glauca forma sclopetifera	grey raspwort, grey raspweed
Haloragis odontocarpa forma octoforma	mulga nettle, toothed raspwort
Haloragis odontocarpa forma pterocarpa	mulga nettle, toothed raspwort
Myriophyllum verrucosum	red milfoil, red water-milfoil
JUNCACEAE	
Juncus aridicola	inland rush, tussock rush
Juncus bufonius	toad rush
Juncus kraussii	sea rush
JUNCAGINACEAE	
Triglochin calcitrapum	spurred arrowgrass
Triglochin centrocarpum	dwarf arrowgrass
LABIATAE	
**Marrubium vulgare*	horehound
Mentha australis	river mint
Prostanthera althoferi ssp. longifolia	
Prostanthera striatiflora	striated mintbush, jockey's cap
**Salvia verbenaca form B*	wild sage
Teucrium albicaule	scurfy germander
Teucrium racemosum	grey germander
Westringia rigida	stiff westringia, stiff western rosemary

LEGUMINOSAE

Acacia aff. papyrocarpa	myall
Acacia aneura var. aneura	mulga, narrow-leaf mulga
Acacia ayersiana var. ayersiana	blue mulga
Acacia ayersiana var. latifolia	broad-leaf mulga
Acacia beckleri	Beckler's rock wattle, Barrier Range wattle
Acacia burkittii	pin-bush wattle, Burkitt's wattle
Acacia calcicola	northern myall, limestone wattle
Acacia cambagei	gidgee, stinking wattle
Acacia cibaria	turpentine mulga, umbrella mulga
Acacia colletioides	veined wait-a-while, veined spine-bush
Acacia jennerae	Coonavittra wattle
Acacia kempeana	witchetty bush
Acacia ligulata	umbrella bush, dune wattle
Acacia minyura	desert mulga, resin mulga
Acacia nyssophylla	spine bush, wait-a-while
Acacia oswaldii	umbrella wattle, Oswald's wattle
Acacia papyrocarpa	western myall
Acacia paraneura	weeping mulga
Acacia ramulosa	horse mulga, sand dune mulga
Acacia rhodophloia	minni ritchi, red-bark wattle
Acacia rigens	nealie, needlebush wattle
Acacia salicina	willow wattle, Broughton willow
Acacia stenophylla	river cooba
Acacia stowardii	bastard mulga
Acacia tarculensis	steel bush, Tarcoola wattle
Acacia tetragonophylla	dead finish
Acacia victoriae ssp. arida	downy elegant wattle, downy bramble wattle
Acacia victoriae ssp. victoriae	elegant wattle, bramble wattle
Bossiaea walkeri	cactus pea, cactus bossiaea
Crotalaria eremaea ssp. eremaea	downy loose-flowered rattle-pod, bluebush pea
Crotalaria eremaea ssp. strehlowii	smooth loose-flowered rattle-pod, bluebush pea
Crotalaria novae-hollandiae ssp. lasiophylla	woolly rattle-pod, woolly bird-flower
Cullen australasicum	tall scurf-pea, verbine scurf-pea
Cullen cinereum	annual scurf-pea, hoary scurf-pea
Cullen graveolens	native lucerne
Cullen pallidum	white scurf-pea, woolly scurf-pea
Cullen patens	spreading scurf-pea, native verbine
Glycine canescens	silky glycine
Glycine clandestina var. sericea	twining glycine
Indigofera australis var. australis	austral indigo, hill indigo
Indigofera psammophila	sand indigo, desert indigo
Lotus cruentus	red-flower lotus, red bird's-foot trefoil
**Medicago minima var. minima*	little medic, small burr-medic
**Medicago polymorpha var. polymorpha*	burr-medic, toothed medic
**Melilotus indica*	King Island melilot, sweet melilot
Neptunia dimorphantha	
**Parkinsonia aculeata*	Jerusalem thorn
**Prosopis juliflora*	mesquite
Senna artemisioides nothossp. artemisioides	silver senna, silver cassia
Senna artemisioides nothossp. coriacea	broad-leaf desert senna, broad-leaf desert cassia
Senna artemisioides nothossp. sturtii	grey senna, dense senna
Senna artemisioides ssp. filifolia	fine-leaf desert senna, fine-leaf desert cassia

Leguminosae (cont.)

