GAWLER RANGES

SOIL CONSERVATION DISTRICT PLAN

REVISED 2004

Gawler Ranges Soil Conservation Board

Government of South Australia

Soil Conservation Council of South Australia

FOREWORD

The Gawler Ranges Soil Conservation Board would like to present to you a copy of its revised District Plan.

The objectives of the plan are: -

- To broadly describe the various land systems and their associated vegetation types,
- To describe the soil and vegetation conservation problems and their associated management techniques
- To convey practices, which promote sound stock management, which will minimise damage to the land and ensure sustainable use of the natural resources.

The plan also describes the district's history and future land use, climate, geology, water resources, land capability and production.

The Gawler Ranges Soil Conservation Board believes that the document is a valuable reference not only for the new comer to the area but also for someone that has lived his or her entire life in the district.

The Board urges you to read and also make use of this progressive document.

Andrew Smart,
Chairperson, Gawler Ranges Soil Conservation Board.

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Front Cover: -
Photo of Pyramid Hills, near Deep Well H.P by Sandy Morris.

ABBREVIATIONS/GLOSSARY

COAG	Council of Australian Governments
DEH	Department for Environment and Heritage, South Australia
DWLBC	Department of Water, Land and Biodiversity Conservation
GIS	Geographic Information System
ICM	Integrated Catchment Management
INRM	Integrated Natural Resource Management
NHT	Natural Heritage Trust.
NLWRA	National Land and Water Resources Audit
NPWSA	National Parks and Wildlife, South Australia.
NRDB	Northern Regional Development Board.
NRM	Natural Resource Management
PIRSA	Primary Industries and Resources, South Australia.
PMIS	Pastoral Management Information System, maintained by the Pastoral Program in WLBC.
RAP	Rangeland Action Project.
RCD	Rabbit Calici Virus, a viral disease which only affects Europe Rabbits, which has spread throughout most of Australia where rabbits occur, since the escape from Wardang Island in October 1995.
RSBEX	Rangeland Soil Board Executive Committee, formed in 1998, initially to produce the rangelands regional Strategy. Made up of Chairpersons (or their representatives) from the seven rangeland soil boards. Currently also responsible for managing the RAP.
RSSA	Rural Solutions South Australia, an agricultural consulting business unit within PIRSA.
SB	Soil Boards, full name is Soil Conservation Boards.
SAMLISA	Strategy for Aboriginal Managed Lands in South Australia.
SSIR	Supporting Sustainable Industries in the Rangelands.
SRRP	Southern Rangelands Rural Plan.
TSA	Transport SA

SUMMARY

The Gawler Ranges Soil Conservation District (SCD) is located across the north of Eyre Peninsula. The dominant land uses within the District are grazing stock on native pastures, iron ore extraction and conservation.

The Gawler Ranges lie on the southern boundary of the arid zone. The District has hot, very dry summers, cool to mild winters and a low annual rainfall. The rainfall variability from year to year is moderate to high. Mean annual rainfall totals range from less than 200 mm in the northeast to around 300 mm in the southwest of the District.

The vegetation, soils, topography, and geology of the Gawler Ranges SCD have been described as ten Land Systems. These land systems describe the variety of country in the District which includes sand dunes and flats with mulga *(Acacia aneura)* woodland, calcareous plains with mulga, western myall and/or blackoak overstorey and chenopod[1] understorey, gibber tablelands with chenopod and samphire[2] shrublands and granitic hills with mallee woodland and porcupine grassland *(Triodia irritans)*.

The water resources of the District are limited; they're being only a few reliable wells and a few springs. The pastoral industry uses a combination of surface water catchments and storages and bore water, which; if of good quality and supply is piped sometimes long distances to tanks. Some stations use water from the Murray River piped through the Woomera and Iron Knob branches of the Morgan-Whyalla Pipeline.

The sustainable management of the soil, vegetation and water resources of this District is achieved by sound stock management on the pastoral lands, and in the case of mineral exploration, extraction and defence operations, and effective rehabilitation.

The land management problems which occur in the District are; loss of perennial vegetation, control of rabbit, goat and kangaroo populations, water erosion on gilgai tablelands and drainage lines, erosion by wind of light textured soils where vegetation is sparse, lack of suitable stock water and damage to vegetation by fire. Woody shrub increase and dryland salinity appear to occur to a minor extent in the District.

Maintenance of the native pasture resource through the management of stock grazing and feral animal and kangaroo populations is the key to the sustainable use of these lands. Stock management through appropriate flock/herd numbers, fencing, water location, and stock handling procedures is the pastoralist's most powerful tool. Other tools, which need to be part of the management of a pastoral enterprise, are land condition monitoring, drought strategies, and feral animal control.

Minimising the impacts of mineral exploration and extraction, defence force exercises, and tourism will involve public education and may include restricting access and where necessary active rehabilitation. Active conservation in dedicated conservation areas and on pastoral and mining leases will provide for the long-term survival of the regions native animal and plant diversity.

[1] Chenopods are plants of the family Chenopodiaceae, this family of plants includes saltbushes, bluebushes, bindyis, copperburrs, fat hen and nitre bush.

[2] Samphire is a salt tolerant chenopod, which commonly occurs on the saline soils of salt lake and pan margins.

INTRODUCTION

THE GAWLER RANGES SOIL CONSERVATION BOARD

The Gawler Ranges Soil Conservation District (SCD) was gazetted on the sixth of April 1989 and the Board held its first meeting in October 1989.

The members of the Gawler Ranges Soil Conservation Board are appointed for a three-year term and are land managers who live and work within the District. The current Board members, their portfolios and contact information is as follows:

Andrew Smart (Chairperson/Kangaroo Management)	Wilkatana Station	Phone 8642 3642
Angus McTaggart (Secretary/Pastoral Production)	Nonning Station	Phone 8648 1814
Craig Nixon (Biodiversity)	Gawler Ranges National Park	Phone 8648 1883
Jane Anderson (Media Liaison)	Cooyerdoo Station	Phone 8646 2097
Sandy Morris (Feral Animals)	Yardea Station	Phone 8648 1880
Christina Haigh (Weeds)	Kondoolka Station	Phone 8648 1886

Members of previous Boards who have contributed are Geoff Mills, Philip Elson, Newton Simpson, Robert Lord, Lester Lord, Andrew Nicolson, Richard Fox, Tony Johnson, Andrew Mc Taggart, Tiffany Lord, Sarah Nicolson, Ashleigh Wilson and Joan Andrew.

DUTY OF LAND MANAGERS

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

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

ROLE OF THE BOARD

The Gawler Ranges Soil Conservation Board is responsible for:

- Administering the *Soil Conservation and Landcare Act* within its District;
- Co-ordinating soil conservation activities in the Gawler Ranges Soil Conservation District;
- Developing community awareness and involvement in land management issues;
- Providing technical advice and assistance to land holders;
- Liaison with the Pastoral Board;
- Encouraging landowners in their duty to take all reasonable steps to prevent degradation of land.

AIMS OF THE BOARD

The aims of the Gawler Ranges Soil Conservation Board are to:

- Provide members of Gawler Ranges community with the means to comprehensively understand the natural resources that they manage
- Promote an integrated approach to land management and an understanding of the relationships between feral animal control, total grazing pressure, weed control, vegetation decline and the native fauna communities (integration of issues)
- Provide information that will enhance the economic performance where there is a link with ecological values
- Investigate information and management practices of tourism
- Work closely with RSBEX and the INRM group and encourage involvement in RAP

OBJECTIVES OF THE DISTRICT SOIL CONSERVATION PLAN

The District Plan has been developed as required by the provisions of the *Soil Conservation and Land Care Act 1989*. The objectives of the Gawler Ranges Soil Conservation District Plan are to: -

- Provide an inventory of the natural resources, and soil conservation problems which occur in the District;

- Provide guidelines and recommendations for the management of land in the District to help ensure that it is used within its capability;

- Determine land resource management priorities within the District;

- Communicate the objectives and plans of the Soil Conservation Board to the Gawler Ranges District community and to other interested people and agencies;

- Provide a Three Year Program of activities to promote sound land management within the District.

REVIEW

This review of the District Plan will occur approximately every three years when the plan will be updated, including the Program of Activities for the Board. Ongoing consultation with the community is recognised by the Board as necessary to maintain the relevance of this plan and the Board's activities to the current land management issues within the District.

It is vital that each of the Soil Board District Plans link and relate to other groups and their respective planning initiatives in the region. Some of these include the Integrated Natural Resource Management Group, Arid Water Catchment Management Board, Pastoral Board, RSBEX, APCC, NPWSA, Outback Areas Community Development Trust, Local Councils, Outback SA, and relevant Aboriginal Groups and Mining Groups.

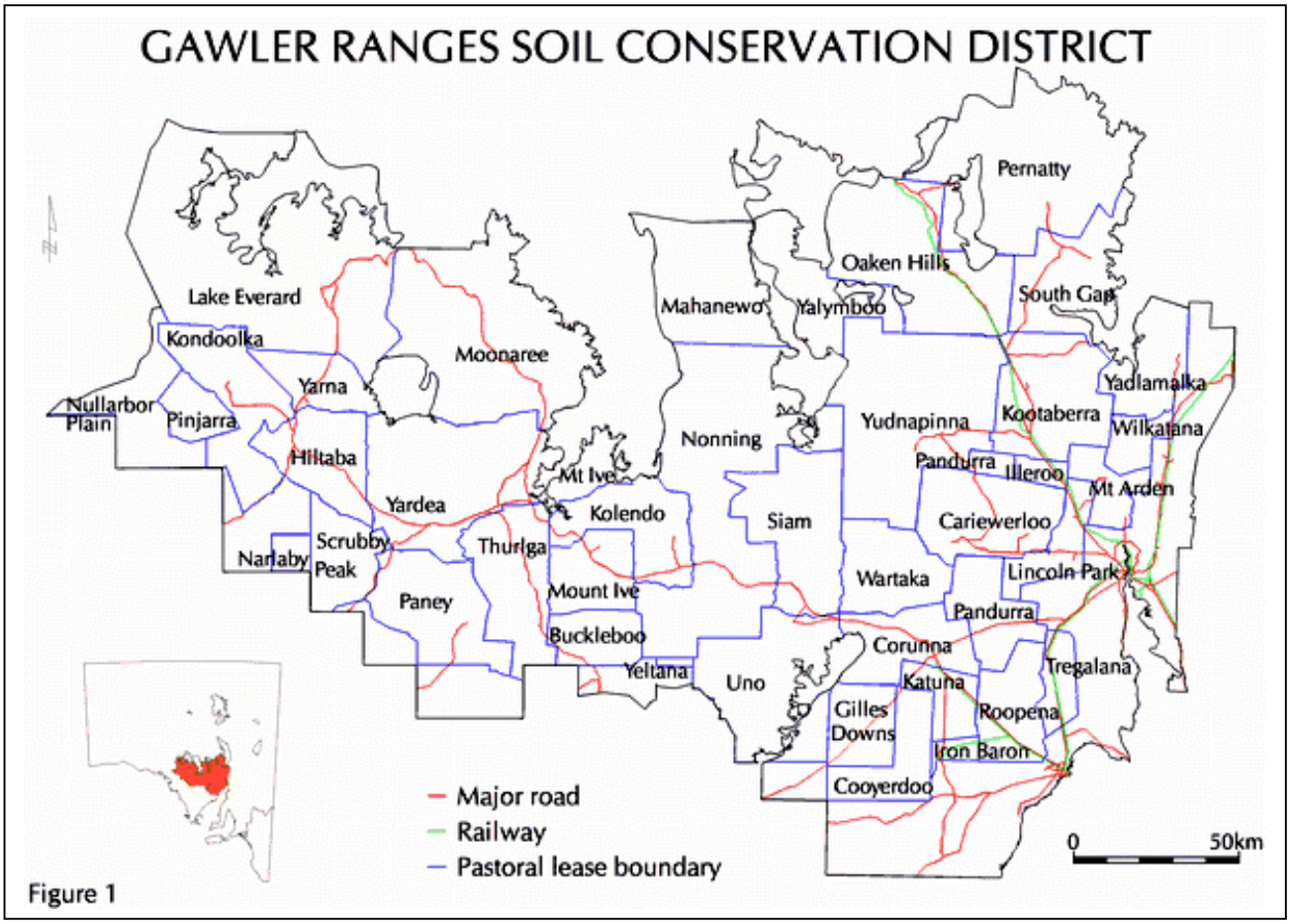
DESCRIPTION OF THE DISTRICT

THE GAWLER RANGES SOIL CONSERVATION DISTRICT

The Gawler Ranges Soil Conservation District is located to the north of Eyre Peninsula in the Pastoral region of South Australia. The District covers an area of 51,900 square kilometres, and comprises 53 pastoral leases, a small number of perpetual leases, an army reserve, two major towns, Port Augusta and Whyalla and parks including; Lake Gilles, Whyalla and Winnowie Conservation Parks and Gawler Ranges National Park

The variety of landscapes in the District include; sand dunes and flats with mulga woodland, calcareous plains with mulga, western myall and/or blackoak overstorey and chenopod understorey, gibber tablelands with chenopod and samphire shrublands and granitic hills with mallee woodland and porcupine grassland.

Figure 1 Location of the Gawler Ranges Soil Conservation District.



CLIMATE

Climatic Controls

The Gawler Ranges lie on the southern boundary of the arid zone. The District has hot, very dry summers, cool to mild winters and a low annual rainfall.

Seasonal variation in the weather patterns is influenced by the location of large-scale high-pressure systems, which form the sub-tropical ridge (see Figure 2). During the warmer part of the year (October to March), the ridge is located south of the continent, and the prevailing surface winds over most of the District are from the southern quadrant. In autumn the mean position of the ridge moves north and from May to September the Gawler Ranges lie south of the ridge axis. Winds are generally from the northwest to southwest quadrants during this time.

Winds

While the large-scale pressure features (Figure 2) determine the broad-scale wind flow, topography can have a marked effect on local wind speed and direction. On the coast, afternoon sea breezes will commonly override the broad-scale regime; over land, during the night and early morning when stable conditions prevail, the wind may drop to calm.

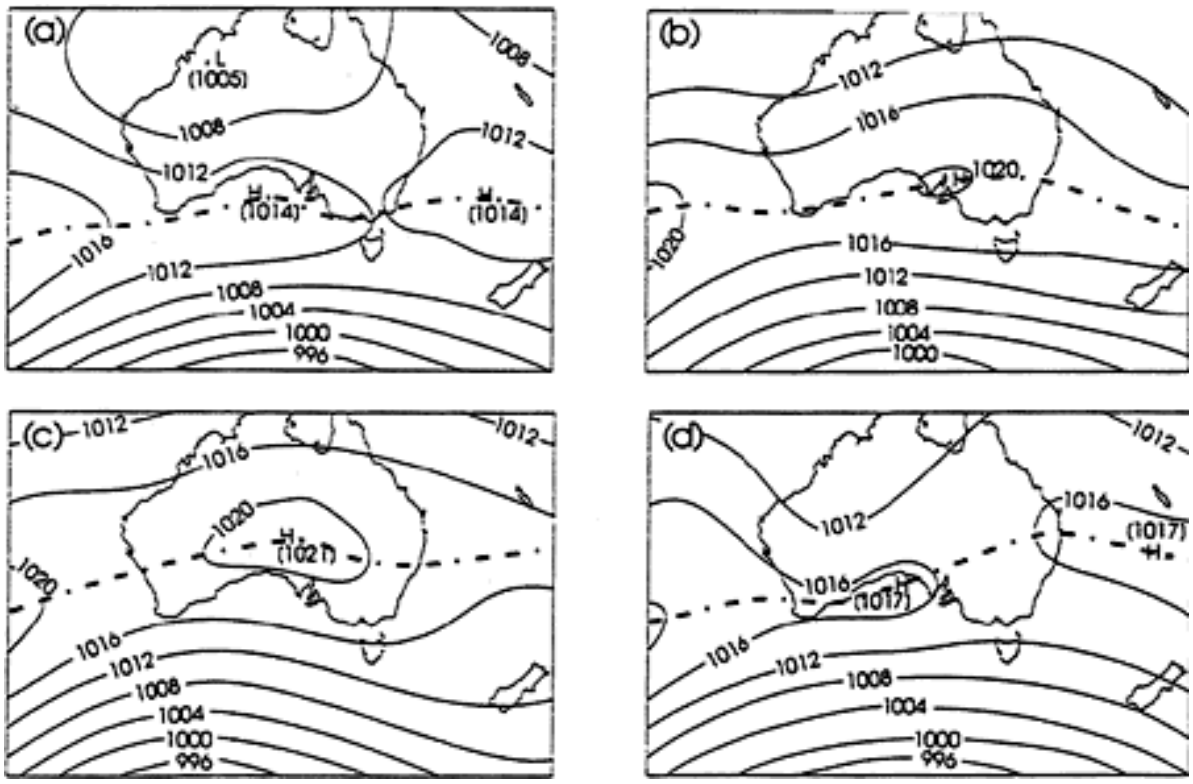


Figure 2. The average mean sea level pressure pattern for January, April, July, and October. (Units are in hectoPascals.) The subtropical ridge (**- - - -**) south of the continent in summer, moves northwards in April and is located north of Gawler Ranges Soil Conservation District from May to September. (Source: National Meteorological Operations Centre, Bureau of Meteorology)

Wind observations are available at Nonning, Woomera, Port Augusta and Whyalla. The Port Augusta and Whyalla records clearly show the local effect of the sea breeze along the coast throughout the year.

Across the District, from December to March, the prevailing air stream is from the south to southeast, but during the day it is common for the wind to turn southwesterly. Speeds are typically 10 - 30 km/hr.

Between April and June, light variable conditions are common, but in July and August, winds generally have a westerly component (from the north-northwest through to the south-southwest). Throughout this period speeds are typically less than 20 km/hr.

From September to November, no directional preference exists, and the strength generally ranges up to 30 km/hr.

The frequency of observed strong winds (greater than 41 kph) is shown at Table 1. On average, the most frequent strong winds are observed during spring (September to November) at inland locations, and in December and January along the coast. Gales (wind strength in excess of 62 kph) are uncommon. They are estimated to occur on average, around two to three times per year inland, and slightly more frequently along the coast.

Table 1. Average number of days per month that strong winds are observed at Nonning, Woomera, Port Augusta, and Whyalla. An asterisk (*) indicates less than 0.5 days per month.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Nonning	*	*	*	*	*	*	*	1	1	1	*	*
Woomera	4	3	2	2	2	1	3	4	5	6	5	4
Pt Augusta	10	7	5	2	2	1	3	3	6	8	8	10
Whyalla	1	1	1	1	*	1	1	2	2	2	2	1

Rainfall

Rainfall variability from year to year is moderate to high. Mean annual rainfall totals range from less than 200mm in the northeast to around 300mm in the southwest of the District. In the south, a weak winter rainfall maximum is evident, but this is not observed in the more erratic rainfall regime northeast of the ranges.

Northwest cloud bands originating over the Indian Ocean, are an important but infrequent source of rain for the District. From time to time in the cooler part of the year, frontal systems in the westerly stream produce significant falls in the south, but it is rare for these to extend north of the ranges. Isolated summer thunderstorms may produce intense, but generally brief rain showers.

Historical rainfall records for selected stations are graphed in Figures 3 to 7. These show:

- The annual, and May to October totals for each year since records commenced;
- The median annual rainfall at each station (line M);
- The lowest 10% of annual totals on record (line D1); and
- The highest 10% of annual totals on record (line D9).

Mean values provide limited information about the rainfall regime of a locality, particularly where there is marked variability from year to year. Decile values (see Appendix A) which show the likelihood (or chance) of receiving less than, or more than, a threshold amount in a given period (e.g. January, winter, one year etc) can supplement the mean rainfall data by providing a measure of rainfall reliability. For example, the decile 1 value (shown by line D1 in Figures 3 to 7) delineates the lowest 10% of falls on record. In other words, on average, one in ten years receives less than the decile 1 value, or alternatively, nine in ten receive more than this amount. There is a 50% chance of receiving less than, or more than, the decile 5 value (shown as the median in Figures 3 to 7).