Senna artemisioides ssp. helmsii	blunt-leaf senna, crinkled senna
Senna artemisioides ssp. oligophylla	limestone senna, blunt-leaf senna
Senna artemisioides ssp. petiolaris	flat-stalk senna, phyllodinous desert cassia
Senna artemisioides ssp. quadrifolia	four-leaf desert senna
Senna cardiosperma ssp. gawlerensis	Gawler Ranges senna
Senna cardiosperma ssp. microphylla	curved-leaf senna
Senna glutinosa ssp. pruinosa	white senna, white cassia
Senna phyllodinea	woody senna, woody cassia
Senna pleurocarpa var. pleurocarpa	stripe-pod senna, firebush
Swainsona adenophylla	violet swainson-pea, wild violet
Swainsona affinis	small-leaf Swainson-pea, common poison pea
Swainsona campylantha	
Swainsona canescens	grey swainson-pea
Swainsona colutoides	bladder swainson-pea, rattle-pod swainson-pea
Swainsona dictyocarpa	
Swainsona formosa	Sturt pea, Sturt's desert-pea
Swainsona microcalyx	wild violet
Swainsona microphylla	small-leaf swainson-pea
Swainsona oligophylla	
Swainsona oliveri	
Swainsona oroboides	variable swainson-pea, kneed Darling pea
Swainsona phacoides	dwarf swainson-pea, lilac Darling pea
Swainsona purpurea	purple swainson-pea
Swainsona stipularis	orange swainson-pea, orange Darling pea
Swainsona villosa	villous swainson-pea
Templetonia egena	broombush templetonia, desert broombush
Tephrosia sphaerospora	mulga trefoil
**Trifolium dubium*	suckling clover, yellow suckling clover
**Trifolium tomentosum*	woolly clover, woolly-headed clover
Trigonella suavissima	sweet fenugreek, Cooper clover
**Vicia monantha*	spurred vetch, one-flower vetch

LILIACEAE

Arthropodium fimbriatum	nodding vanilla-lily, summer vanilla-lily
**Asphodelus fistulosus*	onion weed, wild onion
Bulbine alata	winged bulbine-lily, winged leek-lily
Bulbine semibarbata	small leek-lily, annual bulbine-lily
Murchisonia volubilis	
Thysanotus baueri	mallee fringe-lily
Thysanotus exiliflorus	inland fringe-lily
Wurmbea centralis ssp. australis	inland Nancy, inland star-lily
Wurmbea dioica ssp. citrina	green-flower Nancy, green-flower star-lily
Wurmbea stellata	star Nancy, star-lily

LIMONIACEAE

**Limonium sinuatum*	notch-leaf sea-lavender, perennial sea-lavender

LORANTHACEAE

Amyema gibberulum var. gibberulum	twin-flower mistletoe
Amyema maidenii ssp. maidenii	pale-leaf mistletoe
Amyema miquelii	box mistletoe
Amyema miraculosum ssp. boormanii	fleshy mistletoe

Loranthaceae (cont.)	
Amyema preissii	wire-leaf mistletoe
Amyema quandang var. quandang	grey mistletoe
Diplatia grandibractea	coolibah mistletoe
Lysiana exocarpi ssp. exocarpi	harlequin mistletoe
Lysiana murrayi	mulga mistletoe
Lysiana subfalcata	northern mistletoe
LYTHRACEAE	
Lythrum hyssopifolia	lesser loosestrife, small loosestrife
MALVACEAE	
Abutilon cryptopetalum	hill lantern-bush
Abutilon fraseri	dwarf lantern-bush
Abutilon halophilum	plains lantern-bush
Abutilon leucopetalum	desert lantern-bush, desert Chinese-lantern
Abutilon macrum	slender lantern-bush
Abutilon malvaefolium	scrambling lantern-bush, mallow lantern-bush
Abutilon otocarpum	desert lantern-bush, desert Chinese-lantern
Abutilon oxycarpum var. oxycarpum	straggly lantern-bush, flannel weed
Hibiscus brachysiphonius	low hibiscus
Hibiscus krichauffianus	velvet-leaf hibiscus
Hibiscus sturtii var. grandiflorus	Sturt's hibiscus, hill hibiscus
Hibiscus sturtii var. sturtii	Sturt's hibiscus, hill hibiscus
Lavatera plebeia	Australian hollyhock, native hollyhock
Lawrencia glomerata	clustered lawrencia, small golden-spike
Lawrencia squamata	thorny lawrencia, thorny fan-leaf
**Malva parviflora*	small-flower marshmallow, marshmallow
Malvastrum americanum	malvastrum, spiked malvastrum
Sida ammophila	sand sida
Sida calyxhymenia	tall sida, rock sida
Sida cunninghamii	ridge sida
Sida exedentifolia	
Sida fibulifera	pin sida, low sida
Sida filiformis	fine sida, ngau-ngau
Sida intricata	twiggy sida
Sida petrophila	rock sida
Sida spodochroma	
Sida trichopoda	high sida, narrow-leaf sida
MARSILEACEAE	
Marsilea costulifera	narrow-leaf nardoo
Marsilea drummondii	common nardoo
Marsilea exarata	swayback nardoo
Marsilea hirsuta	short-fruit nardoo
MYOPORACEAE	
Eremophila alternifolia	narrow-leaf emubush, scented emubush
Eremophila arachnoides ssp. tenera	spider emubush
Eremophila decussata	
Eremophila deserti	turkey-bush
Eremophila duttonii	harlequin emubush, Dutton's emubush
Eremophila freelingii	rock emubush, limestone fuchsia-bush

Myoporaceae (cont.)	
Eremophila gilesii	hairy-fruit emubush, Giles' emubush
Eremophila glabra	tar bush, common emubush
Eremophila latrobei ssp. glabra	crimson emubush, Latrobe's emubush
Eremophila longifolia	weeping emubush, long-leaf emubush
Eremophila macdonnellii	Macdonnell's emubush
Eremophila maculata var. maculata	spotted emubush, fuchsia bush
Eremophila neglecta	
Eremophila oppositifolia var. oppositifolia	opposite-leaved emubush, showy-sepal emubush
Eremophila paisleyi ssp. paisleyi	
Eremophila pentaptera	
Eremophila rotundifolia	round-leaf emubush
Eremophila scoparia	broom emubush, silvery emubush
Eremophila serrulata	green emubush, toothed emubush
Eremophila sturtii	turpentine bush, narrow-leaf emubush
Eremophila willsii ssp. integrifolia	Will's emubush
Myoporum brevipes	warty boobialla, pale myoporum
Myoporum montanum	native myrtle, water-bush
Myoporum platycarpum ssp. platycarpum	false sandalwood, sugarwood

MYRTACEAE

Calytrix gypsophila	gypsum fringe-myrtle
Darwinia micropetala	small darwinia
Darwinia salina	salt darwinia
Eucalyptus camaldulensis var. camaldulensis	river red gum, red gum
Eucalyptus camaldulensis var. obtusa	northern river red gum
Eucalyptus concinna	Victoria Desert mallee
Eucalyptus coolabah ssp. arida	coolibah, coolabah
Eucalyptus eucentrica	inland red mallee
Eucalyptus gracilis	yorrell, white mallee
Eucalyptus gypsophila	kopi mallee
Eucalyptus leptophylla	narrow-leaf red mallee
Eucalyptus oleosa	red mallee, acorn mallee
Eucalyptus socialis	beaked red mallee, summer red mallee
Eucalyptus striaticalyx	kopi mallee, Cue York gum
Eucalyptus youngiana	Ooldea mallee
Eucalyptus yumbarrana	Yumbarra mallee
Melaleuca eleutherostachya	hummock honey-myrtle
Melaleuca glomerata	inland paper-bark, white tea-tree
Melaleuca pauperiflora ssp. mutica	boree
Melaleuca uncinata	broombush, broom honey-myrtle
Melaleuca xerophila	boree
Thryptomene maisonneuvei	desert thryptomene

NYCTAGINACEAE

Boerhavia coccinea	tar-vine
Boerhavia dominii	tar-vine, tah-vine
Boerhavia schomburgkiana	Schomburgk's tar-vine

ONAGRACEAE

**Oenothera stricta ssp. stricta*	common evening primrose, sweet-scented evening primrose

OPHIOGLOSSACEAE

Ophioglossum lusitanicum	austral adder's-tongue
Ophioglossum polyphyllum	large adder's-tongue

OXALIDACEAE

Oxalis perennans	native sorrel, native oxalis

PITTOSPORACEAE

Pittosporum phylliraeoides var. microcarpa	native apricot, weeping pittosporum

PLANTAGINACEAE

Plantago drummondii	dark plantain, dark sago-weed
Plantago hispida	hairy plantain

POLYGONACEAE

**Acetosa vesicaria*	rosy dock, wild hops
**Emex australis*	three-corner jack, spiny emex
Muehlenbeckia coccoloboides	sandhill lignum
Muehlenbeckia florulenta	lignum, tangled lignum
Muehlenbeckia horrida	spiny lignum
**Polygonum aviculare*	wireweed, prostrate knotweed
Polygonum plebeium	small knotweed
**Rumex crispus*	curled dock
Rumex crystallinus	glistening dock, bristly dock

PORTULACACEAE

Anacampseros australiana	Australian anacampseros
Calandrinia calyptrata	pink purslane, small parakeelya
Calandrinia disperma	two-seed purslane
Calandrinia eremaea	dryland purslane, small purslane
Calandrinia polyandra var. polyandra	parakeelya
Calandrinia ptychosperma	creeping parakeelya
Calandrinia pumila	tiny purslane
Calandrinia remota	round-leaf parakeelya
Calandrinia reticulata	
Calandrinia volubilis	twining purslane
Portulaca intraterranea	buttercup purslane, inland purslane
Portulaca oleracea	common purslane, munyeroo

PRIMULACEAE

**Anagallis arvensis*	pimpernel, blue/scarlet pimpernel

PROTEACEAE

Grevillea huegelii	comb grevillea, comb spider-flower
Grevillea juncifolia	honeysuckle grevillea
Grevillea nematophylla	water bush
Hakea leucoptera ssp. leucoptera	silver needlewood, needle bush

RANUNCULACEAE

Myosurus minimus var. australis	mousetail
Ranunculus pentandrus var. pentandrus	smooth buttercup, inland buttercup
Ranunculus pentandrus var. platycarpus	smooth buttercup, inland buttercup
Ranunculus pumilio var. pumilio	ferny buttercup, small-flower buttercup