In the northeast of the District, the annual decile 1 value is less than 100mm. In this area, landholders can expect that in one in ten years, on average, the annual rainfall will be below 100mm. In the south, based on the decile 1 value, the one in ten expectation is an annual fall less than 180mm.

Drought Years

The term drought refers to an acute water shortage, although the amount of available water depends to a large extent on storage (in the soil, in artesian basins and in dams and reservoirs) and in losses from evaporation. A lack of wind may limit the availability of underground water (wind drought) and a lack of soil moisture the availability of feed (feed drought). However, the best *single* indicator of water availability is rainfall. Gibbs and Maher (1967) showed that years with an annual rainfall in the first decile range (i.e. in the lowest 10% of falls) correspond well with droughts recorded in other sources. Using this simple guide and rainfall records from a number of stations across the District, 12 years (since 1895) are identified as periods in which drought affected extensive areas of the District. These years are: 1897, 1902, 1914, 1927, 1928, 1929, 1940, 1943, 1948, 1957, 1967, 1982, and 2002. Some drought periods have extended for two years or more, e.g. in the late twenties some stations remained in near drought conditions from 1926 until 1930.

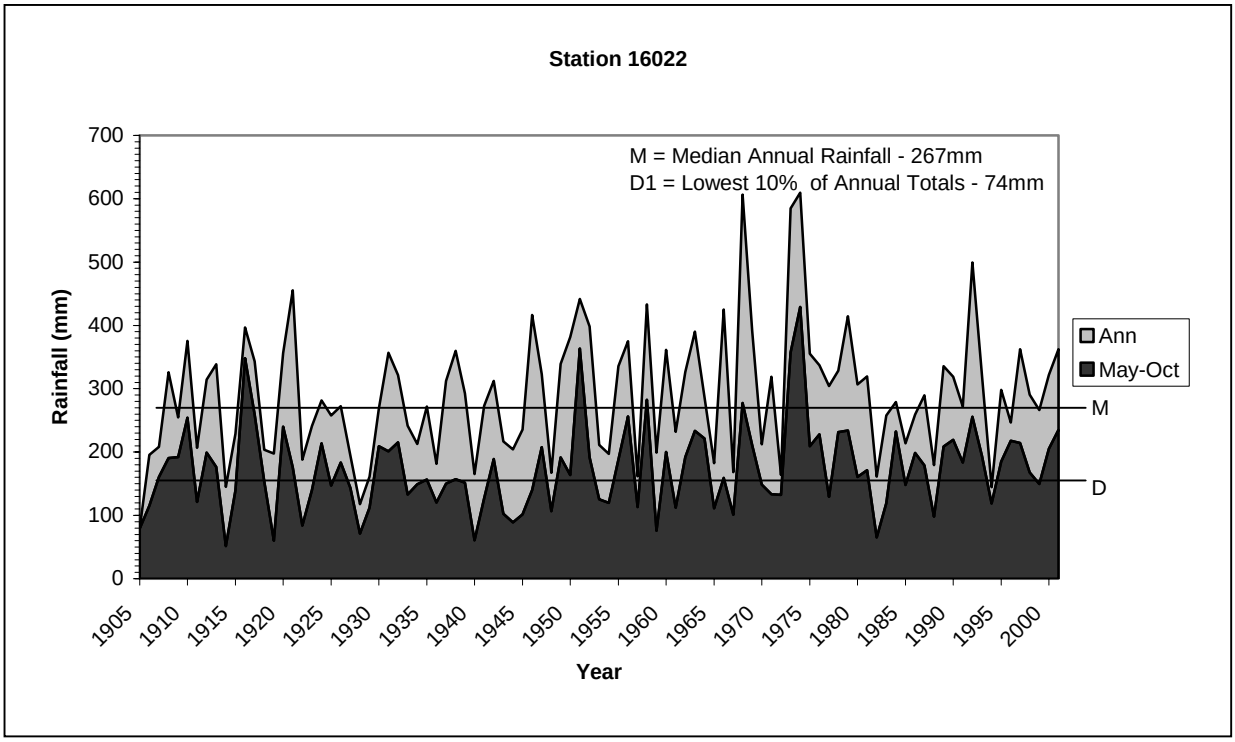


Figure 3. The historical rainfall record for Kondoolka (Station No 16022).

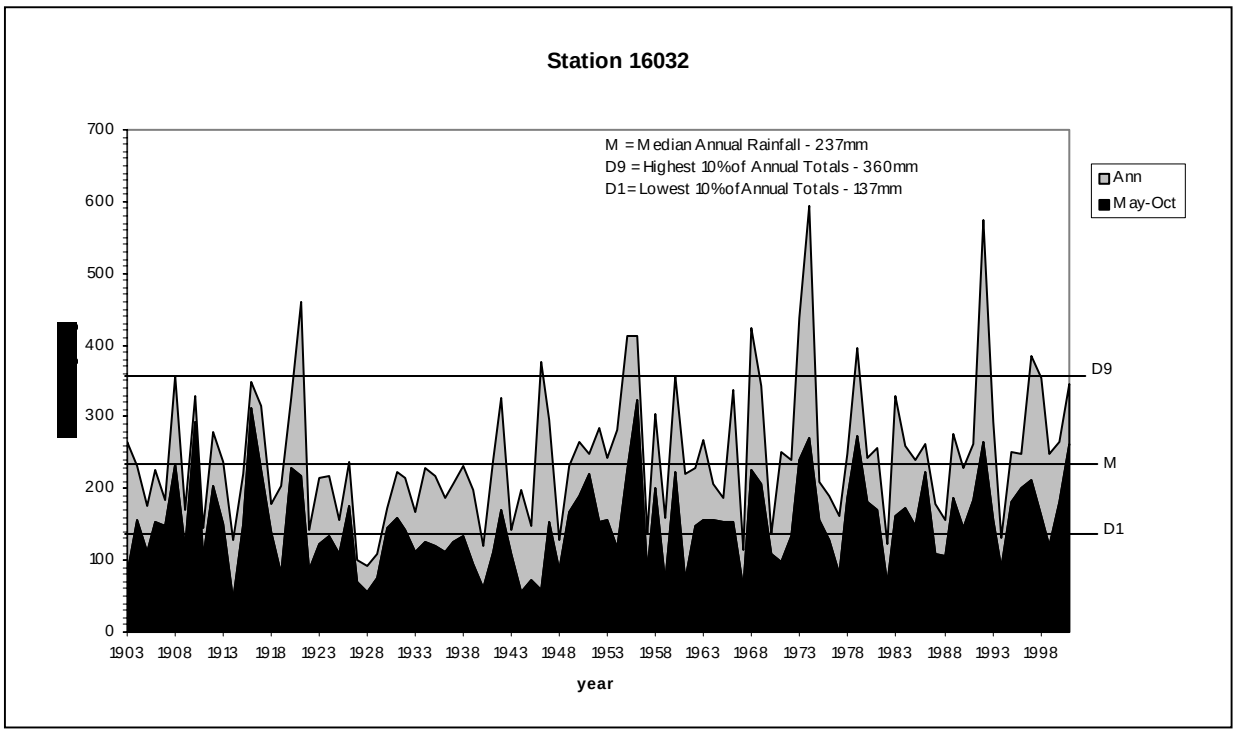


Figure 4. The historical rainfall record for Nonning (Station No. 16032), at 32°31'S, 136°29'E (elevation 205m). The annual and May to October totals are graphed, and the annual median (M), the lowest 10% of annual totals (D1), and the highest 10% of annual totals (D9) marked.

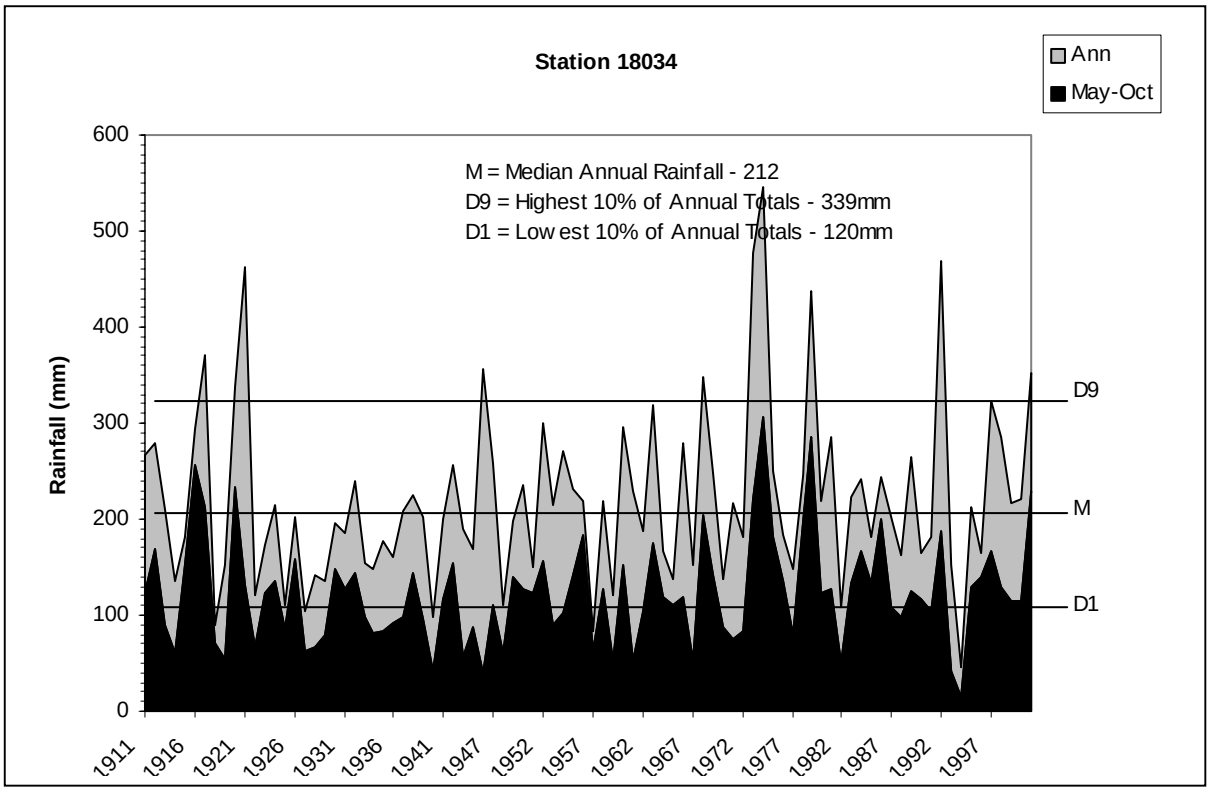


Figure 5. The historical record for Iron Knob Post Office (Station No. 18034), at 32°44'S, 137°09'E (elevation 177m). Data are incomplete for the year 1943. See Fig 4 for further explanation.

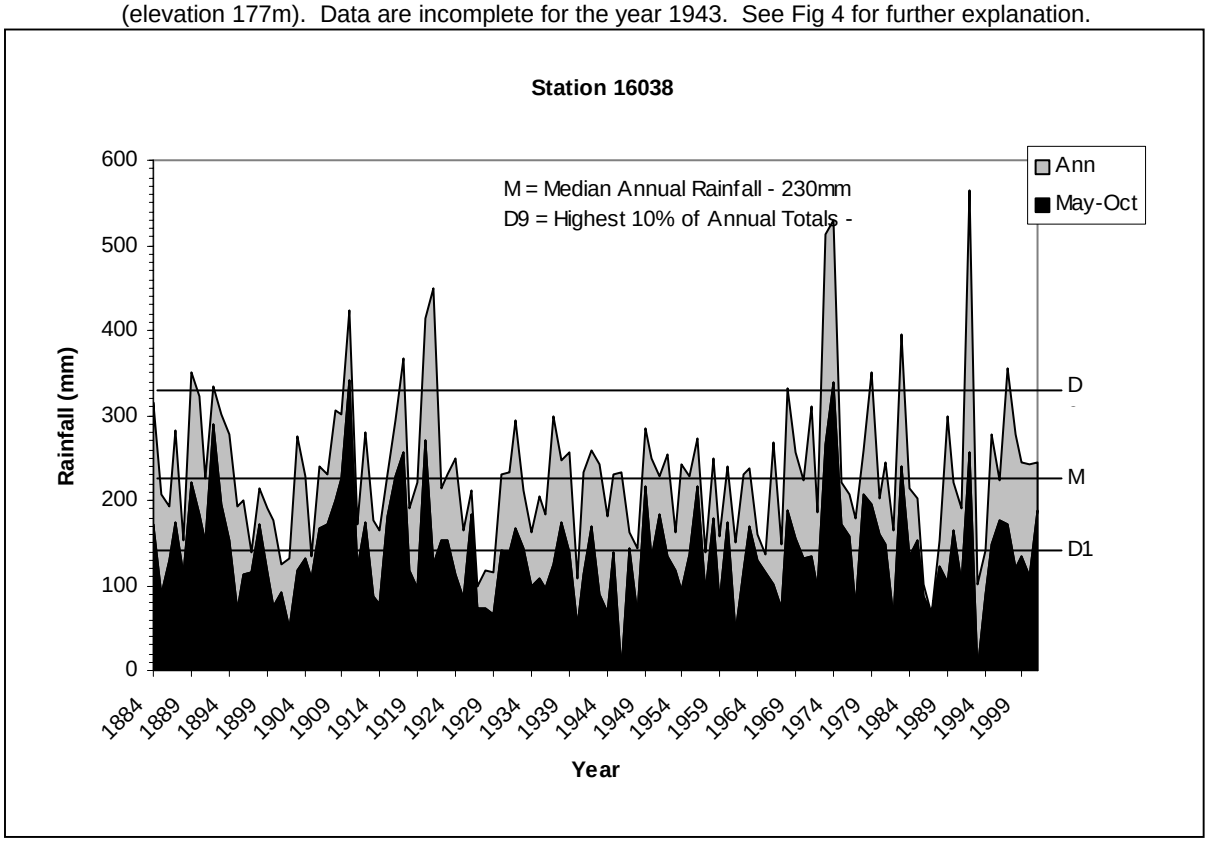


Figure 6. The historical rainfall record for Port Augusta West (Station No. 16038) at 32°29'S, 137°45'E (elevation 9m). See Fig 4 for further explanation.

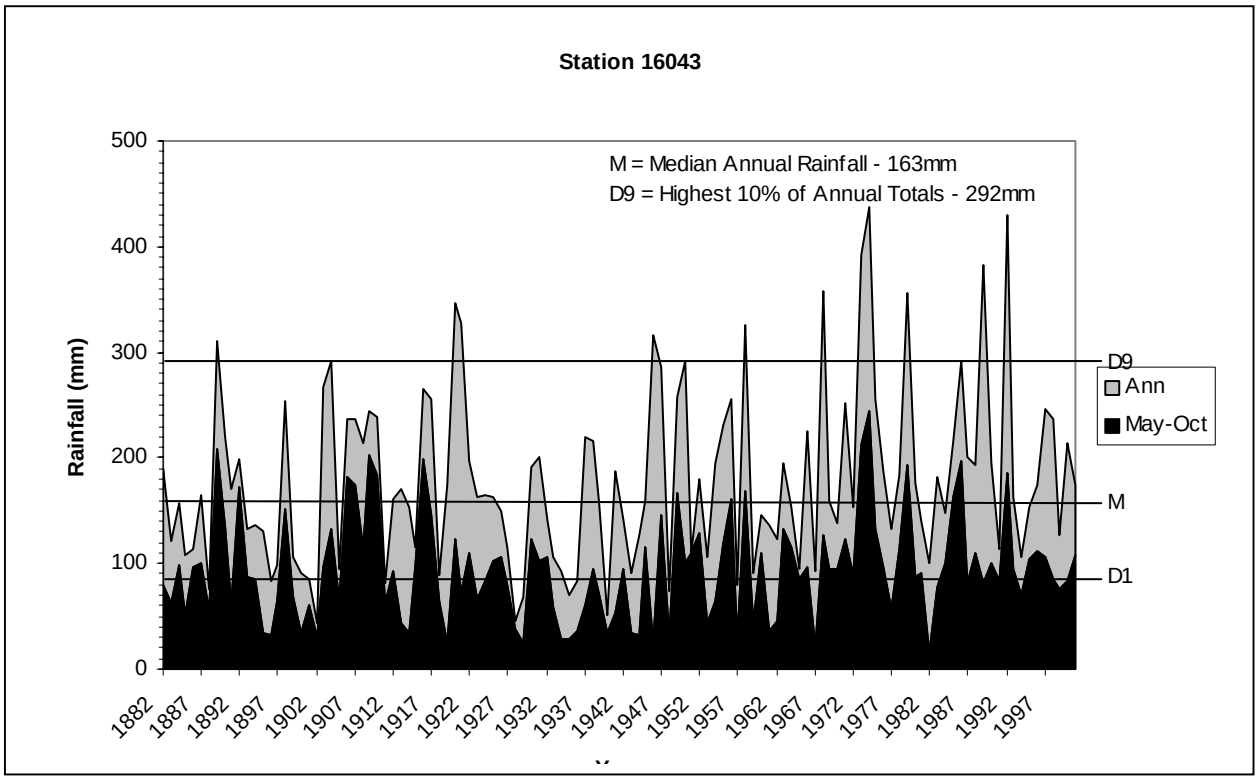


Figure 7. The historical rainfall record for South Gap Station (Station No. 16043) at 31°38'S, 137°37'E (elevation 43m). See Figure 5 for further explanation.

Potential Evaporation

Average annual evaporation ranges from 2300mm in the south of the District to 2700mm in the north. Table 1 shows the average monthly evaporation for the mid-season months. Mean monthly potential evaporation far exceeds the mean monthly rainfall in all months. Along the coast, higher humidity associated with local sea breezes reduces evaporation rates (Bureau of Meteorology 1988).

Table 2. Average monthly evaporation estimates for the mid-season months. Estimates are to the nearest 10mm.

	January	April	July	October
North	380	190	90	260
South	360	170	80	210

Temperature

Daily maximum and minimum temperatures are influenced by latitude, nearness to the coast, and elevation. Along the coast, generally higher humidity and daily sea breezes result in cooler summer maxima, and milder overnight temperatures, all year round. Inland, the limited elevation of the Gawler Ranges has a relatively small effect on daily maximum temperatures, but drainage of cold air overnight into relatively low lying areas, may result in local `frost pockets' in winter.

In the hotter part of the year (December to March) average daily maximum temperatures across the District generally exceed 30°C, but will be 1 or 2 degrees cooler along the coast. Extreme temperatures over 40°C have been recorded in each month between October and March. In January and February, on average, 2 to 4 days per month will exceed 40°C. Average minimum temperatures for the period December to March vary between 14°C and 20°C.
For the cooler months (April to September), average daily maximum temperatures range from around 17°C in winter (June - August), to near 25°C in April and October. Inland, from May to September, average minimum temperatures are below 10°C, and in July fall to around 4°C. Minimum temperatures below zero have been recorded in each month between May and September. Along the coast, temperatures below zero are rare; average minima range from 10°C or 11°C in May and September, to around 7°C in July.

Average monthly maximum and minimum temperatures, as well as monthly extremes for selected stations are graphed in Figure 8, and tabulated in Appendix B.

Sunshine Hours

The Gawler Ranges SCD receives an annual average of 8.5 hours of bright sunshine per day. In January the daily average varies from nearly 11 hours in the north, to just over 10 hours in the south, while in July, the District receives a daily average of around 6.5 hours.

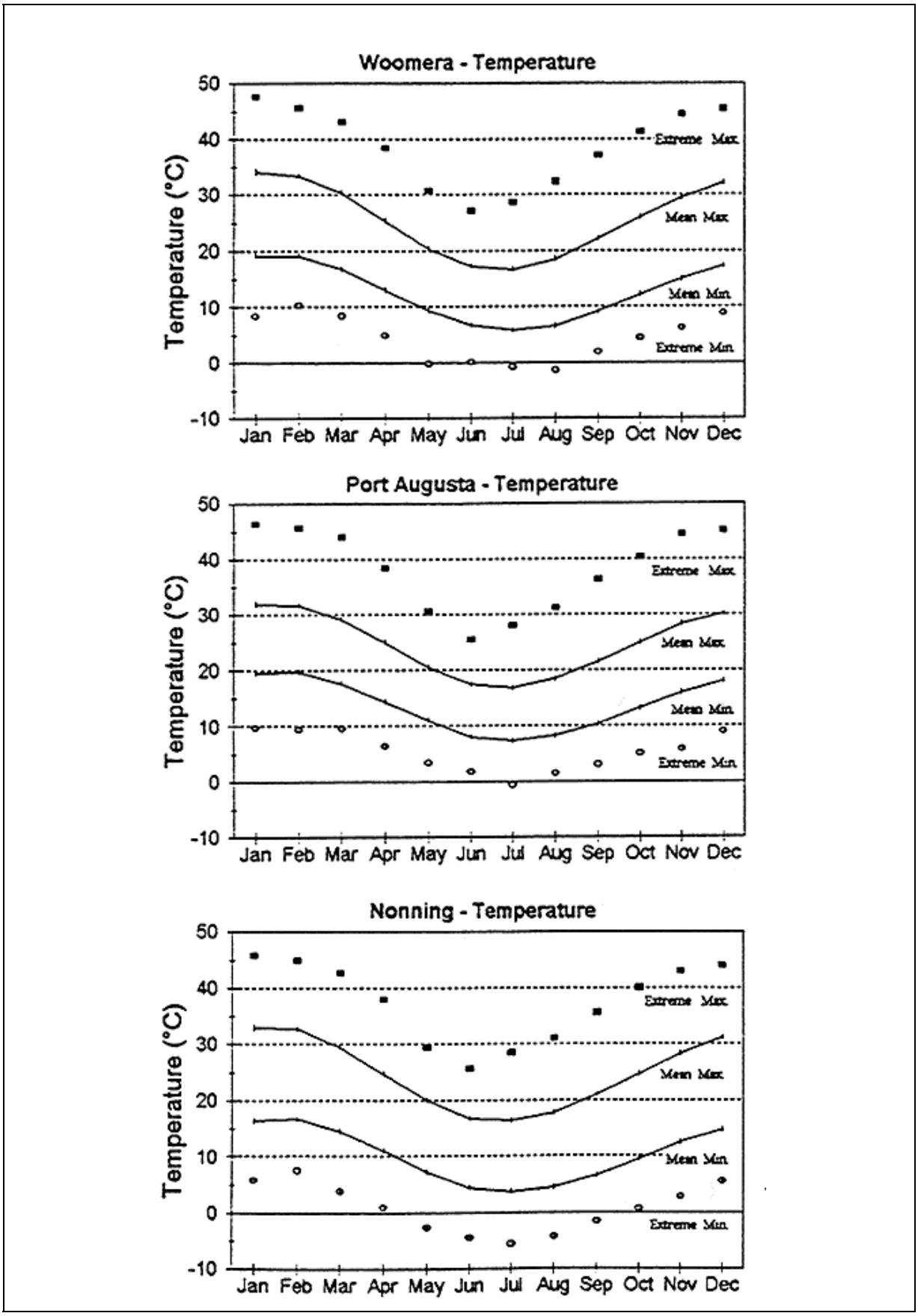


Figure 8. Monthly maximum and minimum temperatures. Solid lines show average monthly maximum and minimum temperatures and extreme temperatures are shown by symbols.

HISTORY OF LAND USE

It is important that we have knowledge of the history of the region, and that we use this knowledge to become better custodians of the land.

The Gawler Ranges have a long history of use for pastoral purposes. Land degradation caused by pastoral use occurred mainly prior to the 1950s and is attributable to a combination of the following factors:

- Ignorance of the country's ability to carry stock;
- Rabbits;
- Lack of distribution of water and the watering of large flocks from few waters;
- Lack of efficient transport.
- Conditions were applied to all leases (greater than 100 square miles), which required stocking and grazing at specified levels (minimum stocking rates).

The Pankalah Aboriginal group lived in the area prior to settlement by graziers.

Matthew Flinders in the Investigator mapped the features of the upper Spencer Gulf including the Middleback Ranges and Mt Brown in 1801. It was at this time that Robert Brown a botanist with the Flinders expedition collected the first specimen of *Acacia papyrocarpa*.

The following recounts of land use and tenure in the District provide some insight into the difficulties experienced by pioneers and the causes of land degradation still visible today.

The early exploitation of the Gawler Ranges was limited by the lack of permanent water, there being only a few good permanent wells and springs. The lack of water limited the effective use of the land and resulted in its degradation.

The early use and settlement of the Gawler Ranges is closely linked with that of western and lower Eyre Peninsula. By the mid 1840s a large stretch of country along the west coast of the peninsula from Pt Lincoln to Fowlers Bay had been taken up in the form of Annual Occupation Licences for pastoral purposes. In 1849 changes to the *Waste Lands Act* allowed the conversion of the Annual Licences to Pastoral Leases with a term of 14 years. The first of these leases was issued in 1851.

The early settlers along the West Coast found that they could shepherd their sheep over winter on the bluebush and saltbush in the Gawler Ranges. "The sheep were all grazed on the coast in flocks of about 1500 in the summer, but in the winter months were taken inland," A.H. King wrote this in his diary in the 1850s (published in the Port Lincoln Times).

The country south-west of Pt Augusta was taken up by pastoralists such as Andrew Tennant, W.R. Mortlock and James Sinclair and were used as staging posts when droving sheep from their properties in the south of Eyre Peninsula to markets on the east side of Spencer Gulf.

The first specimen of *Acacia burkittii* was collected by Mr Burkitt northeast of Lake Gilles. Burkitts Hill on Corunna Station is named after the same man. Burkitt leased land west of Pt Augusta in 1860.

By 1862 the whole of the Gawler Ranges from Uno and Siam to Kondoolka and north to Moonaree was occupied by pastoral leases (Freddricks 1892). By 1885 pastoral leases had been issued for the whole of the north of the State including the Simpson Desert. Needless to say, not many of these applicants had seen their intended leases, and even fewer lived or worked on them.

All of these early leases were pastoral leases under the *Crown Lands Act 1851* and were referred to as waste lands of the Crown. Rentals were high and related to the quality of the land (first quality one pound per square mile, second quality 15 shillings and third quality 10 shillings as determined by valuers and payable in advance). In order to prevent speculation lessees were required to stock the lease with a minimum 100 sheep or 16 cattle per square mile within the first three months (Tynan 1992).

In about 1854 Alfred Henry King was a drover for William Pinkerton who sold his properties in the Elliston area to Price Maurice. At this time, Alfred King mustered 7 000 sheep to drove to "Pinkerton Park" in the Quorn area. After leaving Talia, at the end of May, and having had splendid rains they set out eastwards through thick mallee for 3 or 4 weeks to Lock and Darke Peak. They then turned northwards to the Middleback Ranges where they set up camp to allow the sheep to lamb. There was an 86% lambing after which they set off to Depot Creek and Quorn. It must have been a good year; they lambed without water and carted water for domestic use from a soak near Moonabie.

Amendments relating to the occupation of the wastelands were made in 1857 with the aim of limiting tenure so that agricultural and mining development was not limited. The Waste Land Regulations required lessees to stock their run with 8 head of greater cattle (includes cattle, horses, camels, mules and asses) or 50 head of sheep per square mile within 12 months of the date of the lease and to keep it so stocked at that level for the term of the lease (Tynan 1992).

In 1857 Lincoln Gap lease was granted to Charles Swinden, and A.D Tassie was granted the Point Lowly Lease of 265 square miles at £132-10 rent per year. Lincoln Gap sank over 1000 feet of wells and discovered no water. Wool was down to 7½ pence per pound and the drought of the early 1860s finally finished the venture with a loss of £6 000. John Chambers then held the lease briefly and in 1860 Edward Stirling became the owner. He reputedly released several pairs of rabbits for hunting purposes. Later when Douglas Goode became the owner, the rabbit had become a pest and intensified the dingo problem causing him heavy stock losses. The next owner in the late 1870s was Henry Scott, who set about eradicating the millions of rabbits from the lease. He imported one pair of diseased rabbits from Dr Koch of Melbourne for £50. He enclosed wild rabbits with the diseased rabbits, which prospered and got fat. The disease did not work. (Two fencers arrived at the station when no one was home, and being hungry they cooked and ate one of the £50 rabbits!) Point Lowly was sold in 1879 for £950, which included 146 square miles and 10,000 sheep, two dams and two wells and was fenced into four paddocks.

In 1872, 72 000 sheep were shorn at Pandurra and in 1878 Price Maurice, who had up to 92 000 sheep in the Elliston area drove 25 023 head overland in mobs of 6 000 or more, between 20th of June and the end of July via the Gawler Ranges and Mt Ive Station which he also leased.

1878, Thomas Mc Turk Gibson arrived at Yudnapinna. In the 1880’s John Cook and sons of Laura took up the lease of pastoral country to the north west of Yudnapinna, (called Bowen Hill), with Island Lagoon as northern boundary. Annexed to Yudnapinna and later to become Yalymboo, lots of time and money was spent on boring for water with no success.

In 1888 the 21-year leases issued in 1867 were due to expire and the Pastoral Board undertook a review of the rents. The leases were cancelled and resumed by the Crown, subdivided and offered at public auction with a 21-year lease. Bidding was competitive and the Surveyor General noted that rents offered exceeded valuations by as much as eight times. The high prices undoubtedly resulted in overstocking in an attempt to meet financial commitments (Tynan 1992).

In 1893 the area west and south of Pt Augusta was subdivided into 35 to 60 square mile blocks and auctioned in Adelaide as living areas. The prices were high and most were later abandoned

because the owners were unable to pay the rent. These leases were, in most cases joined together to form areas large enough for economic survival. These Pastoral leases had a term of 42 years and closer settlement leases a term of 21 years.

Wizzo Well was one such lease. It was bought by Lachlan M^{c}Guish a drover from Pt Augusta. The value of improvements was £570-16-0, the area was 35 square miles and the amount payable in instalments (for the improvements) was £44-10-6 for 21 years. Annual rental of the lease commenced on July 1st 1895 and was £26-5-0. The lease was transferred to W.T. Mortlock a sheep farmer in 1898 or 99. The amount payable was reduced to £29-8-8 and rent to £21-0-0. Mortlock also took over five other adjoining small leases to make a run of 288 square miles.

Later in 1893 the auction system for offering pastoral leases was abolished and the first Pastoral Act enacted establishing three classes of pastoral land and 21 year leases with rights to a further 21 years for class C land (further than 75 miles from a railway). The 42 years right of tenure represented a man's working life. The minimum rent was reduced to 2/6 pence per square mile and could not be altered by more than 50%. Remissions for rent were given for the discovery of underground water supplies, and in 1895 rent remissions were granted for up to four bores, each yielding greater than 5 000 gallons and its surrounding 100 square miles (Tynan 1992).

From this period most leases in the Gawler Ranges were large areas such as Nonning, Yardea and Siam.

In 1897 a Royal Commission was appointed to inquire into the Pastoral Lands and to report on the action that should be taken by Parliament to induce the occupation and development of the Pastoral Lands. The Commission found that the pastoral industry was extremely depressed and attributed this unsatisfactory condition to the lack of security of tenure, excessive rents, heavy charges for improvements on small blocks, the deterioration of the country caused by rabbits, loss of stock to wild dogs, a decline in the prices of wool and stock and frequently recurring drought (Tynan 1992).

Mining leases were granted in the Iron Knob area for gold, copper and iron ore exploration in 1890. In 1898 BHP took over the leases and mined iron ore to use as flux in the silver smelter at Pt Pirie. The ore was taken by bullock wagon to Pt Augusta and from there by train via Quorn, Orroroo and Peterborough to Pt Pirie. In 1901 the ore was transported by tramway from Iron Knob to Whyalla (then called Hummock Hill) and then shipped by barge to Pt Pirie. The Whyalla jetty was extended in 1914 and on January 8th 1915, 2 800 tons of ore was loaded onto SS Emerald Wings for Newcastle Steelworks which opened on the June 2nd 1915. This was the beginning of steel making in Australia.

In 1893 the *Wild Dog Act* was proclaimed. It was also about this time that the vermin control districts were established to control rabbits, although some rabbit proof fencing had been erected prior to this.

The *Pastoral Act* was amended in 1904 and conditions of leases changed such that there was a minimum stocking rate of five sheep per square mile in the first seven years of the lease and not less than 20 sheep per square mile for the remaining term and the lessee was not to over-stock in the final three years of the term.

In 1939 the *Pastoral Act* was amended so that the Pastoral Board could limit the number of stock on a lease to prevent soil erosion. This amendment was incorporated under the *Soil Conservation Act 1939* following reports of soil erosion in the pastoral lands. The amended *Pastoral Act* reduced the minimum stocking rate from 20 to 5 sheep per square mile, gave the Pastoral Board the power to reduce the number of stock on a lease when the land was likely to be permanently injured if the stock remained, and allowed the Pastoral Board to include

stocking maximum in the lease covenants. All leases issued after 1939 included a stock maximum. It was these amendments that first recognised the necessity to protect the soil and vegetation resource.

Myxomatosis spread during the three years following its escape in 1950 from a test site near Albury (NSW) and was present in the district by 1953. By its third season myxomatosis had produced a widespread general mortality of a very high order (Fenner 1965). Fenner and Ratcliff have estimated that myxomatosis caused a 90% kill and in some areas a 99% kill was achieved. By 1955 rabbits were showing signs of resistance to myxomatosis and soon in some drier areas the population of rabbits had increased to pre myxomatosis levels.
The *Pastoral Act* was amended again in 1960 when most leases had 14 years remaining of the 42-year term. The amendment allowed lessees to obtain a new 42-year lease and provided for up to 50% adjustment in rents and revaluation every seven years. Lessees were still required to invest in the improvement of the lease.

In 1989 the *Pastoral Land Management and Conservation Act* and *Soil Conservation and Land Care Act* were enacted. These Acts provide for the sustainable use of the renewable resources for pastoral purposes, the monitoring of land condition, the prevention of degradation of the land and its indigenous plant and animal life, and the rehabilitation of the land in cases of damage.

The last 20-30 years has seen the advent of polyethylene pipe, which is cheap and easily installed. Poly-pipe has made it possible to extend water further into paddocks and in conjunction with modern fencing have vastly improved the management of stock and the spread of grazing pressure by enabling the reduction in flock sizes. The use of trucks to transport stock from the pastoral leases to sale yards and when conditions are dry has increased management flexibility. The impact of these advances in technology on the condition of the land cannot be underestimated.

Due to the unreliability and irregular location of water supplies, the Gawler Ranges luckily, suffered less degradation than most districts during the period when there was little knowledge of the country's capabilities. The introduction of myxomatosis and RCD, the invention of polyethylene pipe, the development of efficient road transport and earth moving equipment have led to the reversal of historical degradation and a consistent improvement in the land condition.

PRESENT LAND USE

One of the major land uses in the District is extensive sheep grazing. Some properties also run small numbers of cattle.

The two cities Pt Augusta and Whyalla and the township of Iron Knob are located within the District.

The facilities for the extraction of iron ore at Iron Knob and Iron Baron occupy small areas northwest of Whyalla and provide the major employment in the region.

Tourism is emerging into a significant land use including camping, day tours and other nature based tourism attractions. There are tourist facilities in the cities of Pt Augusta and Whyalla and at Mt Ive and Pandurra.

There are four Parks in the District, Lake Gilles, Whyalla and Winninowie Conservation Parks and the Gawler Ranges National Park. The recent establishment of the Gawler Ranges National Park is likely to increase the attractiveness of the region as a nature based tourism destination.

Other land uses include mining; some manufacturing and a substantial Army training area near Port Augusta incorporating live firing ranges.

FUTURE LAND USE OPPORTUNITIES

The *Pastoral Land Management and Conservation Act 1989* limits the uses to which pastoral leasehold land can be put without prior approval from the Pastoral Board.

Extensive grazing of sheep and cattle on native pastures is the most extensive enterprise on pastoral lands at present. Diversification into other livestock maybe future possibilities for industry development. These would include damaras and other meat sheep, domestic goats (after the outcomes of the Pastoral Board trials are known) kangaroos, alpaca and camels.

Arid land horticulture is also a possible land use within the District though it would be on a relatively small scale and limited by groundwater quality and quantity. Crops could include dates, quandong, desert lime and sandalwood.

PIRSA geomagnetic surveys within the Gawler Craton indicate the potential for mineral deposits similar in composition and extent to that at Olympic Dam. Further exploration is being carried out and data from current surveys is being processed.
Dominion Mining has already begin production at the Challenger Gold mine and will begin an underground mine development in 2004.

NATURAL RESOURCES

GEOLOGY

Dominating the geology of the Gawler Ranges Soil Conservation District are the volcanic rocks from which the rounded, rocky hills of the Gawler Ranges have formed. These volcanic rocks resulted from a violent, short-lived episode of volcanism almost 1 600 million years ago. About seven million years later, intrusions of Hiltaba Granite penetrated the base of the volcanic pile and surrounding areas to the south and west. The volcanic rocks are called the Gawler Range Volcanics and comprise flat-lying rhyolite[3], rhyodacite and dacite, which are very resistant to erosion despite having abundant joints or fractures. Flat-floored valleys were formed in a criss-crossing pattern between the rounded hills following erosion along intersecting fracture zones in the volcanic rocks. The granites are equally resistant to erosion. Some conglomerate and sandstone considered to be about the same age are present in the Corunna and Uno Ranges (Corunna Conglomerate).

The older basement rocks on which the volcanics were deposited are exposed as hills south and southeast of the Ranges. They are part of a complex group of very old rocks, which underlie most of Eyre Peninsula as well as areas to the west and north of the Gawler Ranges. They formed from a succession of sedimentary, volcanic, metamorphic and igneous rocks between 2 640 and 1 600 million years ago. In the Gawler Ranges SCD, these rocks were subjected to massive tectonic forces and heating which folded and tilted the strata and changed them into metamorphic rocks, at the same time intruding them with granites. Prominent among these rocks are the iron-rich sediments of the Middleback Ranges, which are quarried for iron ore.

Rocks younger than the volcanics of the Gawler Ranges are dominantly sediments, ranging in age from about 1 425 million years old to the present day. In the Whyalla-Lake Gairdner-Pernatty Lagoon area, the red sandstone of the Pandurra Formation forms low ranges and hills and was deposited in response to an episode of erosion of the Gawler Range Volcanics (refer to Figure 9).

The prominent flat-topped hills and plateaus extending northwards from Whyalla to the western shores of Lake Torrens are the eroded remnants of a relatively thin, flat-lying blanket of Adelaidian sandstone, siltstone and shale which extended onto the older rocks of the region about 750 to 650 million years ago from a major sedimentary basin to the east. This basin was then receiving the thick sediments, which were later to form the Flinders Ranges.

From this time until now, the rocks described above have remained virtually undisturbed, the only change being their slow wearing away by erosion and gradual covering by young unconsolidated sediments. These sediments are predominantly less than 2 million years old and were deposited in three major environments during a period of increasingly arid climate. Reddish gravel, sand, silt and clay form aprons around most of the outcrops of older rock and are the result of deposition on alluvial slopes and plains and from creeks. Salt lakes contain gypsum-rich and salty sand, silt and clay deposited from present and past lakes and rivers occupying these corridors. Longitudinal sand dune fields are present west and northeast of the Gawler Ranges and are a result of wind forming extensive areas of dunes from sand blown from areas to the west.

[3] Rhyolite, rhyodacite and dacite are very fine-grained volcanic (igneous) rocks similar in composition to granite.

LAND SYSTEMS

The vegetation, soils, topography, and geology of the Gawler Ranges Soil Conservation District have been described as land systems. Land systems are an area or group of areas throughout which there is a recurring pattern of topography, soils, and vegetation.