RESEDACEAE

**Reseda lutea*	cut-leaf mignonette, yellow mignonette

RUBIACEAE

Asperula gemella	twin-leaf bedstraw
Dentella pulvinata	
**Galium spurium ssp. ibicinum*	bedstraw
Pomax umbellata	pomax
Synaptantha tillaeacea	

RUTACEAE

Eremocitrus glauca	desert lime, wild lime

SANTALACEAE

Exocarpos aphyllus	leafless cherry, leafless ballart
Santalum acuminatum	quandong, native peach
Santalum lanceolatum	plumbush, northern sandalwood
Santalum spicatum	sandalwood, Australian sandalwood

SAPINDACEAE

Alectryon oleifolius ssp. canescens	bullock bush, cattle bush
Dodonaea lobulata	lobed-leaf hop-bush, lobed hop-bush
Dodonaea microzyga var. microzyga	brilliant hop-bush
Dodonaea stenozyga	desert hop-bush
Dodonaea viscosa ssp. angustissima	narrow-leaf hop-bush, slender hop-bush

SCROPHULARIACEAE

Limosella curdieana var. "curdieana"	large mudwort
Mimulus repens	creeping monkey-flower
Peplidium aithocheilum	
Peplidium foecundum	dwarf peplidium
Peplidium muelleri	
Stemodia florulenta	bluerod

SOLANACEAE

Duboisia hopwoodii	pituri, pitcheri
Lycium australe	Australian boxthorn
**Lycium ferocissimum*	African boxthorn
**Nicotiana glauca*	tree tobacco, tobacco bush
Nicotiana occidentalis ssp. obliqua	western tobacco
Nicotiana rosulata ssp. rosulata	
Nicotiana simulans	native tobacco, wild tobacco
Nicotiana velutina	velvet tobacco
Solanum cleistogamum	shy nightshade

Solanaceae (cont.)	
Solanum coactiliferum	tomato-bush, western nightshade
Solanum ellipticum	velvet potato-bush, potato-bush
Solanum esuriale	quena
Solanum lacunarium	lagoon nightshade
Solanum lasiophyllum	flannel bush
**Solanum nigrum*	black nightshade, black-berry nightshade
Solanum oligacanthum	desert nightshade
Solanum orbiculatum ssp. orbiculatum	round-leaf nightshade
Solanum petrophilum	rock nightshade
Solanum quadriloculatum	plains nightshade, tomato bush
STACKHOUSIACEAE	
Stackhousia clementii	limestone candles
Stackhousia muricata	yellow candles, western candles
STERCULIACEAE	
Gilesia biniflora	western tar-vine
THYMELAEACEAE	
Pimelea microcephala ssp. microcephala	shrubby riceflower, shrubby riceflower
Pimelea simplex ssp. continua	desert riceflower
Pimelea simplex ssp. simplex	desert riceflower
Pimelea trichostachya	spiked riceflower, annual riceflower
TYPHACEAE	
Typha domingensis	narrow-leaf bulrush, narrow-leaf cumbungi
UMBELLIFERAE	
Daucus glochidiatus	native carrot, Australian carrot
Eryngium supinum	little devil
Eryngium vesiculosum	prostrate blue devil, prickfoot
Hydrocotyle trachycarpa	wild parsley
Trachymene glaucifolia	blue parsnip, wild parsnip
Trachymene ornata var. ornata	sponge-fruit trachymene, sponge-fruit
Uldinia ceratocarpa	creeping carrot
URTICACEAE	
Parietaria cardiostegia	mallee smooth-nettle, mallee pellitory
Parietaria debilis	smooth-nettle, shade pellitory
VERBENACEAE	
**Verbena officinalis*	common verbena, common vervain
**Verbena supina var. erecta*	trailing verbena
**Verbena supina var. supina*	trailing verbena
VIOLACEAE	
Hybanthus monopetalus	slender violet, slender violet-bush

ZYGOPHYLLACEAE

Nitraria billardierei	nitre-bush, Dillon bush
Tribulus eichlerianus	Eichler's caltrop, bull-head
Tribulus hystrix	spiky caltrop
**Tribulus terrestris*	caltrop, cat-head
Zygophyllum ammophilum	sand twinleaf
Zygophyllum angustifolium	scrambling twinleaf
Zygophyllum apiculatum	pointed twinleaf, gallweed
Zygophyllum aurantiacum	
Zygophyllum compressum	rabbit-ears twinleaf
Zygophyllum confluens	forked twinleaf
Zygophyllum crassissimum	thick twinleaf
Zygophyllum crenatum	notched twinleaf, lobed twinleaf
Zygophyllum emarginatum	notched twinleaf
Zygophyllum eremaeum	pale-flower twinleaf, climbing twinleaf
Zygophyllum glaucum	pale twinleaf
Zygophyllum howittii	clasping twinleaf
Zygophyllum iodocarpum	violet twinleaf
Zygophyllum ovatum	dwarf twinleaf
Zygophyllum prismatothecum	square-fruit twinleaf
Zygophyllum simile	white twinleaf

APPENDIX G

G: LIST OF ANIMALS KNOWN TO OCCUR IN THE KINGOONYA SOIL CONSERVATION DISTRICT

Sources: Read (1994), J.L. Read (pers. comm.), Ehmann and Tynan (1997), Bellchambers and Carpenter (1990), Read and Ebdon (1998), Read et al. (2000).
Names and taxonomic arrangement of birds follows Christidis and Boles (1994).