The land systems described in this document were mapped by combining the work of Laut *et al* (1977), geological maps and Board member's knowledge of the District. A land systems map is presented in Figure 10.

The land systems and their component units are described in Tables 3 - 12 and illustrated with a photograph of land typical of the land system (Figures 11 - 20). The Tables briefly describe the land units occurring in each land system and their geology, soils and types of soil erosion, vegetation, carrying capacity, productivity and any forms of degradation. The following sections describe and discuss more fully the importance of each of these features to land management.

The relationship between the land systems mapped by the Gawler Ranges Soil Conservation Board and the Pastoral Program (DWLBC) is shown in Appendix C.

The Board is aware of other initiatives that involve reviewing land system descriptions. It is aware that this process is complex and sometimes confusing. Therefore the board has decided for its purposes and the purpose of the District Plan that the Land System descriptions will remain as per the 1996 plan.

SOILS AND SOIL EROSION

A brief description of the predominant soil types occurring in each of the units of the land systems is described in the land systems tables (Tables 3 - 12).

It is the texture, fertility and position in the landscape of soils that determines which plant species will occur where soils in low-lying or run-on areas receive nutrients and eroded material from runoff areas which become depleted of nutrients (Tongway 1994). Soils therefore provide a variety of habitats for plants, and plants in turn reflect the nutrient status and texture of soils.

Soils and the plant communities, which grow upon them, are hence mutually dependent upon each other. If the soil environment is changed the plant community will also change. Alterations to the soil resource, which are not reversible, are called soil degradation. Soil degradation in pastoral areas is the result of accelerated (compared with natural) wind or water erosion. Land units susceptible to erosion are given in the land systems Tables 3 to 12.

Figure 9 Geology of the Gawler Ranges SCD

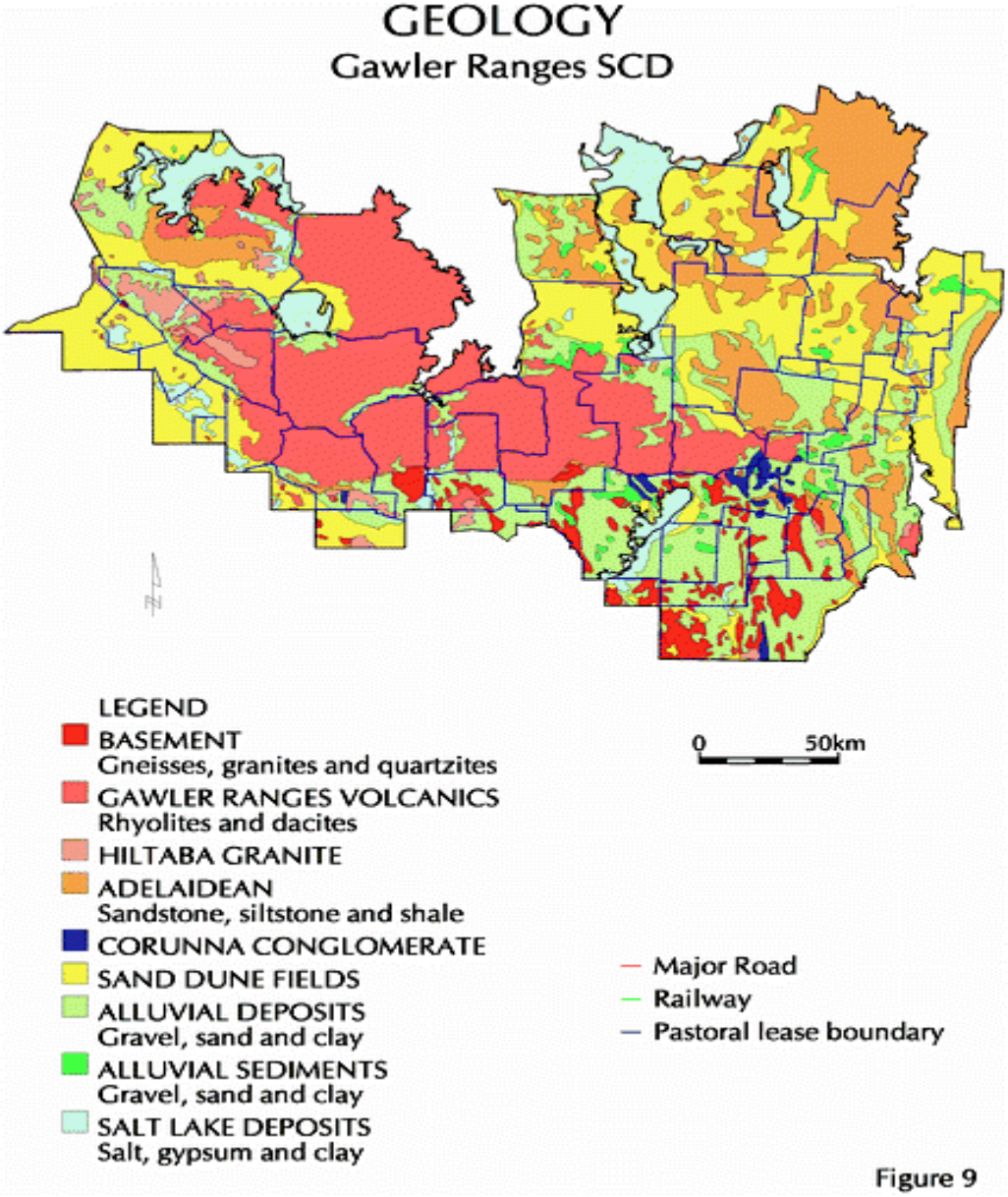
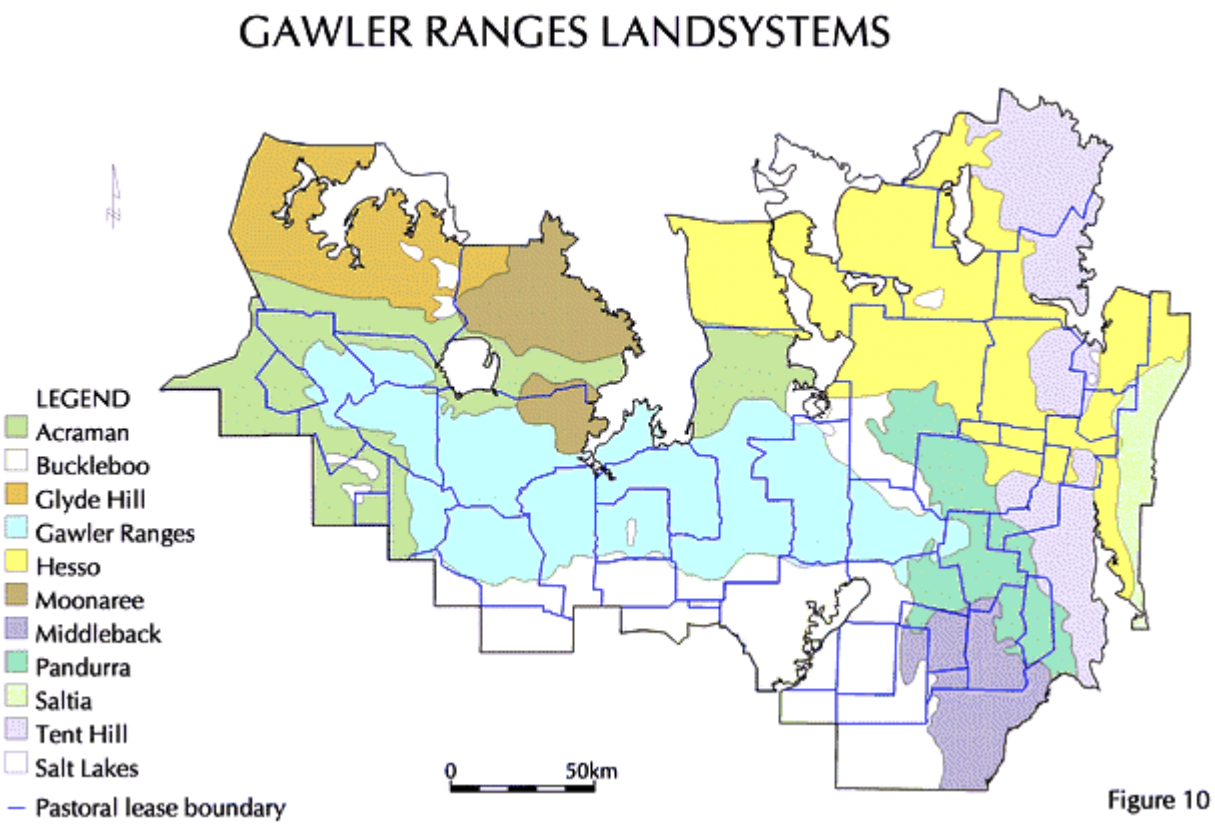


Figure 10 Land Systems of the Gawler Ranges Soil Conservation District.



VEGETATION

The land systems described within the District are characterised by distinct vegetation associations. These include mulga and mallee woodlands and chenopod shrublands. The descriptive species are given in the land systems tables (Tables 3 - 12), and common and scientific plant species lists are given in Appendices D and E.

In the Gawler Ranges SCD native vegetation is grazed to produce sheep, wool and cattle. The sustainable management of the land resources in this District must therefore conserve the plant density (soil cover) and diversity and maintain the ability of the vegetation resource (e.g. seed reserves, root stocks) to respond to seasonal influences.

Plants can be used as indicators of rangeland condition or the 'health' of the vegetation or pasture. The occurrence, abundance and intensity of grazing of certain plants indicate levels of range condition for a particular soil-vegetation association. There are several types of indicator plants, termed decreaser plants, increaser plants and invader plants. Decreaser plants are most commonly used for describing land condition.

Decreaser plants are plants, which are preferred by stock and which decrease in density and are eventually eliminated from zones of high grazing pressure. Bladder saltbush *(Atriplex vesicaria)* and low bluebush *(Maireana astrotricha)* are decreaser plants. Increaser plants are plants which are not preferred by stock for grazing and which increase in density and eventually dominate zones of high grazing pressure (replacing decreaser plants). Poverty bush, silvertails and sandhill wattle can be increaser plants in some situations. Invader plants are plants, which establish and subsequently dominate sites on which they were formerly scarce or absent. The invasion usually occurs after, or as a result of, soil disturbance such as vegetation clearance, fire or high grazing pressure. Woody shrubs are invader plants.

The grazing impact on palatable decreaser species needs to be managed so that these species are maintained in the pasture. Where the mixture of species is detrimentally altered, degradation of the plant community has occurred.

It is also necessary to conserve the biodiversity of the region. Biodiversity is the variety of life - the different plants, animals and microorganisms and the genes they contain and the ecosystems of which they form a part. Biodiversity as a concept emphasises the relationships between species in the provision of nutrient pathways, habitat and options for nurturing human welfare. Increasingly the world relies on the remaining natural resources for food, medicines, genetic material and biological processes such as production of oxygen, cleansing water and use of carbon dioxide. Plant and animal species of the arid and semi-arid lands contribute to the biological wealth of the country and has still to be discovered values (Biological Diversity Advisory Committee 1992).

Western myall whitefly is recorded as being associated with the decline and death of western myall trees around Roxby Downs Township in 1998. Surveys during 2000 detected symptomatic trees with associated high populations of western myall whitefly in an area of 10,000 square km to the north and north west of Roxby Downs. Outside this area, whitefly was not detected, however it is important that monitoring of the potential spread of whitefly is co-ordinated throughout the extensive areas of western myall woodland in the Gawler Ranges.

LAND CAPABILITY AND PRODUCTIVITY

High productivity is obtained by a reliable source of water linked with an abundance of preferred perennial pasture. Where both these prerequisites are met the country is classified as having a high productivity. The productivity of these areas is reduced by prolonged periods of low rainfall, (2 - 3 years). In above average rainfall years the production should not be raised markedly so that productivity is maintained in the long term.

Sustainable land use is use of the land in such a manner that productivity and quality of the resource is maintained indefinitely. To manage the land sustainably the land's inherent limiting factors, or weaknesses, need to be understood and the land protected from degradation.

In the following land systems tables the productivity of units within land systems have been rated high, medium or low. The rating provides an indication of the range of carrying capacities within each land system and assumes average-to-good vegetation condition and stable soils. The carrying capacities provide for a range of seasons from good to poor and are a guideline as to how many stock the land can carry. These carrying capacities must be considered in conjunction with local variations in land type (soils and vegetation) within each land system and station improvements (water location and fences) as the problems associated with concentrations of stock also need to be taken into account.

The most productive vegetation types in the District consist of a combination of palatable perennial bush species (e.g. bladder saltbush *(Atriplex vesicaria)* and pearl bluebush *(Maireana sedifolia)*) together with a good quality water supply and good quality ephemeral grasses and herbs. Whilst ephemeral grasses and herbs make up the bulk of feed in most land systems it is the land systems with a palatable perennial component that remain productive in dry seasons.

Low productivity units within land systems tend to be dominated by sandy or shallow stony soils. These land systems support feed after good falls of rain but the feed is short-lived due to the low moisture retaining capacity of the soil. These land systems support very little palatable perennial feed. The productivity of these areas is marked by wide fluctuations, where feed is plentiful after rain and diminishes to little or nil during dry periods.

Productivity is also low in areas where the perennial feed is of low palatability. The spinifex hills are in this category, these hills are rugged and sheep rarely utilise them.

These production constraints need to be taken into account to ensure that the land is used within its capability.

Vegetation condition is determined by the species mix and abundance of palatable (decreaser) and unpalatable (increaser) perennial shrubs, and the condition of the soil surface.

Superscript letters in Tables 3 -12 shows indicator Species.

Indicator Species are plants the occurrence or abundance of which can be used to indicate levels of land condition for a particular soil vegetation association.

Increaser Species are plants which are not preferred by stock for grazing and which increase in density and eventually dominate zones of high grazing pressure (replacing decreaser plants). Black bluebush, hopbush and silver cassia wattle can be increaser plants in some situations.

Decreaser Species are plants, which are preferred by stock, and which decrease in density and are eventually eliminated form zones of high grazing pressure. Bladder saltbush and pearl bluebush are decreaser plants.

The major decreaser indicator plant in the chenopod shrublands is bladder saltbush *(Atriplex vesicaria).* In dry years this species is normally selectively grazed and under very heavy stocking the first plants out from water may not occur until 2 km or beyond. Conservative Stocking levels with centrally placed waters can often result in the presence of saltbush within 10 m - 30 m of a water point (Tynan 1995).

Some of the species that may decrease under grazing include:

bladder saltbush	*Atriplex vesicaria*
ruby saltbush	*Enchylaena tomentosa*
desert cassia	*Senna artemisioides var coriacea*
low bluebush	*Maireana astrotricha*
bullockbush	*Alectryon oleofolium*
bush minuria	*Minuria cunninghamii*

Under heavy grazing the following may also be reduced:

thorny saltbush	*Rhagodia spinescens*
bitter saltbush	*Atriplex stipitata*
spiny goosefoot	*Rhagodia ulicinum*
copperburr	*Sclerolaena diacantha*

Plants that may increase under grazing include:

pop saltbush	*Atriplex spongiosa*
pale poverty bush	*Sclerolaena divaricata*
tangled poverty bush	*S. Intricata*
salt copperburr	*S. ventricosa*
blackbush	*Maireana pyramidata*
*wards weed	*Carrichterra annua*
*barley grass	*Hordeum leporinum*

(Tynan 1995)

* Introduced species

Table 3: Gawler Ranges Land System

This is the most extensive land system within the Soil Conservation District. It describes the steep rounded granitic hills with long foot slopes, and flood plains of the Gawler Ranges proper.

Component	Hills	Foot Slopes	Flood Plains
Geology	Intrusive volcanics (dactite, rhyodactite, and rhyolite).	Outwash from hills (Pooraka formation)	Outwash from hills (Pooraka formation)
Soils	Shallow reddish loams, alkaline and stony.	Moderately deep red calcareous earths. Light sandy clay loam at surface, & sandy clay loam at depth.	Deep alkaline red duplex[4] soils. Light sandy clay loam at surface, & sandy clay loam at depth.
Dominant Vegetation			
Over storey	Tarcoola wattle *(Acacia tarculensis)*, pointed mallee, white mallee *(Eucalyptus dumosa)*, mulga, emu bush.	Black oak *(Casuarina cristata)*, needle wattle *(Acacia rigens)*, pinbush wattle *(Acacia burkittii)*, [I] silver cassia *(Senna artmisioides ssp artemisioides)*.	[D] Bullock bush, sugarwood, northern cypress pine, black oak, western myall *(Acacia papyrocarpa)*.
Under storey	Porcupine grass, geranium *(Erodium spp)*. Many species of low shrubs.	[D] Pearl bluebush, [D] bladder saltbush, porcupine grass, medic *(Medicago spp)*.	Annual speargrass, wild oats *(Avena spp)*, [D] bladder saltbush, [D] pearl bluebush, [I] black bluebush *(Maireana pyramidata)*, wards weed *(Carrichtera annua)*, medic.
Proneness to wind erosion & water erosion.	Not prone to wind or water erosion.	Slightly prone to gully erosion and scalding.	Prone to severe gully erosion with storms.
Other land management problems	Feral goats, moderate numbers concentrated in the hills to the south of Lake Gairdner.	Rabbits, small numbers. Degraded perennial vegetation around watering points.	Spread of salinity is a significant problem. Rabbits, moderate numbers. Degraded perennial vegetation around watering points.
Productivity	Very low.	Low - Moderate	High
Average stocking rate	8 - 10 sheep per square kilometre.		

[D] Decreaser Species [I] Increaser Species

[4] Duplex soils are soils with light textured/sandy topsoil and heavy textured/clayey subsoil. Duplex soils are also known as texture contrast soils.

Table 4: Moonaree Land System

Associated with the Gawler Ranges land system; the Moonaree land system has lower hills and different more productive vegetation types than those of the Gawler Ranges land system. The land system is composed of low rounded granitic hills with foot slopes and flood plains.

Component	Hills	Foot Slopes	Flood Plains
Geology	Intrusive volcanics (dacite, rhyodacite, and rhyolite).	Outwash from hills (Pooraka formation)	Outwash from hills (Pooraka formation).
Soils	Shallow reddish loams, alkaline and stony.	Moderately deep red calcareous earths. Light sandy clay loam at surface, & sandy clay loam at depth.	Deep, alkaline, red duplex soils. Light sandy clay loam at surface, & sandy clay loam at depth.
Dominant vegetation *Overstorey*	Mulga, Tarcoola wattle.	Mulga, Tarcoola wattle .	Western myall.
Understorey	[D] Pearl bluebush, [D] bladder saltbush. Senna and porcupine clad hills.	[D] Pearl bluebush, [D] bladder saltbush, medic, geranium, copper burr, speargrass.	[D] Pearl bluebush, [D] bladder saltbush, geranium, medic, speargrass, bindii *(Sclerolaena spp)*.
Proneness to wind erosion & water erosion.	Not prone to wind or water erosion.	Slightly prone to gully erosion.	Slightly prone to gully erosion and scalding.
Other land management problems	Rabbits, low numbers.	Rabbits, low numbers. Degraded perennial vegetation around watering points.	Rabbits, moderate numbers. Degraded perennial vegetation around watering points.
Productivity	Moderate - High	Moderate - high	High
Average stocking rate	9 - 11 sheep per square kilometre		

[D] Decreaser Species

Table 5: Glyde Hill Land System

Associated with the Gawler Ranges land system. This land system is composed of low rounded volcanic hills, extensive undulating plains and flood plains.

Component	Hills	Undulating Plains	Flood Plains
Geology	Intrusive volcanics (dactite, rhyodactite, and rhyolite).	Aeolian[5] calcareous sediments of marine origin (Wiabuna formation).	Outwash from hills (Pooraka formation) and wind blown calcareous sediments (Wiabuna formation).
Soils	Shallow reddish loams, alkaline and stony.	Red calcareous clay.	Deep, alkaline, red duplex soil.
Dominant vegetation *Overstorey* *Understorey*	Mulga, Tarcoola wattle. [D] Bladder saltbush, geranium, speargrass, bindii, medics, annual grasses.	Mulga, black oak, [D] bullock bush. [D] Bladder saltbush, [D] pearl bluebush, geranium, medics speargrass, tussock grasses.	[D] Bladder saltbush, [D] pearl bluebush, [I] black blue bush Medics, speargrass, annual grasses.
Proneness to wind erosion & water erosion.	Not prone to wind or water erosion.	Prone to scalding.	Moderately prone to gully erosion during high intensity rain storms. Prone to scalding.
Other land management problems	Lack of underground water Rabbits, low numbers.	Lack of underground water Rabbits, low numbers. Degraded perennial vegetation around watering points.	Rabbits, low numbers. Degraded perennial vegetation around watering points.
Productivity	Low	Low - Moderate	Moderate
Average stocking rate	8 - 9 sheep per square kilometre		

[D] Decreaser Species [I] Increaser Species

[5] Aeolian deposits are wind blown deposits.

Table 6: Acraman Land System

A system of parallel dunes, plains and salt lakes in the western part of the Soil Conservation District. This is the least productive land system in the District.

Component	Dunes	Plains
Geology	Aeolian quartz sands (Moornaba formation).	Aeolian calcareous sediments of marine origin (Wiabuna formation).
Soils	Red calcareous sandy loams.	Red Sands.
Dominant vegetation *Overstorey* *Understorey*	Red mallee *(Eucalyptus oleosa)*, gilja *(Eucalyptus brachycalyx)*, mallee cypress pine *(Callitris verrucosa)*, mulga, black oak. Porcupine grass, medic, annual grasses.	Western myall, mulga, red mallee, sugarwood *(Myoporum platycarpum)*. [D] Pearl bluebush, tussock grasses, ephemeral forbs, annual grasses, medic.
Proneness to wind erosion & water erosion.	Prone to wind erosion when perennial cover is removed or disturbed. Loss of perennial bush in mulga country where rabbit numbers are high.	Not prone to water erosion, wind sheeting of surface occurs when plant cover low.
Other land management problems	Lack of water surface and ground. Rabbit numbers: . moderate in general . high around Lake Acraman.	Lack of surface and ground water. Rabbits numbers high in good seasons.
Productivity	Very Low	Low
Average stocking rate	Opportunistic grazing only.	

[D] Decreaser Species

Table 7: Hesso Land System

This land system covers a major portion of the north-east part of the Soil Conservation District. The main components of the system are plains, rises, sand dunes and salt lakes.

Component	Plains	Rises	Sand Dunes
Geology	Aeolian calcareous sediments of marine origin (Wiabuna formation).	Aeolian calcareous sediments of marine origin (Wiabuna formation).	Aeolian quartz and gypsiferous sand (Moornaba formation).
Soils	Red calcareous sandy loams.	Red calcareous clay.	Red Sands and loamy sands.
Dominant vegetation *Overstorey*	Western myall, mulga, black oak, [I] hop bush	[D] Bladder saltbush, [I] hop bush	Horse mulga *(Acacia ramulosa)*, mulga, northern cyprus pine, [I] hop bush
Understorey	[D] Bladder saltbush, [D] pearl bluebush, geranium, medics, spear grass, bindii, copper burr, [I] cannonball *(Dissocarpus paradoxus)*.	Geranium, [D] plover-daisy. Soft annuals in crabholes.	Tussock grasses, geranium, medic.
Proneness to wind erosion & water erosion.	Prone to gully erosion during storms.	Slightly prone to water erosion.	Prone to wind erosion when cover is removed or disturbed.
Other land management problems	Rabbits, moderate numbers, but high numbers around salt lakes and in kopi country. Degraded perennial vegetation around watering points.	Rabbits, moderate numbers. Degraded perennial vegetation around watering points.	Rabbits, opportunistically high numbers at times, especially around salt lakes.
Productivity	High	Moderate	Low
Average stocking rate	8 - 11 sheep per square kilometre		

[D] Decreaser Species [I] Increaser Species

Figure 11 Gawler Ranges Land System

Figure 12 Moonaree Land System

Figure 13 Glyde Hill Land System

Figure 14 Acraman Land System

Figure 15 Hesso Land System

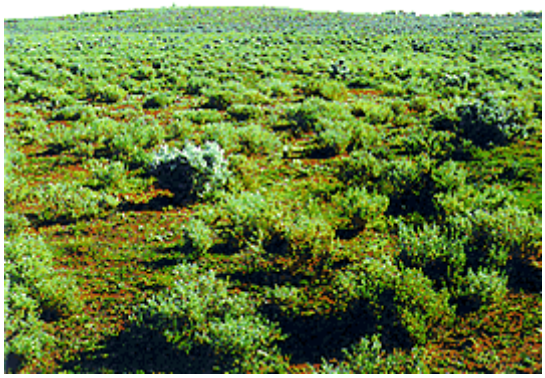


Figure 16 Pandurra Land System

Figure 17 Middleback Land System

Figure 18 Tent Hill Land System

Figure 19 Buckleboo Land System

Figure 20 Saltia Land System

Table 8: Pandurra Land System

The Pandurra land system covers an extensive area of land in the southeast of the District. It is the most productive land system in the District. The main components of this system are plains, watercourses, sand ridges and sandstone ridges.

Component	Plains	Water Courses	Sand Hills	Hills
Geology	Alluvial & aeolian sediments.	Alluvial & aeolian sediments.	Aeolian quartz sand (Moornaba formation).	Red feldspathic[6] sandstone with bands of shale & siltstone (Pandurra formation).
Soils	Gravels, sands, & clay sands, with clay lenses.	Alluvial gravel, sand & clays.	Red sands.	Shallow powdery red calcareous loam.
Dominant vegetation *Overstorey*	[D] Bladder saltbush	[D] Bladder saltbush, [I] black bluebush.	Black oak, western myall	[I] Hopbush *(Dodonaea spp)*, cassia.
Understorey	Medic, annual grasses & herbs.		Grasses, [D] pearl bluebush, [D] bladder saltbush.	[D] Bladder saltbush, [D] pearl bluebush.
Proneness to wind erosion & water erosion.	Sandy areas highly prone to wind erosion in denuded areas.	Moderately prone to gully erosion resulting from high intensity rain storms.	Highly prone to wind erosion in denuded areas.	Not prone to wind or water erosion.
Other land management problems.	Rabbits, high numbers in small areas. Degraded perennial vegetation around watering points.	Rabbits, high numbers in small areas. Degraded perennial vegetation around watering points.	Rabbits, moderate numbers.	Rabbits, low numbers.
Productivity	Very High	Very High	Moderate	Moderate
Average stocking rate	20 - 23 sheep per square kilometre			

[D] Decreaser Species [I] Increaser Species

[6] Containing feldspar as a principal ingredient, feldspar is a common rock-forming mineral.

Table 9: Middleback Land System

This land system is located in the south-east of the District. The majority of the area is an easterly sloping plain, with outcropping hills of conglomerate, sandstone and metamorphics.

Component	Plains	Water Courses	Hills & Rises
Geology	Alluvial & aeolian sediments.	Alluvial & aeolian sediments.	Outcrops of conglomerate, sandstone, quartzite, jaspilite[7], schist, & gneiss.
Soils	Thin red brown, alkaline sand and clay soil.	Alluvial gravel, sand & clays.	Shallow, dense brown loams.
Dominant vegetation *Overstorey*	Western myall, black oak.	[I] Hopbush, pinbush wattle, needle wattle.	[I] Cassia, northern cyprus pine, mallee, black oak, western myall.
Understorey	[D] Bladder saltbush, [D] pearl bluebush.	[D] Bladder saltbush, [I] blackbush, medic bindi.	[D] Bladder saltbush, medic, porcupine grass, annual grasses.
Proneness to wind erosion & water erosion.	Prone to wind & water erosion around watering points in autumn after a dry summer.	Prone to stream bank erosion during flash floods.	Some potential for water erosion during flash floods.
Other land management problems	Rabbits, high numbers in small areas. Kangaroos Degraded perennial vegetation around watering points.	Rabbits. Spread of salinity	Euros, large numbers. Feral goats, small numbers.
Productivity	Moderate - High	High - very high (good opportunistic winter feed)	High - Very High
Average stocking rate	10 - 15 sheep per square kilometre		

[D] Decreaser Species [I] Increaser Species

[7] Jaspilite is a rock consisting of red jasper (a fine grained crystalline quartz) and iron oxides.

Table 10: Tent Hill Land System

This land system occurs in a band running north and south in the eastern part of the Soil Conservation District. The system is composed of dissected quartzite hills and plateaus, with foot slopes of alluvial material from the hills.

Component	Hills	Foot Slopes
Geology	Quartzite (Tent Hill Formation)	Alluvial material from hills.
Soils	Shallow, stony, powdery red calcareous loams.	Moderately deep, alkaline, gravely red duplex soil.
Dominant vegetation *Overstorey* *Understorey*	[D] Low bluebush, [D] bladder saltbush, [D] bush minuria (*Minuria cunninghamii*) [D] Plover daisy *(Ixiolaena spp)*, wallaby grass *(Danthonia caespitosa)*, medic, annual grasses.	Western myall, black oak. [D] Bladder saltbush, [D] pearl bluebush, medic, annual grasses.
Proneness to wind erosion & water erosion.	Not prone to wind or water erosion.	Prone to wind erosion in denuded areas.
Other land management problems	Feral goats, moderate numbers in this land system northwest of Port Augusta.	Rabbits, moderate numbers. Degraded perennial vegetation around watering points.
Productivity	High	High
Average stocking rate	8 - 12 sheep per square kilometre	

[D] Decreaser Species

Table 11: Buckleboo Land System

The major portion of this land system occurs to the south of the Gawler Ranges. The majority of this system consists of undulating plains, with occasional hills and sand dunes.

Component	Plain	Hills	Sand Dunes
Geology	Aeolian calcareous sediments of marine origin (Wiabuna formation).	Quartzite, dactite & rhyolite outcrops.	Aeolian quartz sand (Moornaba formation).
Soils	Red calcareous sandy loams.	Shallow, stony, brown calcareous loams.	Red sands and loamy sands.
Dominant vegetation *Overstorey*	Western myall, black oak, red mallee, yorrell, mulga, bullock bush, [S] emu bush, [I] cassia.	Western myall, [S] bullock bush, mulga, [S] emu bush.	Pointed mallee *(Eucalyptus socialis)*, mallee cyprus pine, black oak, mulga
Understorey	[D] Pearl bluebush, [D] bladder saltbush, medics tussock grasses.	[D] Pearl bluebush, [D] bladder saltbush.	[D] Pearl bluebush, [D] bladder saltbush, tussock grasses. annual forage species
Proneness to wind erosion & water erosion.	Not prone to wind or water erosion.	Not prone to wind or water erosion.	Prone to wind erosion when perennial cover is removed or disturbed.
Other land management problems	Degraded perennial vegetation in some areas. Lack of underground water. Rabbits, low numbers.	Lack of underground water. Rabbits, low numbers.	Lack of underground water. Rabbits, low numbers
Productivity	Low - Moderate	Low	Low
Average stocking rate	7 - 10 sheep per square kilometre		

[D] Decreaser Species [I] Increaser Species [S] Indicator Species

Table 12: Saltia Land System

This land system occupies a small section of the eastern side of the Soil Conservation District. It is part of the western fringe of the Flinders Ranges. This land system is made up of steep hills and outwash fans.

Component	Hills	Outwash Fans
Geology	Part of the Adelaide Geosyncline - quartzites, sandstones, shales, and siltstones.	Outwash from hills (Pooraka formation)
Soils	Shallow, stony, reddish clay loams.	Deep, red, alkaline, duplex soils.
Dominant vegetation *Overstorey* *Understorey*	Northern cyprus pine, black oak, gilja. Grasses & ephemeral forbs.	[D] Pearl bluebush, [D] low bluebush, [D] bladder saltbush.
Proneness to wind erosion & water erosion.	Prone to water erosion when soil cover is lacking.	Prone to gully erosion during severe storms.
Other land management problems	Feral goats, moderate numbers.	Rabbits, low numbers. Degraded perennial vegetation around watering points.
Productivity	Low - Moderate	High
Average stocking rate	9 - 12 sheep per square kilometre	

[D] Decreaser Species

WATER RESOURCES

Water resources suitable for 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 as this influences the distribution of stock. Water is therefore one of the most important factors affecting production and is also the most powerful tool in the management of the stock and pasture condition.

Underground Water

Groundwater occurs in joints and fractures in the hard rocks and also in younger sediments such as unconsolidated gravel, sand or silt. Salinity levels are generally very high throughout the area because of the low rainfall, although better stock quality groundwater can be found in areas where surface water concentrates after heavy rainstorms, such as swamps and drainage lines.

The Gawler Ranges has limited underground water of suitable quality for animal production. There are only a handful of wells from which stock quality water can be piped. These are: Wizzo Well, Artaming Well, Thurlga Homestead Well, Kalinta, Narkana Well, Crown Well, Paney Well, Shepherds Bore, Mullina Well, Box Creek Well, Pine Well and Ti Tree Well. These wells are local aquifers, which currently have a supply of greater than 10,000 gallons per day.

Several springs of good quality water (about 700ppm) occur in the Saltia land system, these are: South Creek, B-Spring, Depot Creek and Yadlamulka Spring.

Numerous minor wells able to water a small number of stock occur throughout the District. These are of indifferent quality and low supply and do not appear to show a direct relationship to land systems. Many properties have little or no useable underground water. However, the Polder Basin on Eyre Peninsula supplies water to the southern end of Uno Station.

Because of increased mineral exploration and development in the area, extensive investigations will need to be carried out by PIRSA to delineate possible water supplies for any future mining activity.

Surface Water

Throughout the District there are pockets of good clay on which earth tanks and dams have been built. Dams are up to 50,000 cubic yards in capacity and boast upwards of three years supply. The largest dams have long pipeline systems radiating from them. Even the largest dams may become dry due to periods of only light rains, which do not produce any runoff. The early 1980s was one such time when dams throughout the District were dry and as a result stations carried very few stock.

Smaller dams with capacities, which last less than one-year water individual paddocks, and are located throughout the District.

Murray Water

The Mannum to Woomera, Whyalla and Iron Knob pipelines provide River Murray water to stations located along their routes.

LAND MANAGEMENT

PERENNIAL VEGETATION

Maintaining the density and diversity of perennial plants is most important to maintain or improve productivity and the condition of the native vegetation. A reduction in the density of perennial vegetation, or a loss of perennial vegetation from areas where stock concentrate leads:

- Reduced productivity;
- Change in species composition, often with an increase in unpalatable increaser plants and;
- Increased susceptibility to soil erosion;
- Reduced biodiversity.

Causes

The main cause of perennial vegetation decline is uncontrolled grazing through: -

- Inappropriate stocking (stock numbers and time of grazing);
- Inadequate spread or poorly positioned watering points;
- Inadequate or poorly positioned subdivision fencing;
- Inadequate feral animal and kangaroo control.

Concentrations of stock will also lead to bush death and the inhibition of plant recruitment. Poor distribution of stock and waters, poor fence locations and poor planning for shearing, crutching and lamb marking can lead to concentrations of stock that may cause the decline in bush density and condition.

Rabbits inhibit the regeneration of trees and shrubs, ring bark shrubs, graze vegetation to ground level out of the reach of stock and dig and eat roots in dry seasons. Rabbits do not require a source of free water. Feral goats are very mobile, are not controlled by fences, eat a wide variety of plants and can graze vegetation to more than 2 metres above the ground. The grazing impact of feral goats is very difficult to manage (Henzell 1993).

In the woodland land systems fire is another threat to vegetation condition. Fire may kill all plants and destroy the seed of some species in these land types. Re-establishment of plant cover may take many years depending on timing and amount of rainfall and vegetation type and degree of fire damage.

Extent

Small areas of degraded vegetation and the potential for more areas to become denuded exist on all leases, mainly around watering points. Fire has also denuded areas within the District. Loss of perennial bush has been noted in the following land systems: -
Gawler Ranges, Moonaree, Glyde Hill, Hesso, Pandurra, Middleback, Tent Hill, Buckleboo, Saltia.

The Pastoral Program, DWLBC, in the lease assessment process examined over 1200 paddocks and installed 1043 photopoint monitoring sites. A restricted random sampling method was employed to determine overall land condition on each lease. The results indicate that of the 3611 sample observations of land condition (LCI), approximately:

- 16% had high disturbance levels (rating 1)
- 32% were moderate (rating 2) and,
- 52% had low disturbance levels, (rating 3) (Tynan 1995).

Highly disturbed sites were characterised by a lack of palatable perennial plants, severe soil disturbance and soil loss. Most of these observations were related to areas around old water points, or where waters were located on southern fence-lines (Tynan 1995).

Moderately disturbed areas generally have some remaining perennial plant cover, or annual/biennial cover, to protect the soil surface. Soil erosion levels are generally low and the area has the potential to recover if appropriate land management practices are followed (Tynan 1995).

Low disturbance areas are generally remote from the influence of stock grazing or may be close to water sources in well-managed paddocks, and are characterised by the presence of palatable plants and low levels of soil disturbance (Tynan, 1995).

Some degraded areas relate to cropping and cultivation practices in the 1890s, with crops planted and hay grown. Evidence given at the 1898 Royal Commission reveals that hay was grown in 1896 at Thurga (Thurlga), Pondinna and Yartoo and crops at Thurga for 13 years yielded ½ - 2 tons / acre (Tynan 1995). However, there is evidence of cropping and cultivation occurring much later than this, up until relatively recent times. For example, cropping for hay production was conducted west of Yarea homestead in the 1940's and on Thurlga and Pondinna up to 1973, (pers com Sandy Morris).

A total of 109 paddocks were classified as priority paddocks and these have areas that require priority action to address land management issues

Trends

Historical records and anecdotal evidence indicate an overall improvement in the condition of the vegetation in the past 15-20 years. In many previously degraded areas the density of perennial bush has increased (see Figure 21). Areas around old waters which have been bare for several decades have been recolonised by less palatable perennial species like black bluebush and bitter saltbush. More recently these same areas are being colonised by more favourable species and the density of bush is increasing. However, whilst many areas have improved from their previously degraded state, there are some areas that have not. Some of these areas would benefit from active rehabilitation measures.

The improvement in rangeland condition has occurred since the advent of pipelines (particularly polypipe) and the ability to spread water and hence spread stock more evenly over the country and a decade of favourable rainfall. The management of stocking rates and the ability through improved roads and road transport to remove stock quickly in dry times have also contributed to the improved management options and rangeland condition.

Figure 21 Trends in vegetation condition.

Note: Photographs by Pastoral Management; the 1955 photo was taken during a pastoral inspection. In 1992 and 2002 the position from which it was taken was located as nearly as possible and re-photographed.

Harts Paddock, Yardea Station, August 1955;

The same site 37 years later in October 1992.

The site in May 2002

Remedies

Prevention is better than cure. Once bush is lost it is very difficult to economically reintroduce species due to the low return per area and the unreliability of rainfall. It is very important that the condition of the country be continually monitored and stock numbers adjusted to suit the prevailing conditions.

The chenopod shrublands of the Gawler Ranges District are best set-stocked with small mobs. This style of management enables the bush to put on growth in good seasons and maintains bush for drought fodder. In most seasons the stock will rely on annual grasses and herbs for feed. Monitoring the condition of the annual feed and palatable bush is necessary. Modify stock numbers and/or feral grazing pressure to ensure that the country is able to support the total grazing pressure of the stock and other native and feral grazing animals.

The ideal sheep mob size for most types of country in the District is 300 sheep. Stock movement patterns, water location and quality, soil and vegetation type and condition, and topography of the paddock must all be considered when determining stock placement and mob size.