E denotes species that once occurred in the district but are now locally extinct in the wild.
EI denotes species that have been reintroduced to the District
* denotes introduced species.
? denotes species likely to occur, but not recorded within the Kingoonya SCD

MAMMALS

MONOTREMES

Echidnas

Tachyglossus aculeatus	Short-beaked Echidna

MARSUPIALS

Dasyurids (carnivorous marsupials)

Antechinomys laniger	Kultarr
Planigale gilesi	Paucident Planigale
Planigale tenuirostris	Narrow-nosed Planigale
Sminthopsis crassicaudata	Fat-tailed Dunnart
Sminthopsis macroura	Stripe-faced Dunnart
Sminthopsis ooldea	Ooldea Dunnart

Bettongs

Bettongia lesueur (EI)	Burrowing Bettong
Bettongia penicillata (E)	Brush-tailed Bettong

Bandicoots

Macrotis lagotis (EI)	Greater Bilby
Perameles bougainville (EI)	Western Barred Bandicoot

RODENTS

Rats And Mice

Leggadina forresti	Forrest's Mouse
Leporillus conditor (EI)	Greater Stick-nest Rat
**Mus domesticus*	House mouse
Notomys alexis	Spinifex Hopping-mouse
Notomys fuscus	Dusky Hopping-mouse
Pseudomys australis	Plains Rat
Pseudomys bolami	Native Mouse
Pseudomys desertor	Desert Mouse
Pseudomys hermannsburgensis	Sandy Inland Mouse
Rattus villosissimus	Long-haired Rat

WOMBATS

Lasiorhinus latifrons	Southern Hairy-nosed Wombat

KANGAROOS

Macropus fuliginosus	Western Grey Kangaroo
Macropus robustus	Euro
Macropus rufus	Red Kangaroo
Petrogale xanthopus (E)	Yellow-footed Rock-wallaby

BATS

Chalinolobus gouldii	Gould's Wattled Bat
Eptesicus pumilis	
Nycticeius balstoni	Western Broad-nosed Bat
Nycticeius greyi	Little Broad-nosed Bat
Nyctophilus geoffroyi	Lesser Long-eared Bat
Nyctophilus timoriensis	Central Long-eared Bat
Tachyglossus aculeatus	
Tadarida australis	White-striped Mastiff-bat
Tadarida planiceps	Little Mastiff-bat

RABBITS

**Oryctolagus cuniculus*	Rabbit

DOGS AND FOXES

**Canis lupus dingo*	Dingo
**Vulpes vulpes*	Fox

CATS

**Felis catus*	Cat

HORSES

**Equus caballus*	Horse

CATTLE, SHEEP AND GOATS

**Bos taurus*	European Cattle
**Capra hircus*	Goat
**Ovis aries*	Sheep

CAMELS

**Camelus dromedarius*	Arabian Camel

BIRDS

Taxonomy and the order of families follow that of Robinson et al (2000). Birds are listed under Order, Family, common name, genus and species.
* denotes introduced species.

STRUTHONIIFORMES –Ostriches, cassowaries and emus

Casuariidae

Emu	*Dromaius novaehollandiae*

GALLIFORMES – Megapodes, pheasants, quails and allies

Phasianidae

Stubble Quail	*Coturnix pectoralis*

ANSERIFORMES – Swans, geese, ducks and allies

Anatidae

Musk Duck	*Biziura lobata*
Freckled Duck	*Stictonetta naevosa*
Black Swan	*Cygnus atratus*
Australian Shelduck	*Tadorna tadornoides*
Australian Wood Duck	*Chenonetta jubata*
Pacific Black Duck	*Anas superciliosa*
Australasian Shoveler	*Anas rhynchotis*
Grey Teal	*Anas gracilis*
Chestnut Teal	*Anas castanea*
Pink-eared Duck	*Malacorhynchus membranaceus*
Hardhead	*Aythya australis*

PODICIPEDIFORMES - Grebes

Podicipedidae

Australasian Grebe	*Tachybaptus novaehollandiae*
Hoary-headed Grebe	*Poliocephalus poliocephalus*
Great Crested Grebe	*Podiceps cristatus*

PELICANIFORMES – Tropicbirds, gannets, boobies, darters, cormorants, pelicans and frigatebirds

Anhingidae

Darter	*Anhinga melanogaster*

Phalacrocoracidae

Little Pied Cormorant	*Phalacrocorax melanoleucos*
Pied Cormorant	*Phalacrocorax varius*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Great Cormorant	*Phalacrocorax carbo*

Pelicanidae

Australian Pelican	*Pelecanus conspicillatus*

CICONIIFORMES – Herons, bitterns, ibises, spoonbills and storks

Ardeidae

White-faced Heron	*Egretta novaehollandiae*
Little Egret	*Egretta garzetta*
White-necked Heron	*Ardea pacifica*
Great Egret	*Ardea alba*