To encourage recruitment of plants, particularly perennial bush in areas where bush density has been reduced or bush has been removed: -

- Total grazing pressure needs to be reduced (stock, rabbits, kangaroos, feral goats,);
- Degraded areas may need to be fenced off to reduce/remove grazing pressure;
- Spelling areas from grazing after wet periods to allow seed set and recruitment;
- Rip rabbit warrens to encourage revegetation. Rabbits must be removed prior to re-seeding to ensure maximum benefit;
- Direct seed into furrows if a seed source is not within a few hundred meters (one fruiting bush may be enough);
- Contour furrow or rip bare scalded areas to increase moisture retention, reduce wind speed, provide a seed bed and prevent sheet erosion by runoff;
- Monitor the recruitment of bush to establish when to safely reintroduce stock.
- Relocate poorly located water points particularly those on southern fence lines or in paddock corners, however advice should first be sought from the Pastoral Program (WLBC) as this has implications under the Native Vegetation Act 1991. The Pastoral Board has the delegated authority for this Act on pastoral leases.

MONITORING RANGELAND CONDITION

Rangeland condition is the 'health' of the vegetation and soil resource relative to their potential condition in that particular area. Condition is determined by comparing similar soil and vegetation sites under different grazing pressures or, the same site over time.

Changes in rangeland condition can occur over short or long periods of time and may be reversible or irreversible and usually detrimental to long-term productivity. Rangeland condition is often a reflection of past management.

The two main factors, which influence rangeland condition, are seasonal conditions, and total grazing pressure from domestic, native and feral animals and insects. Indicators of high grazing pressure are:

- Loss of the more palatable perennial species and the remaining perennial species in poor condition;
- Replacement of perennial species with annual and ephemeral species;

- Replacement of palatable species with less palatable increaser species e.g. replacement of pearl bluebush with blackbush;
- Depletion of lichen crust;
- Bare unstable soil surface with associated water and wind erosion;
- Reduced recruitment from seed and reshooting of plants in response to sufficient rain.

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

Monitoring the condition of the pasture is a necessary tool in land management. The use of photographs at established locations provides a record of the trend in pasture condition. These records assist in making appropriate management decisions. The Board considers photographs to be a better method of monitoring than unrecorded visual observations.

Photographs and a few notes about the plants, season, feral grazing and stock management contribute to a body of information for future reference. More information on monitoring rangeland condition can be obtained from the Gawler Ranges Soil Conservation Board and the Pastoral Program of DWLBC.

The Pastoral Program of DWLBC has established 1043 permanent photopoint sites in the District. A photopoint site is located in nearly every permanently stocked paddock in the District. Managers are encouraged by the Soil Conservation Board and Pastoral Program to monitor these sites. The Pastoral program (WLBC) provided all pastoral leasehold properties with a photopoint-monitoring manual with photos and information collected at these sites. The Pastoral Program provides free film and processing for photographic monitoring of these sites. The Board has run successful Plant Identification and Monitoring Courses to assist land managers in this process. The Board has also undertaken monitoring of some Perpetual lease properties.

A Field Guide to the Plants of Outback South Australia has been produced by the Pastoral Program in conjunction with a number of Rangeland Soil Boards and funded by the Natural Heritage Trust. A free copy of the book will be provided to all pastoral leasehold properties. Additional copies may also be purchased.

The Current Gawler Ranges and Kingoonya Soil Conservation Districts Vegetation Monitoring Project

The Pastoral Program, DWLBC, has undertaken regional vegetation monitoring across the Gawler and Kingoonya Soil Conservation districts. The project was based on the extensive network of photopoints that were established under the Pastoral Lease Assessment program. The principle aim of the project was to objectively measure trend in a given vegetation type over last 8 to 10 or more years. The project results will be of use in providing a benchmark for measuring change across the two Districts and contribute to the development of methodologies for determining trends in other Rangeland Soil Board Districts.

Natural vegetation groupings across the area have been determined by analysing vegetation data from the photopoints. This has yielded 15 vegetation groups. 10% of the photopoint sites within each vegetation group have been randomly selected from the total number of sites falling within each group. Using random selection removes observer bias and allows for more robust statistical analysis of the data to be undertaken. Reference sites, established by the reference area project, were also being visited within each type.

Fieldwork was being undertaken during 2001 and 2002. In all, approximately 200 sites were visited. The work involved relocating the randomly chosen sites, photographing and measuring them using the same methods as when they were established.

Analysis of the shrub density data from the sites has shown a statistically significant increase in bladder saltbush *Atriplex vesicaria,* density across three of the six vegetation groups (see figure 1). At many of these sites regeneration of this species was common but numbers of juveniles varied both positively and negatively with those counted in 1992. Within the area, this species is regarded as highly desirable and prone to decline under moderate to high grazing pressure.

Other key species in the study area such as pearl bluebush *Maireana sedifolia* and blackbush *Maireana pyramidata,* remained stable. Although no significant statistical increase in bitter saltbush *Atriplex stipitata* was found, several sites showed large increases in bush density. A number of sites that were originally considered to be in fair to poor condition in 1992 had large increases in *Atriplex stipitata* numbers in 2001. This plant is often referred to as “recovery bush” as it can colonize areas with low perennial plant cover. This was particularly evident in vegetation group 11, Gawler Ranges valleys and plains, which has been heavily impacted by grazing over a long period of time and is now mostly dominated by speargrass and wards weed. Young *Atriplex stipitata* plants were recorded at a number of sites while sites considered to be in better condition had high densities of adult plants.

A report was produced for the National Land and Water Resources audit detailing results for the Gawler Ranges portion of the Gawlers Bioregion. Copies may be downloaded from www.rangelands.sa.gov.au.

1992: 159 bladder saltbush

2001:294 bladder saltbush

TOTAL GRAZING PRESSURE MANAGEMENT

Stock Management

Preservation of perennial feed and prevention of land degradation relies on managing grazing pressure. The key factor in grazing management is to stock the land within its carrying capacity. This requires avoiding concentrations of stock above the carrying capacity. Concentrations of stock are a particular management problem on water points, and in holding paddocks during handling operations. The following stock management practices need to be used to minimise the impact of grazing.

Paddock and water point development

Paddocks enable individual management of vegetation types and separation and management of stock by age and sex.

The shorter the distance between good quality feed and water the better the condition of the vegetation. To keep distance between feed and water short, paddocks need to be designed to hold small mobs of sheep (300 - 400) and to encourage the best utilisation by stock of the feed in the paddock. Sheep will walk six kilometres from water into the prevailing wind to feed. The dominant wind direction in the Gawler Ranges District is southerly. Therefore ideal paddocks are about 8 kms long from north to south and about 6 kms wide with waters north of the centre of the paddock.

The topography and mix of vegetation types in the paddock need also to be considered when designing the paddock layout. If stock are concentrated by the combination of fences, water and/or topography, the condition of the vegetation is likely to deteriorate. In these situations the location of fences and waters needs to be altered.

Maintaining fences in stock proof condition is essential to avoid the congregation of too many stock in a paddock or at a water.

The provision of two or more waters per paddock increases both management options and the spread of grazing pressure. Stock movements and grazing patterns can be manipulated by changing water availability. Waters may be turned off to alter the pattern of stock use or, stock will utilise the water, which is located into the prevailing wind. Often ephemeral waters (small catches or dams) are built in paddocks. Shifting stock and hence grazing pressure to another less used water supply by denying stock access to a water in the paddock, provides the vegetation near the "closed" water a spell. Spelling vegetation when soil moisture is high is likely to result in plant growth and seeding.

It is also necessary to regularly clean troughs to reduce the salinity of the water. Troughs need to be cleaned more frequently in summer than in winter. Stock will tend to "sip" saline water all day and stay close to the water rather than go out into the paddock to feed.

Availability of Water

Saline groundwater is available throughout the District, however stock quality ground water is not available over much of the District particularly in the western region (also see page 40). Many areas therefore, cannot be utilised for grazing stock due to the lack of water supplies, and there is a tendency to overstock places where water is available.

Cattle are less able to tolerate salinity in water than sheep, for this reason it is not possible to graze cattle throughout much of the District. Sheep will tolerate salinities of up to 8000 - 9000 ppm however productivity is reduced at these high salinities.

The higher the salt content of the water, the greener and fresher the feed needs to be to maintain stock condition. Stock on salty water and salty feed (e.g. saltbush) will decline in condition and wool production will be of low quality and quantity. Sheep on highly saline feed and/or water will stay around the waters rather than walk to feed. This can lead to the destruction of vegetation near the water.

To ensure that the limitation of the water resource does not lead to a decline in the condition of the vegetation resource, it is necessary to locate waters so that stock is not concentrated. Distribution of waters, number of waters per paddock and number of stock per paddock or water must all be planned and managed to ensure that stock get a satisfactory balance of feed quality and water quality. As referred to previously, when planning new water pints within a paddock, it is important to consider the ramifications of the Native Vegetation Act 1991. The pastoral Board has the delegated powers under this act and should be consulted before any work is done.

Extent

Acraman, Buckleboo and Glyde Hill are land systems where water availability is a management problem.

Remedies

The placement of property improvements, especially water points and fences needs to be carefully planned so that stock movements are spread over the paddock. In locating a water point, consideration needs to be given to the stability of the soil and its associated vegetation cover. For example, heavy soil growing pearl bluebush will be more suitable than light sand with mulga or mallee. Plans for property improvement need to include the relocation of waters away from southern fence-lines and paddock corners.

The potential benefits of taking the grazing pressure off a historically degraded area must be weighed against the creation of a new area of pressure or potential degradation. Consideration needs also to be given to maintaining biodiversity in areas of high habitat value. Financial costs and benefits will also be a consideration.

Dams, pipelines and the use of water harvesting technologies to maximise the catchment of runoff are all methods that can be implemented to improve water availability, and to increase stock management options.

Stock handling yards

The management of sheep for wool production requires that the sheep be brought together several times a year for shearing, crutching, lamb marking, jetting and sale. Careful and detailed planning is necessary to minimise the grazing and trampling impact of these operations on vegetation.
The movement of each mob into and out of the yards, staff requirements to ensure smooth operations, and the establishment of infrastructure to handle the stock need to planned well in advance.

Combining as many of these stock-handling procedures as possible into one operation is an effective means of reducing the potential for problems. The shearing of sale sheep needs to be

planned to coincide with the fast removal of these stock to market, hence limiting the need to keep them in holding paddocks. Jetting sheep for fly strike can often be combined with crutching or weaning if the timing of crutching is planned to coincide with the season for fly strike. Lamb marking is combined with crutching on some properties.

The establishment of infrastructure needs to be planned to ensure that it adequately copes with these stock-handling procedures. Sheep handling yards need to be spread around the run so that small mobs can be held for lamb marking and crutching operations. Mobile crutching units are becoming a more popular method of avoiding concentrations of stock during these operations. The use of crutching yards and mobile crutching yards provides the shearing shed holding yards with the maximum spell period.

It is necessary to maintain the condition of the vegetation in the shearing shed paddocks to provide stock feed at shearing and to prevent soil erosion. The large numbers of stock held in these paddocks can readily expose the soil to wind and water erosion.

At shearing all stock are put through the shearing shed. Planning this operation is essential to ensure the efficient movement of stock into the shed and back to their paddocks with the minimum of holding sheep in small paddocks. Large mobs need to be held in large paddocks to minimise their impact on the vegetation and soils. If possible, use different routes when droving sheep to and from the shed to spread the impact of stock grazing and trampling. This may take longer but benefits to the country may also be significant. Often the shearing shed is poorly located on the property and this makes the quick movement of stock difficult. Rearranging the paddocks around the shed may allow for faster movement of stock.

Set stocking and deferred grazing

In the chenopod shrublands research and the experience of land managers has shown that set-stocking paddocks with conservative numbers of sheep is the most sustainable method of management. Set stocking means stocking paddocks with similar numbers of sheep every year independent of season. The set stock rate is such that in good years the perennial vegetation is not grazed as the sheep prefer the annuals, but in poor years the perennial bush provides fodder. This system of management provides the bush with the opportunity to grow and seed in good years. Where the stock numbers are too high the bare area around the water (piosphere) will increase in size.

When placing stock in paddocks after shearing and crutching etc the condition of the paddock needs to be assessed. Use of monitoring points and photographs will assist with this assessment. The type of soil and vegetation, the type of stock, salinity of the water and previous stocking history of the paddock need to be considered when assessing the carrying capacity of the paddock. Also take into account the history of the paddock, and any particular needs or plans for pasture condition improvement.

Deferred grazing is the use of ephemeral flood out or soft opportunity country when flushes of feed become available after rain to spell the harder set stocked shrub country. The soft sandy country and flood outs grow prolific green feed after good rains. In most cases it is not possible to fully utilise this flush of growth. Not all runs have a suitable mix of country to use the deferred grazing strategy but where opportunity country exists this is an ideal method of spreading grazing and spelling the harder country and permanent waters. Opportunity country needs to be carefully managed to ensure that the vegetation's ability to respond to good seasons is maintained and the high stock numbers do not lead to soil erosion. Indications as to stocking rates are given in the land systems tables (tables 3 - 12).

Certain practices need to be avoided. These are as follows:

- Congregating, or allowing the congregation of large numbers of stock;
- Congregating sheep too many times during the year;
- Retaining stock too long during dry times;
- Locating watering points at the southern end of paddocks;
- Stock waters too close to fence lines or the corners of paddocks, or too close together;
- Long narrow paddocks;
- Over-grazing vegetation; unmanaged total grazing pressure.

These situations lead to land degradation.

It is also necessary to plan:

- The prevention of stock concentrations;
- Station improvements including relocation of poorly positioned improvements;
- Control of feral and native grazing pressure.

And, to work to your plan.

Drought Strategy

It is dry country and pastoralists need to plan with the thought in mind that it won't rain.

If in doubt, sell, is the motto. If green feed is lacking, the condition of dry feed is deteriorating and stock are not gaining condition, the number of stock held needs to be reconsidered. Stock sold in good condition brings good money on the day. When stock are held too long into a dry spell, the end result is poor stock which bring low prices and country that is damaged and will need spelling in the next good season.

Pastoralists need to have alternative plans for stock; if it does not rain more stock are sold than if it does rain. The quitting of stock during dry seasons generally follows the following progression; culls are quit first followed by wethers and older ewes. The last stock to be quit are young breeding ewes.

Enterprise Mix

When considering changing from sheep to cattle pastoralists should be aware of the capability of the country to run cattle. Cattle require better quality feed and water than sheep. Cattle are able to walk further than sheep to feed, but walk better on the softer country. Cattle are able to, and will browse shrubs up to two metres from the ground and out of reach of sheep.

The Tent Hill crabhole country, the alluvial soils, which support clover after rain, and sandy country of the Hesso and Saltia Land Systems, are suitable for cattle fattening. It is necessary to reduce sheep numbers by at least 7-8 sheep per head cattle to compensate for the introduction of cattle. Cattle are also run on creek flood outs where Noogoora Burr prevents sheep from being run. Attention should also be given to the property improvements and their ability to control cattle, cross breed sheep and the exotic breeds of sheep, such as damaras and dorpers. There is potential for wool contamination if the exotic sheep are run with merino wool sheep. This enterprise mix needs to be well managed.

Rabbits

Rabbits graze and kill perennial vegetation, remove seeds and graze seedlings and regrowth preventing recruitment and regeneration of perennial trees and shrubs. There is no recruitment of mulga and western myall in the worst rabbit-infested areas of the District.

Rabbit grazing, even at densities as low as 2 rabbits per hectare, has a significant impact on recruitment of trees and shrubs in the semi-arid woodlands and shrublands (Linton and Cooke 1994). Rabbits inhibit the recruitment of the perennial species mulga, witchetty bush *(Acacia kempeana)*, western myall, blackoak and pearl bluebush and bladder saltbush as well as many of the most palatable annual and ephemeral species.

Areas where rabbit populations are high can be completely denuded. These areas will revegetate when rabbit numbers crash, however the plant composition is often altered and is generally dominated by less palatable and less productive plants and annual plants, which provide less stability in the long term. Soil erosion caused by rabbits may result from digging, or more commonly from the removal of the stabilising perennial vegetation.

Extent

Rabbits occur throughout the Gawler Ranges Soil Conservation District. They are a substantial problem in sand dunes and adjacent the salt lakes of the Hesso and Acraman land systems and in the Pandurra land system. Rabbit populations are low to moderate in the Gawler Ranges, Moonaree, Glyde Hill, and Middleback land systems particularly along watercourses and in parts of the Tent Hill land systems. Rabbit numbers are low in Saltia and Buckleboo land systems.

Trends

Several pairs of rabbits were released onto Lincoln Gap Station for hunting purposes in about 1860 and within a decade the next owner of the station set about eradicating rabbits (Don Nicolson, pers. comm.) By 1893 rabbits were 100 km west of Fowlers Bay and reached the Western Australian border by 1894 (Stodart and Parer 1988).

There are lower rabbit numbers throughout the District since introduction of myxomatosis and the escape of RCD in 1995.

Remedies

Rabbits often breed to plague proportions following a run of good seasons, as populations can increase five fold in one year.

The warren is the key to rabbit survival in the arid zone. It provides protection from dehydration, high temperatures and predation and is required for breeding. Warren destruction is therefore the key to rabbit control.

Warren destruction is the most effective form of rabbit control and is recommended for the highly productive or intensively used areas of the most productive land systems. Control is most effectively carried out when numbers are low during a dry spell, following a myxomatosis outbreak or following poisoning (eg with 1080) (Linton and Cooke (1992), and Linton pers comm 1994. When planning a rabbit control program, land holders need to focus control measures on highly productive or intensively used areas first, and be careful not to take on too much as follow-up is required to ensure success. In sand dune country mechanical control may not be feasible due to problems arising from extensive soil disturbance.

The Board supports the continued research and development of biological control agents.

Feral goats

The Board acknowledges and recognises that potentially, a domestic goat industry may develop within the District. However, the following applies to the management of feral goats, which are not considered to be stock and therefore are not managed as a property asset. Feral goats are uncontrolled (i.e. they are not fenced into paddocks within a property boundary) and so their impact on the vegetation and natural resources needs to be managed in a different manner to management of domestic stock.

Feral goats will eat almost any plant and have the ability to browse up to 2 metres from the ground. Most vegetation in goat habitat in the pastoral areas is therefore at risk from uncontrolled goat grazing. Feral goats contribute to the grazing pressure and can be particularly difficult to control. They are very mobile, thrive in rugged terrain, are relatively free of disease and parasites, and are drought tolerant. Feral goats also have a high reproductive rate. Female feral goats may breed at as young as 3 months old. A typical nanny drops two kids every eight months. The goat population can thus increase by up to 75% in one year.

Extent

Feral goats have the potential to be a serious problem. Mustering, trapping and shooting programs keep the population under reasonable control. It is estimated that the feral goat population in the District is in the order of tens of thousands. Though many thousands are mustered and trucked out of the District each year the population of feral goats in the District, fluctuates with seasonal conditions and may appear to be increasing during exceptionally good seasons. However, over an extended period of time, the population remains static.

Feral goats occur throughout the District except for the northwest corner. The main concentrations are in the hills of the Gawler Ranges land system, to the south of Lake Gairdner and in the hills of the Tent Hill land system northwest of Port Augusta. Feral goats occur in the following land systems: - Gawler Ranges, Middleback, Tent Hill, Saltia and Buckleboo.

Remedies

The Gawler Ranges Soil Conservation District is involved in a co-ordinated approach to feral goat eradication in the pastoral areas. Co-ordinated and on-going feral goat mustering, shooting and, shoot-on-sight are necessary strategies for the control and eventual eradication of feral goats from the District. At present high prices for feral goats are providing an incentive for feral goat mustering.

The Gawler Ranges Soil Board continues to support the eradication of uncontrolled and unmanaged feral goats in the district.

Kangaroos

The distribution of permanent water throughout the District, and the elimination of the dingo has allowed the population of reds and western grey kangaroos or "scrubbers" to increase. Kangaroos move to areas where rain has produced annual grassy feed and are a significant problem as they contribute to the total grazing pressure.

Western greys are difficult to count and it is felt that the population has been underestimated.

Kangaroo tag allocation for individual properties are calculated by using the following formula- Property size x average kangaroo density x quota %.

Trends

The DEH Kangaroo Management Group has monitored red and western grey kangaroo numbers in the Gawler Ranges SCD by aerial survey since 1978. Ground based surveys were conducted during the period 1986 to 1989 including intensive line transects conducted on foot to determine Euro densities in areas of optimal habitats. In addition, preliminary work has commenced on determining the status of the Yellow-footed Rock-wallaby, a vulnerable species of kangaroo that occurs in very low numbers in the Soil Conservation District.

Aerial survey figures supplied by DEH indicate an average Red Kangaroo density of 3.3 /km2 during that time and an average Western Grey Kangaroo density of 3.2 /km2. Euro densities in their optimum habitat within the region have averaged 5.4/km2 based on limited survey information.

The Board believes that western grey kangaroo densities have consistently been under estimated. Recent research on correction factors relating to visibility of this species from the air supports that belief. The Board believes that densities of 3.4/km2 for red kangaroos and 6.6km/2 for Western Greys are more realistic.

Remedies

The current practice is to issue permits on the basis of the district average kangaroo densities. Due to the variation in land systems within the District and the associated variability in species make up and densities, DEH is requested to issue permits on the basis of half-degree block survey information. However, the Board has revised the target densities and recommends the following:

Red Kangaroos –1.5 to 3.5/km2, Greys - 1.5 to 3.5km/2, Euros - 3 to 5km/2.

Figure 22 Average annual rainfall and kangaroo densities in Gawler Ranges SCB from 1978 – 2002.

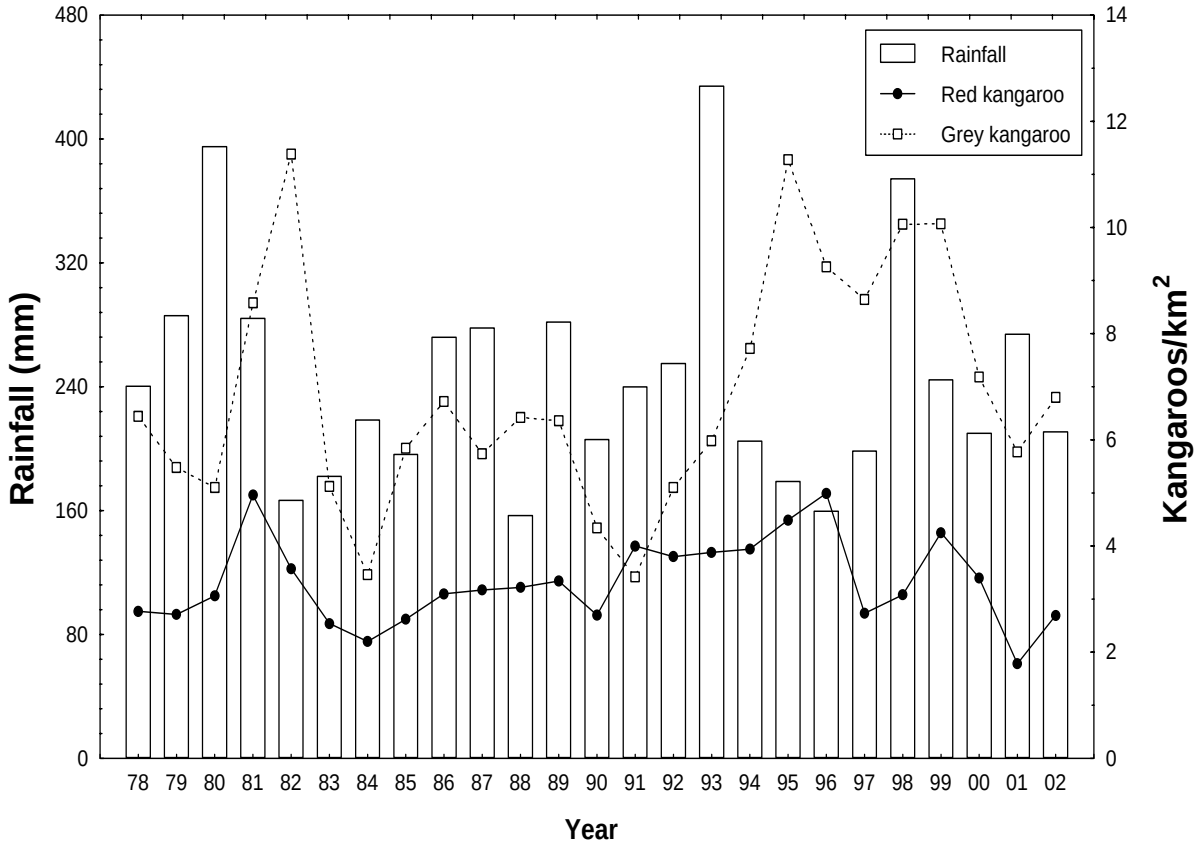


Table 13 Red **and Grey Kangaroo and Euro Densities and Estimated Total Numbers**

Year	Reds per/km ^{2}	Total Reds	Greys per km^2	Total Greys	Euros per km^2	Total Euros
1981	5.0	225,000	4.3	195,000		
1982	3.6	162,000	5.7	258,000		
1983	2.5	115,000	2.6	116,000		
1984	2.2	100,000	1.7	78,000		
1985	2.6	119,000	2.9	133,000		
1986	3.1	141,000	3.4	152,000	3.0	Hills only
1987	3.2	144,000	2.9	130,000	4.5	Hills only
1988	3.2	146,000	3.2	146,000	8.0	Hills only
1989	3.3	151,000	3.2	144,000	6.0	Hills only
1990	2.7	122,000	2.2	99,000		
1991	4.0	181,000	1.7	78,000		
1992	3.8	173,000	2.6	116,000		
1993	3.9	176,000	3.0	136,000		
1994	3.9	179,000	3.9	175,000		
1995	4.5	204,000	5.6	256,000		
1996	4.99	227,000	9.26	420,000		
1997	2.73	124,000	8.64	248,000	5	57,000
1998	3.08	140,000	10.06	457,000		
1999	4.25	193,000	10.07	457,000		
2000	3.4	154,000	7.18	326,000		
2001	1.78	81,000	5.77	262,000	6	68,000
2002	2.69	122,000	6.8	309,000		

The Kangaroo Management Group, DEH, has supplied the following management objectives.

Objective 1	To harvest Red Kangaroos, Western Grey Kangaroos and Euros as a sustainable resource.
Action	A sustainable use harvest quota of 15% for Red Kangaroos, 12% for Western Grey Kangaroos and 15% for Euros of the estimated populations on each property will be issued each year based on survey results of the previous year. Permits are issued in whole at the beginning of each calendar 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, Western Grey Kangaroo and Euro numbers and concentration of excessively large numbers of these species on dwindling food and water resources during the onset of drought.
Action	Encourage the use of the 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 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 Australian kangaroo harvesting quota is available to lower unusually high kangaroo numbers or address specific land management issues identified at a regional level. In years where drought conditions are developing, the Board, in consultation with DEH, will seek to achieve a lowering of kangaroo densities in the region. This will be done through additional kangaroo harvesting quotas or shoot and let lie permits when conditions are severe and the kangaroo industry is unable to take the required numbers being culled.
Objective 3	To protect isolated colonies of Yellow-footed Rock-wallabies that occur within the district.
Action	Monitor the outcome of efforts to assist the recovery of remnant colonies of this species in the district.

Role of the Soil Board

The state wide kangaroo harvesting quota consists of two portions; -
- The sustainable use portion which is fully allocated to properties at the beginning of each year
- The land management component, which will only be released when necessary to address regional land management issues.

Under the program the boards are requested to advise the DEH on land management issues that require additional allocation of kangaroo harvesting quotas. This advice is sought in relation to long term grazing impact of kangaroos on a regional basis but individual property issues can be addressed within this context.

Continuation of the improvement in economic value of kangaroos and kangaroo products is a key to realising a sustainable regional harvest. The basis of this is: -
- Protection to land managers from extremes in kangaroo numbers under most circumstances
- A commercially viable kangaroo industry that can maintain a kangaroo harvesting regime at no cost to the land manager
- Enabling the development of a commercial value for kangaroos so that land managers can gain some financial reward from the kangaroos harvested on their property
- Improvement in the acceptance of moderate numbers of kangaroos on pastoral lands.

Personal use of kangaroos
A system allowing personal use is available through the issue of personal tags. If issued in quantities above 50 animals, these tags will be subtracted from a properties commercial quota. These maybe issued to sporting or recreational shooters, however any carcass or skin must not be used for resale or any other commercial purposes, obviously including export. All kangaroos taken must be shot in accordance with the Code for Humane Shooting of Kangaroos.

Management of total grazing pressure is an important land management issue. The use of the land management component of kangaroo harvesting is linked to a regional approach and this requires co-operation between the Soil Boards, the Pastoral Board DEH and other interested bodies. The Gawler Ranges SCB will continue to work with DEH to ensure that kangaroo numbers are maintained in balance with the sustainability of the vegetation and other natural resources of the region.

WATER EROSION

Water erosion is a process where soil particles are detached and transported by the action of rainfall, runoff or seepage. There are several forms of water erosion including splash, sheet, rill and gully erosion. Sheet erosion may lead to the development of scalds or "clay-pans".

Potential for water erosion is determined by:
- Density and nature of soil surface cover (annual/perennial vegetation, lichen crust, stone or litter);
- Slope of the land (length of slope and size of catchment);
- Soil type and the structural stability of the soil.

The potential for management will increase water erosion practices which: -
- Break down soil structure into fine readily transportable particles e.g. by stock trampling, vehicle movements;
- Remove protective vegetation, lichen crust or stone cover (especially Tent Hill land system) or mulch cover e.g. by over grazing or track building;
- The creation of furrows or tracks up and down slopes.

Causes

Most rill and gully erosion occurs during high intensity rainfall events in areas where there is not sufficient ground cover. Overgrazing leads to the loss of perennial cover and the pulverisation of soils which leaves areas prone to water erosion.

Water erosion is worst in bare areas particularly areas around catchments of dams, and at the bottom of hills and slopes. Dams are often located down slope of relatively bare areas as they provide a good watershed. Gully erosion can be a problem along access tracks especially on the deeper clay soils.

Sheet erosion is the loss of a thin layer of topsoil from large areas where vegetation cover is very sparse and shallow-rooted.

Extent

There has been no significant new gully erosion in recent years and sheet erosion has occurred in some areas in the past particularly along gentle foot slopes. Land systems prone to water erosion are Gawler Ranges, Middleback, Tent Hill and Saltia.

Remedies

The aim of land management needs to be to prevent water erosion. To prevent water erosion:
- The density of perennial vegetation needs to be maintained or improved;
- Lichen crusts on the soil surface needs to be maintained;
- Stone cover on Tent Hill land system needs to be maintained;
- Steep drains and banks into dams need to be avoided;
- Divert water away from areas likely to gully and gully heads;
- Access tracks need to be planned and properly constructed;
- Tracks on steep country need to be avoided.

To rehabilitate sheet-eroded or scalded land: -
- Runoff needs to be controlled;
- Wind velocity needs to be reduced at the soil surface;
- Adequate moisture needs to be provided for seed germination and seedling establishment;
- A seed-bed suitable for root penetration needs to be provided;
- Reduce topsoil salinity by increasing water infiltration where necessary;
- Seed needs to be provided to the site by:
- A source of mature bushes of appropriate species within 50 metres of the site or,
- Direct seeding.

These needs may be met by mechanically altering the site. Ripping, furrowing and water ponding have been shown to be the most successful treatments for reclaiming scalds. Disc pitting has been trialed extensively but is not always successful on scalded areas due to the filling of pits and crusting of the soil surface by dispersive and/or slaking soils. A mechanical rehabilitation program needs to be planned. Select small areas on the most important or productive land types, which have high chance of success. Natural rehabilitation of scalds will occur over time where grazing and trampling pressure is removed.

WIND EROSION

Wind erosion is the process by which soil is removed and transported by wind and will occur where soil surface protection is low and where soil particles are light enough to be moved by the wind.

Factors affecting wind erosion are:
- Size of the soil particles - finer grained soils are more susceptible to wind erosion;
- Density and height of soil cover such as plants, stone and litter - the most serious wind erosion occurs during droughts or where the soil has been disturbed and/or grazed bare;
- Wind velocity, direction, duration and season (soil moisture) determine its capacity to erode - strong winds in autumn and in spring after a dry winter have the potential to cause most damage;
- Topography affects turbulence and wind velocity.

The major cost to the producer of wind erosion is the loss of nutrients and organic matter as dust. These losses reduce productivity, which in turn reduces plant growth and increases susceptibility to further erosion. The sand blasting effect of eroding soil may damage plants, particularly seedlings.

Forms and symptoms of wind erosion in arid pastoral areas include: -
Hummocks and mounds - The redistribution of soil by wind at the local level accumulates at the bases of shrubs and around other obstructions.

Scalds - A bare area 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 the semi-arid and arid regions. Scalds are difficult to revegetate due to the lack of topsoil, low permeability, and often-saline surface.

Drift - Accumulation of wind blown soil, often deposited around obstacles such a fences, tanks, troughs or vegetation.

Deflation - The removal of fine particles of soil by wind.

Pedestals - The removal of soil from the base of a plant, exposing roots and leaving the plant on a pedestal above the surrounding land surface.

Causes

The potential for management will increase wind erosion practices which: -
- Reduce the density or height of vegetation;
- Remove perennial vegetation and its replacement by annual plants;
- Remove or damage the lichen crust which protects the soil surface;
- Remove litter, which provides soil surface protection.

Fire is the biggest single contributing factor to wind erosion in the District. The lighter soils support mulga woodlands, which are most susceptible to fire. Fire kills the mulga overstorey, burns the grasses and depletes the seed store. After a fire even gentle winds will erode this country. The soil remains bare until suitable rains provide moisture for germination, and even then it is annuals that begin the colonisation process. It can be more than a decade before perennial plants are recruited in sufficient densities to stabilise the soils. Management of fire-affected areas is discussed later in this plan.

Extent

Wind erosion is not considered a big land degradation problem in the Gawler Ranges Soil Conservation District. There has been a significant reduction in the frequency of wind erosion events since the introduction of myxomatosis and RCD, a decrease in rabbit numbers in the District.

Fire affected areas are most prone to wind erosion until vegetation cover is re-established. Fires do not occur frequently though when they do occur quite large tracts of land can be affected. The hills covered in porcupine grass burn frequently, this vegetation form is well adapted to fire and does not pose a wind erosion problem.

Areas around watering points and dam catchments (considered a sacrifice areas) can be susceptible to wind erosion due to the low density of plant cover.

Wind erosion is potentially worst on the deep sands of the Acraman, Hesso and Buckleboo land systems, in the plains areas of the Pandurra and Middleback land systems and the foot slopes of the Tent Hill land system.

Remedies

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

Measures for the prevention of wind erosion include:
- The density of perennial vegetation cover needs to be maintained or increased;
- Annual grass and litter need to be maintained to provide cover on sandy soils,
- Avoid placing access tracks and water points on sandy soils;
- Fire affected areas need to be managed to ensure maximum recruitment of plants and establishment of perennial plants in the longer term;
- Rabbits need to be controlled or, if possible, eradicated;
- The lichen crust on soil surfaces needs to be maintained.

To revegetate areas where wind erosion has occurred it is necessary to restrict grazing pressure. Reseeding where a seed source is absent, and providing seed and nutrient traps in the form of dead timber and deep ripping of scalds will contribute to the establishment of vegetation.

SALINITY

The semi-arid rangelands are relatively saline environments due to the recent geology of the region. However saline patches appear to be expanding in some areas particularly in the flood plain areas of the Gawler Ranges land system. The mechanism for this salination is not known. A rise in the water table due to a succession of relatively wet seasons or due to a reduced density of perennial vegetation is possible explanations.

The Board sees a need for long term monitoring of the situation.

WEEDS

Woody shrub increase

Grazing practices in the pioneering days of the District caused the removal of palatable perennial plants from some areas and has lead to the increase in density of some species of woody shrubs. These include senna (previously called cassia) and hopbush. These species are considered weeds because they are unpalatable and tend to grow in thickets, which make mustering difficult. These woody species are native to the area. Experience interstate indicates that these species increase where the vegetation and soils have been disturbed and/or where there is a lack of competition for soil moisture from chenopod shrubs and grasses. In these situations the growth of woody shrub seedlings is not limited by competition and shrubs may establish in high densities.

The increase in density of woody shrubs is not a big or extensive problem in the Gawler Ranges District. The Board considers it important that the situation be monitored, and that an understanding of the factors leading to woody shrub increase be gained.

To prevent an increase in woody shrubs it is necessary to stock country so that the density of palatable perennial bush species is not reduced and soil stability is maintained.

This is a very complex problem and it is very 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 vigorous deep-rooted plants is also necessary. Approval from both the Pastoral Board and the Native Vegetation Council are required prior to removing native vegetation.

Other weeds of significance in the district
These include: -

- African boxthorn
- Onion weed
- bathurst burr
- Horehound
- noogoora burr
- caltrop
- Prickly pears

MANAGEMENT OF FIRE AFFECTED AREAS

Causes

In most years there is not enough fuel for wild fires to burn in the pastoral areas of South Australia. It is only after seasons of exceptional rainfall (about twice the average annual) that enough fuel exists to carry a fire (Lay 1976). Spear grass and kerosene grass (*Stipa nitida and Aristida contorta*) contribute most to the fuel load. Lightening strikes occurring as part of dry monsoon weather patterns during the months November through February starts most wild fires.

Different plant communities are affected in different ways by fire. Key factors in the impact of fire on plant communities are, temperature of burn, season of burn and adaptation of species within the vegetation community.

In porcupine grasslands, most shrubs and tree species regrow immediately after fire from adventitious buds or roots (Griffin 1984). Although mulga is extensively killed by wildfires it has

a good ability to regenerate from seed (provided rabbits are not a problem). During the recovery phase of mulga woodlands the biomass of both perennial and ephemeral pasture is greater due to the reduced competition from trees and shrubs (Morrisey 1984). Mallee lands comprise some of the most inflammable in the semi-arid zone, largely because of the litter they produce. Some of the porcupine grass hills have a mallee overstorey, both are highly resinous and flammable.

Spring burning can result in significant mallee seedling recruitment and autumn burns may reduce mallee density if there is sufficient fuel (Noble 1984).

Chenopod shrublands are not adapted to a regular fire regime; chenopods are not intrinsically flammable and fuel (herbage) levels are low (Graetz and Wilson 1984). During exceptionally wet seasons spear grass grows prolifically in the chenopod shrublands. Spear grass is highly flammable and is the chief fuel for fires in the shrublands. When chenopod shrublands are burned bladder saltbush may be removed completely whilst pearl and black bluebush often reshoot from rootstocks. More importantly, seed is necessary for regeneration of many species particularly bladder saltbush, and seedlings are readily lost and the seed bank exhausted if grazing pressure is not checked.

Extent

Losses of station improvements, stock and vegetation can be great as a result of wild fire. All areas within the District are susceptible to wild fire when fuel loads are high.

Fires do not occur frequently though when they do occur quite large tracts of land can be affected. In 1921 a fire burned between Lowe Hill on North Siam to Oakden Hills; in 1974 a fire burned between Mahanewo, Yalymboo and Oakden Hills; in 1989 an area burned on Cooyerdoo, and 1993 a small area on Corraberra was burnt. The hills covered in porcupine grass burn frequently, this vegetation form is well adapted to fire and does not pose an erosion problem.

Remedies

The post-fire management of an area needs to recognise that these areas are particularly susceptible to wind and water erosion until vegetation cover regenerates. Fires consume all fine fuel (leaves, small branches and litter) in its path leaving a bare soil surface, except for larger branches and fallen trees. The rate and extent of revegetation are primarily governed by soil moisture and prevalent temperatures but also depends on the density of sprouting and tillering plants, and the size composition and distribution of the soil seed store. Grazing pressure needs to be removed from fire-affected areas whilst perennial plants are utilising food reserves to produce new leaves and new plants are establishing from seed (Hodgkinson et al 1984).