Cattle Egret	*Ardea ibis*
Nankeen Night Heron	*Nycticorax caledonicus*
Glossy Ibis	*Plegadis falcinellus*
Australian White Ibis	*Threskiornis molucca*
Straw-necked Ibis	*Threskiornis spinicollis*
Royal Spoonbill	*Platalea regia*
Yellow-billed Spoonbill	*Platalea flavipes*

FALCONIFORMES – Ospreys, hawks, eagles, falcons and allies

Accipitridae	
Black-shouldered Kite	*Elanus axillaris*
Letter-winged Kite	*Elanus scriptus*
Black-breasted Buzzard	*Hamirostra melanosternon*
Black Kite	*Milvus migrans*
Whistling Kite	*Haliastur sphenurus*
Spotted Harrier	*Circus assimilis*
Swamp Harrier	*Circus approximans*
Brown Goshawk	*Accipiter fasciatus*
Collared Sparrowhawk	*Accipiter cirrhocephalus*
Wedge-tailed Eagle	*Aquila audax*
Little Eagle	*Hieraaetus morphnoides*
Falconidae	
Brown Falcon	*Falco berigora*
Australian Hobby	*Falco longipennis*
Black Falcon	*Falco subniger*
Peregrine Falcon	*Falco peregrinus*
Nankeen Kestrel	*Falco cenchroides*

GRUIFORMES – Cranes, rails, bustards and allies

Gruidae	
Brolga	*Grus rubicunda*
Rallidae	
Buff-banded Rail	*Gallirallus philippenis*
Australian Spotted Crake	*Porzana fluminea*
Spotless Crake	*Porzana tabuensis*
Purple Swamphen	*Porphyrio porphyrio*
Dusky Moorhen	*Gallinula tenebrosa*
Black-tailed Native-hen	*Gallinula ventralis*
Eurasian Coot	*Fulica atra*
Otididae	
Australian Bustard	*Ardeotis australis*

TURNICIFORMES – Button-quails

Turnicidae	
Little Button-quail	*Turnix velox*

CHARADRIIFORMES – Plains-wanderer, sandpipers and allies, Painted Snipe, stone-curlews, oystercatchers, stilts, plovers, dotterels, pratincoles, gulls and terns

Pedionomidae	
Plains Wanderer	*Pedionomus torquatus*
Scolopacidae	
Black-tailed Godwit	*Limosa limosa*

Eastern Curlew	*Numenius madagascariensis*
Marsh Sandpiper	*Tringa stagnatilis*
Common Greenshank	*Tringa nebularia*
Wood Sandpiper	*Tringa glareola*
Common Sandpiper	*Actitis hypoleucos*
Ruddy Turnstone	*Arenaria interpres*
Red-necked Stint	*Calidris ruficollis*
Sharp-tailed Sandpiper	*Calidris acuminata*
Curlew Sandpiper	*Calidris ferruginea*
Recurvirostridae	
Black-winged Stilt	*Himantopus himantopus*
Banded Stilt	*Cladorhynchus leucocephalus*
Red-necked Avocet	*Recurvirostra novaehollandiae*
Charadriidae	
Grey Plover	*Pluvialis squatarola*
Red-capped Plover	*Charadrius ruficapillus*
Oriental Plover	*Charadrius veredus*
Inland Dotterel	*Charadrius australis*
Black-fronted Dotterel	*Elseyornis melanops*
Red-kneed Dotterel	*Erythrogonys cinctus*
Banded Lapwing	*Vanellus tricolor*
Masked Lapwing	*Vanellus miles*
Glareolidae	
Oriental Pratincole	*Glareola maldivarum*
Australian Pratincole	*Stiltia isabella*
Laridae	
Silver Gull	*Larus novaehollandiae*
Gull-billed Tern	*Sterna nilotica*
Caspian Tern	*Sterna caspia*
Whiskered Tern	*Chlidonias hybridus*

COLUMBIFORMES – Pigeons and doves

Columbidae	
*Rock Dove	*Columba livia*
*Spotted Turtle Dove	*Streptopelia chinensis*
Common Bronzewing	*Phaps chalcoptera*
Flock Bronzewing	*Phaps histrionica*
Crested Pigeon	*Ocyphaps lophotes*
Diamond Dove	*Geopelia cuneata*
Peaceful Dove	*Geopelia placida*

PSITTACIFORMES – Cockatoos and parrots

Cacatuidae	
Galah	*Cacatua roseicapilla*
Little Corella	*Cacatua sanguinea*
Major Mitchell's Cockatoo	*Cacatua leadbeateri*
Cockatiel	*Nymphicus hollandicus*
Psittacidae	
Australian Ringneck	*Barnardius zonarius*
Blue-bonnet	*Northiella haematogaster*
Mulga Parrot	*Psephotus varius*
Budgerigar	*Melopsittacus undulatus*
Bourke's Parrot	*Neopsephotus bourkii*
Blue-winged Parrot	*Neophema chrysostoma*

Scarlet-chested Parrot	*Neophema splendida*

CUCULIFORMES - Cuckoos

Cuculidae	
Oriental Cuckoo	*Cuculus saturatus*
Pallid Cuckoo	*Cuculus pallidus*
Black-eared Cuckoo	*Chrysococcyx osculans*
Horsfield's Bronze Cuckoo	*Chrysococcyx basalis*

STRIGIFORMES - Owls

Strigidae	
Southern Boobook	*Ninox novaeseelandiae*
Tytonidae	
Barn Owl	*Tyto alba*

CAPRIMULGIFORMES – Frogmouths, nightjars and owlet-nightjars

Podargidae	
Tawny Frogmouth	*Podargus strigoides*
Caprimulgidae	
Spotted Nightjar	*Eurostopodus argus*
Aegothelidae	
Australian Owlet-nightjar	*Aegotheles cristatus*

APODIFORMES - Swifts

Apodidae	
White-throated Needletail	*Hirundapus caudacutus*
Fork-tailed Swift	*Apus pacificus*

CORACIIFORMES – Kingfishers, bee-eaters and rollers

Alcedinidae	
Red-backed Kingfisher	*Todiramphus pyrrhopygia*
Meropidae	
Rainbow Bee-eater	*Merops ornatus*

PASSERIFORMES - Songbirds

Climacteridae	
White-browed Treecreeper	*Climacteris affinis*
Maluridae	
Splendid Fairy-wren	*Malurus splendens*
Variegated Fairy-wren	*Malurus lamberti*
White-winged Fairy-wren	*Malurus leucopterus*
Thick-billed Grasswren	*Amytornis textilis*
Pardalotidae	
Red-browed Pardalote	*Pardalotus rubricatus*
Striated Pardalote	*Pardalotus striatus*
Acanthizidae	
Rufous Fieldwren	*Calamanthus campestris*
White-throated Gerygone	*Gerygone olivacea*
Chestnut-rumped Thornbill	*Acanthiza uropygialis*
Inland Thornbill	*Acanthiza apicalis*
Slender-billed Thornbill	*Acanthiza iredalei*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*

Southern Whiteface	*Aphelocephala leucopsis*
Banded Whiteface	*Aphelocephala nigricincta*
Chestnut-breasted Whiteface	*Aphelocephala pectoralis*
Meliphagidae	
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*
Yellow-throated Miner	*Manorina flavigula*
Singing Honeyeater	*Lichenostomus virescens*
Grey-fronted Honeyeater	*Lichenostomus plumulus*
White-plumed Honeyeater	*Lichenostomus penicillatus*
White-fronted Honeyeater	*Phylidonyris albifrons*
Pied Honeyeater	*Certhionyx variegatus*
Crimson Chat	*Epthianura tricolor*
Orange Chat	*Epthianura aurifrons*
White-fronted Chat	*Epthianura albifrons*
Gibberbird	*Ashbyia lovensis*
Petroicidae	
Red-capped Robin	*Petroica goodenovii*
Hooded Robin	*Melanodryas cucullata*
Pomatostomidae	
White-browed Babbler	*Pomatostomus superciliosus*
Eupetidae	
Chiming Wedgebill	*Psophodes occidentalis*
Chirruping Wedgebill	*Psophodes cristatus*
Cinnamon Quail-thrush	*Cinclosoma cinnamomeum*
Neosittidae	
Varied Sittella	*Daphoenositta chrysoptera*
Pachycephalidae	
Crested Bellbird	*Oreoica gutturalis*
Rufous Whistler	*Pachycephala rufiventris*
Grey Shrike-thrush	*Colluricincla harmonica*
Dicruridae	
Restless Flycatcher	*Myiagra inquieta*
Magpie-lark	*Grallina cyanoleuca*
Grey Fantail	*Rhipidura albiscapa*
Willie Wagtail	*Rhipidura leucophrys*
Artamidae	
White-breasted Woodswallow	*Artamus leucorhynchus*
Masked Woodswallow	*Artamus personatus*
White-browed Woodswallow	*Artamus superciliosus*
Black-faced Woodswallow	*Artamus cinereus*
Grey Butcherbird	*Cracticus torquatus*
Australian Magpie	*Gymnorhina tibicen*
Campephagidae	
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Ground Cuckoo-shrike	*Coracina maxima*
White-winged Triller	*Lalage tricolor*
Corvidae	
Australian Raven	*Corvus coronoides*
Little Crow	*Corvus bennetti*
Muscicapidae	
*Eurasian Blackbird	*Turdus merula*
Sturnidae	
*Common Starling	*Sturnus vulgaris*
Hirundinidae	

White-backed Swallow	*Cheramoeca leucosternus*
Barn Swallow	*Hirundo rustica*
Welcome Swallow	*Hirundo neoxena*
Tree Martin	*Petrochelidon nigricans*
Fairy Martin	*Petrochelidon ariel*
Sylviidae	
Australian Reedwarbler	*Acrocephalus australis*
Little Grassbird	*Megalurus gramineus*
Rufous Songlark	*Cinclorhamphus mathewsi*
Brown Songlark	*Cinclorhamphus cruralis*
Dicaeidae	
Mistletoebird	*Dicaeum hirundinaceum*
Passeridae	
*House Sparrow	*Passer domesticus*
Motacillidae	
Richard's Pipit	*Anthus novaeseelandiae*
Estrildidae	
Zebra Finch	*Taeniopygia guttata*
Painted Finch	*Emblema pictum*

REPTILES AND AMPHIBIANS

The list from KSCB (1996) has been updated with additional records from Ehmann and Tynan (1997).
? indicates records requiring confirmation.

LIZARDS

Geckoes	
Diplodactylus byrnei	Gibber Gecko
Diplodactylus ciliaris	Spiny-tailed Gecko
Diplodactylus conspicillatus	Fat-tailed Diplodactylus
Diplodactylus damaeus	Beaded Gecko
Diplodactylus elderi	Jewelled Gecko
Diplodactylus galeatus	Mesa Gecko
Diplodactylus stenodactylus	
Diplodactylus tessellatus	Tessellated Gecko
Gehyra purpurascens	
Gehyra variegata	Tree Dtella
Heteronotia binoei	Bynoe's Gecko
Nephrurus deleani	Pernatty Knob-tailed Gecko
Nephrurus levis	Knob-tailed Gecko
Nephrurus milii	Barking Gecko
Rhynchoedura ornata	Beaked Gecko
Legless Lizards	
Delma australis	Legless Lizard
Delma butleri	
Delma nasuta	
Lialis burtonis	Burton's Snake Lizard
Pygopus lepidopodus	Common Scaly-foot
Pygopus nigriceps	Black-headed Scaly-foot
Dragon Lizards	
Ctenophorus cristatus	Crested Dragon
Ctenophorus fionni	Arcoona Dragon
Ctenophorus fordi	Mallee Dragon
Ctenophorus gibba	Gibber Dragon
Ctenophorus isolepis	Military Dragon
Ctenophorus junjalca	
Ctenophorus maculosus	Lake Eyre Dragon
Ctenophorus nuchalis	Central Netted Dragon
Ctenophorus pictus	Painted Dragon
Ctenophorus reticulatus	Western Netted Dragon
Ctenophorus vadnappa	Red-barred Dragon
?Diporiphora winneckei	Two-lined Dragon
Moloch horridus	Thorny Devil
Pogona minor	Western Bearded Dragon
Pogona vitticeps	Bearded Dragon
Tympanocryptis intima	Gibber Earless Dragon
Tympanocryptis lineata	Lined Earless Dragon
Tympanocryptis tetraporophora	Long-tailed Earless Dragon
Goannas	

Varanus gilleni	Pygmy Mulga Monitor
Varanus gouldii	Gould's Goanna
Skinks	
Cryptoblepharus plagiocephalus	
Ctenotus brooksi	Striped Skink
Ctenotus leae	Striped Skink
Ctenotus leonhardii	Striped Skink
Ctenotus olympicus	Striped Skink
Ctenotus regius	Striped Skink
Ctenotus robustus	
Ctenotus schomburgkii	Striped Skink
Ctenotus strauchii	Striped Skink
Egernia stokesii	Stoke's Skink
Eremiascincus richardsonii	Broad-banded Sand Swimmer
Lerista bipes	
Lerista bougainvillii	
Lerista desertorum	
Lerista dorsalis	
Lerista elongata	
Lerista labialis	
Lerista muelleri	
Lerista terdigitata	
Lerista xanthura	
Menetia greyii	Greys Skink
Morethia adelaidensis	Snake-eyed Skink
Morethia boulengeri	Snake-eyed Skink
Morethia butleri	
Tiliqua occipitalis	Western Blue Tongue
Trachydosaurus rugosus	Sleepy Lizard

SNAKES

Blind Snakes	
Ramphotyphlops australis	Blind Snake
Ramphotyphlops bituberculatus	Blind Snake
Ramphotyphlops endoterus	Blind Snake
Pythons	
?Aspidites ramsayi	Woma
Antaresia stimsoni	Large-blotched Python

Elapid Snakes

Demansia psammophis	Yellow-faced Whip Snake
Furina ornata	Orange-naped Snake
Pseudechis australis	Mulga or King Brown Snake
Pseudonaja modesta	Ringed Brown Snake
Pseudonaja nuchalis	Western Brown Snake
Simoselaps bertholdi	Desert Banded Snake
Simoselaps bimaculatus	Western Black-naped Snake
Simoselaps fasciolatus	Narrow-banded Snake
Suta monachus	Monk Snake
Suta suta	Curl Snake

FROGS

Cyclorana platycephala	Water-holding Frog
Litoria rubella	Brown Tree Frog
Neobatrachus centralis	Trilling Frog

FISH

Craterocephalus eyresii	Lake Eyre Hardyhead
**Gambusia holbrooki*	Plague minnow