The Gawler Ranges Soil Conservation Board in conjunction with Primary Industries SA are monitoring the recovery of some western myall - pearl bluebush country, which burned in December 1993. The aim of the monitoring and trials is to gain knowledge and understanding of post fire recovery in this country. The fire killed the western myall trees and completely removed bush and litter. Since the fire little rain has fallen, however most pearl bluebush, and some yanga bush and acacias have reshot from root stock (see Figure 23).

Three trial plots have been established to evaluate camel pitting[8] and seeding with bladder saltbush. The first plot has been camel pitted, the second camel pitted and seeded with bladder saltbush and the third camel pitted, seeded with bladder saltbush and "harrowed" by dragging a piece of weld mesh over the seeded plot to cover the seed with soil. Since the light winter rains saltbush seedlings have germinated in both the seeded plots, with almost twice as many seedlings in the "harrowed" plot as the camel pitted and seeded plot. No bladder saltbush has germinated in the unseeded, camel pitted plot. Monitoring of these trials and photographic monitoring of the burned site will continue for some time.

Figure 23 Impact of Fire on Vegetation.

(a) Bush fire on Corraberra Station, December 1993.

(b) The same paddock four months later, March 1994.

(c) The same paddock ten months after the fire, September 1994.

[8] Camel pitting - the use of an off-set disc implement to make shallow pits or depressions in the soil which retain water from rainfall and thus encourage growth of vegetation.

CONSERVATION AND BIODIVERSITY

There are three Conservation Parks in the District. These are Lake Gilles, Whyalla, and Winninowie Conservation Parks. The Gawler Ranges, Lake Torrens and Lake Gairdner National Parks form part of the northern boundary of the District. These areas are managed by the Department of Environment and Heritage.

Privately initiated conservation practices are the core of a potentially large and effective conservation strategy for pastoral lands in the District. Long-term survival of many species will only be possible if active management of animal and plant diversity by landholders and managers occurs.

To this end the Gawler Ranges Soil Conservation Board encourages all land managers to control cats, foxes, rabbits and feral goats where-ever possible as these feral animals are considered destructive to native animals and plants. The Board also encourages the protection of endangered plants and plant associations and the habitat of native animals. Plant conservation is achieved by the sustainable management of the grazing enterprise through the maintenance of biodiversity. Desert limes, a plant classified as vulnerable exists in small pockets within the district. Station land managers are aware of the species' status and are taking steps to ensure its survival.

Habitat conservation needs to be based on adequate information about each species' life requirements and its population dynamics. A manual has been developed for land managers in this area on behalf of the Pastoral Board which:

- Allows pastoralists to identify endangered fauna species or species of interest and their habitat types, and provide general information about species behaviour and biology;
- Provide information on best management practices to maintain or enhance fauna diversity;
- Include information for accessing advice and wildlife management funding.

Animal species, which are particularly significant and/or worthy of consideration when changing land use or intensity of land use, are listed below. This list has been prepared from the preliminary results of a wildlife management project conducted by Harald Ehmann.

Birds
Thick-billed Grass Wren, Samphire or Slender-billed Thornbill, Mallee Fowl, Peregrine Falcon, Australian Bustard, Bush Stone Curlew (survival in the district uncertain), Purple-crowned Lorikeet, Night Parrot (this district is the area from which most of the known specimens were taken in the late 1800s, (survival in the district is uncertain), Burkes Parrot, Scarlet-chested Parrot.

Mammals
Yellow-footed Rock Wallaby *Petrogale xanthopus*, Bettong *Bettongia ssp* (unconfirmed recent sightings), Mitchells Hopping Mouse *Notomys mitchellii*, Hairy-nosed Wombat *Lasiorhinus latifrons*.

Reptiles
Pernatty Knob-tailed Gecko *Nephrurus deleani*, Carpet Python *Morelia spilota*, Samphire Slender Bluetoungue *Cyclodomorphus ssp* (undescribed species occurring in samphire habitat, occurrence in the district to be confirmed).

Amphibians
The Burrowing Frogs *Neobatrachus pictus and N. centralis*. In the district hybridisation occurs between the southern species *N. pictus* and the northern species *N centralis*. Locations where hybridisation is known or found (that is low-lying flood prone situations where the two species

meet) may need to be conservatively managed (H. Ehmann, pers. comm).

RESEARCH

Middleback Field Centre is a rangeland research, education and training facility located on Middleback Station (20km north-west of Whyalla). The Field Centre was constructed in 1979 by the Botany Department of The University of Adelaide with the support of the Nicholson family, lessees of Middleback, Roopena and Katunga Stations, who allowed part of their lease to be set aside as a scientific reserve.

The Field Centre is now run and funded through a unique joint venture between the SA Government (through the Pastoral Program, Department of Water, Land and Biodiversity Conservation), The University of Adelaide, and the SA Pastoral Industry (represented by the Nicolson family). A Board of Management represents these organisations.

The North Terrace and Roseworthy Campuses of The University of Adelaide and the School of Biological Sciences at Flinders University use the Field Centre as a base for research and teaching activities. They use the Centre for undergraduate field courses where up to forty students visit the station and carry out projects toward their Bachelor of Science or Applied Science degrees.

Staff and postgraduate students also base their research work at the Centre and have access to the Roopena and Katunga leases for their studies. Research has focussed on the ecology and grazing management of the chenopod shrublands, and has contributed to the knowledge of sustainable grazing practices.

The facilities at the Field Centre include a lecture theatre which seats up to 55 people, a basement laboratory, large undercover work area and glass and shade houses. Accommodation is provided in a flat attached to the lecture theatre and in the station Shearer's quarters. A nominal fee is charged for use of the facilities to contribute to running costs.

MANAGING RISK

Property Management Planning
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 to sub-optimal management.

Property Management Planning (PMP) offers a challenging and productive approach to pastoral enterprise management. It is a management process that integrates personal goals with animal production, economics, marketing and natural resources management. If implemented a good property management plan results in the development of a sustainable and viable pastoral business.

Funding is available through Farm Bis to assist with this process, please contact Rural Solutions SA, Port Augusta office.

The process offered through Rural Solutions SA works through six steps, the result of which would be an effective Property Management Plan for your property and business. The steps, and the sorts of activities, which make up a plan are:

Setting direction;
- Set personal and business goals,
- Identify strengths, weaknesses, opportunities and threats.

Natural resources and property layout;
- Stock take of the property's soil, vegetation and water resources and existing property layout,
- Discuss climatic variability,
- Develop general plans for sustainable grazing management.

Human resources and business position;
- Identify the people involved in the business and their skills,
- Equity, cash flow and net profit/loss,
- Identify and discuss business structures.

Enterprise evaluation;
- Livestock performance indicators.

Enterprise planning;
- Methods for assessing proposed management changes, diversification etc.

Business planning;
- Estate and retirement planning,
- Identify short, medium and long term objectives,
- Plan monitoring and business controls.

The Pastoral Program of DWLBC has available updated paddock plans. These maps have been produced using an accurate standard map base. These maps provide an excellent basis for property planning as they show fences, waters, shacks and paddock size. The maps are updated following pastoral lease inspection. The maps can also be provided to show map grid reference and land systems. Copies of maps are available to lessees and managers by request.

Climate Risk Management Workshops
The workshops, which cover the following topics and can be run over one day or as four separate modules: -

Module 1 – Understanding Risk
- Determining how attitudes to risk are formed
- Estimating actual risk on individual properties

Module 2 – Understanding Weather and Climate in Southern Australia
- Weather map interpretation
- Understanding climate systems and their influence at a local level
- Making planning decisions using Australian RAINMAN

Module 3 – Using Decision Support Tools to Manage Climate Risk
- Using rainfall deciles
- Learning the appropriate decision support tools for your region

Module 4 – Developing Climate Risk Plans
- How to effectively use the information to develop a plan for managing your climate risks.

Overall the workshops allows the property manager to understand how climate forecasts can be used as trigger points to implement management strategies, with the end point being a potential increase in business profit by maximising opportunities in good seasons and minimising looses in bad seasons.

OTHER LAND MANAGEMENT ISSUES

MINING AND EXPLORATION

Problems
- Excessive clearing for roads during the exploration stage.
- Gully erosion of access tracks.
- Deep rutting of ground whilst moving heavy equipment around, leading to water/gully erosion.

Board Policy
- Disturbed areas need to be rehabilitated. Rehabilitation needs to include the removal of rubbish, battering off steep slopes, respreading topsoil, and ripping to promote seed capture, water accumulation and seed germination. Large areas need to be seeded with suitable locally collected native seed.
- The SCB and the lessee need to be consulted prior to exploration and their recommendations and concerns given due consideration.
- Access tracks should be built on the contour to avoid gully erosion.

DEFENCE FORCE ACTIVITIES

Problems
Military activities involving heavy vehicles have the potential to cause lasting damage to vegetation and soils. Damage to station improvements and water supply is also of concern.

Board Policy
The Soil Conservation Board and affected lessees, and the Pastoral Program of the Department of Environment and Heritage need to be consulted prior to activities outside the Army Reserve.

Rehabilitation of land disturbed by the exercises needs to be carried out to the satisfaction of the SCB.

The Army Reserve is managed in accordance with accepted local land management standards to ensure its future productivity.

Monitor the disturbance and rehabilitation of sites used for exercises.

TOURISM

The community's interest in the rangelands as a recreational resource has increased in the last few years and this has brought with is a range of issues.

Problems
- Erosion problems result from 4WD access in unstable areas.
- Removal of wood for fires.
- Uncontrolled grazing can result from tourists leaving gates open.
- Unacceptable rubbish disposal.

Board Policy

- Tourism provides an opportunity for diversification of the pastoral enterprise.
- Tourist access needs to be controlled, lessees may erect 'no public access' signs to deter unauthorised entry of travellers.
- Access needs to be restricted to dedicated access tracks, campgrounds, and points of interest.
- Board to have input into the selection of Public Access Routes under the *Pastoral Land Management and Conservation Act 1989*.
- Educate outback travellers by making available the 'Sharing the Outback' pamphlet, which outlines the dos and don'ts of travelling in the pastoral areas.

THREE-YEAR PROGRAM

This Three Year Program reviews the previous program and outlines new activities for the board to address land management issues in the District.

Review of previous District Plan 3 Year Program

Review of Aims	**1. Did we achieve this? Yes or no?** **2. Still valid? Continue as is or suggested changes.**	**1. If not achieved - not, why not?, valid reason?** **2. Any other issues associated with this aim?**
1. Promote the ethic that land be used sustainably	Yes. How – successful property inspections, field days, projects plant ID and monitoring course. Should be continued.	
2. Promote sound stock management to prevent damage to the land resource and ensure the sustainable use of the natural resource	Yes, as above	
3. Encourage the control of goats and work towards their eradication	Change this to “feral goats” and use words “work towards the ideal of their eradication.”	Achieved to some degree, goats as an industry in the rangelands are still undergoing debate.
4. Increase productivity of degraded areas by facilitating regeneration of native vegetation	Yes, fire site on Cariewerloo, revegetation projects on Myola, Carierwerloo, Wilkatana, direct seeding and contour furrowing on Tregalana. Recommend continue.	Need to show the costs and the benefits of this, any new trials should incorporate this, find new sponsor for this activity.
5. Support the control of the kangaroo population within the district	Yes, as part of total grazing pressure. Andrew Smart is board contact. Western Greys are starting to dominate, maybe changing their range and distribution	In conjunction with the Pastoral Board (incorporate into Inspection reports), need to recognise that there is a problem, need to demonstrate the impact, put together an argument directed to the broader community re increased control of western greys.
6. Maintain the biodiversity of the region by informing land managers of its importance	Yes but need clear activities that involve demonstrating this.	

and promoting sustainable land management		
7. Encourage the control of rabbits in high priority areas	Yes. Continue.	
8. Encourage the control and eventual eradication of foxes and cats	Regular baiting programs occur on Myola and Oakden Hills, need activities that demonstrate the benefits of this, see Vicki Linton's work on foxes, Bounceback on cats.	
9. The board is committed to land holder co-operation and an educational approach to prevent and control land degradation within the district	Yes, continue	

Review of Activities **<u>Goat eradication</u>**	**1. Did we achieve these? Yes or no?** **2. Was this effective in achieving our aims?** **3. Continue? Yes or No?** **3. Suggested changes.** **Change to feral goat**	**1. If not achieved, why not?** **2. Other issues.**
1. Fund goat control co-ordinator	Achieved but not necessarily effective, goat control occurred because the price went up, control is price and seasonally driven	
2. Establish cells and nominate leaders	Achieved but not effective	Promote the concept of co-ordination but do not push/force it
3. Facilitate the co-ordination of mustering within cells	Lacked commitment to this, requires a change in attitude to the way we work	
4. Purchase portable yards to loan to land holders	Yes, very effective, assisted and stimulated people to work on control	
5. Set up a fund to hire aircraft	Showed that it could be done	Did not demonstrate the cost effectiveness of this method
6. Provide info on use of spotter planes, helicopter mustering and sporting shooter associations	Yes, worked well	
7. Develop and implement strategies to eradicate after control is achieved	Partly, this is ongoing and a role for the new board!!	
8. Encourage discussions between experts to establish needs/ further activities	Add in relevant experts, held goat meetings across the region.	

Review of Activities

Review of Activities **Mgt of Rangeland Condition**	**1. Did we achieve these? Yes or no?** **2. Was this effective in achieving our aims?** **3. Continue? Yes or No?** **4. Suggested changes.**	**1. If not achieved, why not?** **2. Other issues.**
1. Apply for funds to hire botanist and produce herbarium	Secured funds for a Ute Guide for across the region, project not completed as yet.	Board needs to get regular up dates on progress of this project (Brendan Lay, DWLBC, Pastoral Program)
2. Produce herbarium of species useful for animal production and assessment of condition for each land manager and educational institution in the district	As above	
3. Hold plant identification and collection field days	Done, ask if another is required for new people to the district.	
4. Encourage land managers to monitor condition of vegetation by providing skills and information through fact sheets and field days including wether trial and plant id field days	Held monitoring workshop, promote as useful tool. New board can decide if there is demand for another similar workshop.	

Review of Activities **<u>Identify District Soil Conservation and Land Management Needs</u>**	**1. Did we achieve these? Yes or no?** **2. Was this effective in achieving our aims?** **3. Continue? Yes or No?** **4. Suggested changes.**	**1. If not achieved, why not?** **2. Other issues.**
1. Identify community expectations of the Board and project ideas by conducting a survey of land managers and community groups to assist in establishing priorities for activities.	Held open meetings around the district, which were very successful and would encourage new board to continue.	
3. Plan activities to address issues raised	E.g. purchase more goat yards and a weed sprayer.	
<u>Flock quality</u>		
1. Involve the community in gaining info to assist in decision making re mgt of flock structure/ vegetation resource by establishing a wether trial over several years on different land types.	Very successful, need to more clearly demonstrate the relationship between economics and natural resource in good condition. Need to focus on crossbreeds and alternative breeds – damaras and dorpers.	

Review of Activities **<u>Rabbit eradication</u>**	**1. Did we achieve these? Yes or no?** **2. Was this effective in achieving our aims?** **3. Continue? Yes or No?** **4. Suggested changes.**	**1. If not achieved, why not?** **2. Other issues.**
1. Assist with ID rabbit densities on different land types and determine which areas rabbits have most impact on production by setting up transects on different land types and doing spot light counts to estimate densities	RCD took the pressure off, however still need to encourage "habitat" destruction, ie warren destruction, so if they do come back (RCD no longer virulent), no where to live and breed.	
<u>Salinity</u>		
1. Establish the extent of **2.** Spreading salinity and determine likely causes by establishing monitoring /photopoint sites	Not done. Could monitor salt levels in wells and watch watercourse country for loss of bush, very long term e.g. Coorabinnie/Nonning/Salt Creek?	
3. Encourage research 4. Of the issue by post graduate student	Not done, remove.	

Review of Activities **<u>Woody shrubs</u>**	**1. Did we achieve these? Yes or no?** **2. Was this effective in achieving our aims?** **3. Continue? Yes or No?** **4. Suggested changes.**	**1. If not achieved, why not?** **2. Other issues.**
1. Determine extent of woody shrub increase in the district by co-ordinating with monitoring by Pastoral assessment	Yes? Recognising it is a cyclic process, all you maybe able to do is monitor. Suggest Oakden Hills, Yalymboo and Moonabie, long way from water.	
2. Establishing new Monitoring sites	As above	
3. Encouraging research into the issue by post graduate student	Remove.	

New Activities

Activities	**What?**	**Who will do it?**	By when?
Focus on education, as suggested new aims for the board	Contact new managers in the district, welcome them to the district, explain the Soil Board process and other processes eg Pastoral Assessment Newsletter – what you have been doing with list of current members and contact info, advertise SB meetings Develop education package on rangelands for School children – CD that fits into School curriculum Develop a Gawler Ranges Soil Board Web site with links to other appropriate sites, see Arid Water Resources site as good example.	Chairperson Whole Board Soil Con Council, Chairperson/Polly Smart	As required, invite to Soil Board meetings and annual open meetings
Integration of NRM issues	Demonstrate the relationship between weeds and decline in vegetation and grazing pressure – promote holistic mgt. Link economic performance with ecological health Work with RSBEX and INRM Group. Involvement in RAP	Whole board Whole board/Craig Nixon	
Tourism	Work with Tourism SA on best mgt practices, including monitoring impact on the natural resources Conduct an inventory/audit of tourism infrastructure Work with Gawler Ranges Marketing and Development Board to focus on Gawler Ranges as a tourist destination	Whole board	
Plant ID Course	Hold another similar style course in the district over a weekend	Whole Board with Sandy Gunter's help	Sept 2004
Biodiversity Workshop	Purpose is to raise awareness on biodiversity and conservation issues and management, look at possibility of generating income form eco tourism	Whole Board with DEH/Geoff Axford	Sept 2002 (achieved)

FURTHER INFORMATION

Conservation	Department of Environment and Heritage SGIC Building Mackay Street Port Augusta 5700 Phone (086) 48 5319 Brendan Lay Pastoral Program GPO Box 1047 Adelaide 5001 Phone (08) 204 8865 Fax (08) 204 8859
Climate and Meteorology	Climate and Consultative Services Bureau of Meteorology 25 College Road Kent Town, South Australia PO Box 421 Kent Town SA 5071 Phone (08) 366 2222 Fax (08) 366 2293

Weather and climate observation are routinely recorded and archived from observing stations at Nonning, Port Augusta, Whyalla and Woomera. A volunteer network undertakes additional rainfall observations. Rainfall records are available from almost 60 locations in the District, but only half of these stations are part of the national rainfall observation network today. All climate and rainfall observations are quality controlled and archived in the national climate data bank, to be made available to researchers and other interested users.

Feral Animals Include. Dingoes, foxes, Cats, camels, feral goats, brumbies	Rural Solutions SA 12 Tassie Street Port Augusta 5700 Phone (086) 48 5160 Fax (086) 48 5161
Geology (regional) Groundwater	DWLBC Groundwater Section
Feral Goat Control	Gawler Ranges Soil Conservation Board
Kangaroo Management	Lisa Farroway Department for Environment and Heritage Resource Management Branch 284 Portrush Road Kensington 5068 GPO Box 1047 Adelaide 5001 Phone (08) 204 8764
Land Degradation/Erosion	Soil Conservation Board
Mining and Exploration	Iris Dobrinski Environment Section

	PIRSA
Monitoring Land Condition	Soil Conservation Board
	Pastoral Program GPO Box 1047 Adelaide 5001 Phone (08) 204 8860 Fax (08) 204 8859
Property Management Planning	Paul Erkelenz Rural Solutions SA Clare
Rabbit Control	
	12 Tassie Street Port Augusta 5700 Phone (086) 485160 Fax (086) 48 5161
Revegetation and Reclamation	Sandy Gunter Rural Solutions SA 12 Tassie Street Port Augusta 5700 Phone (086) 485160 Fax (086) 48 5161
Vegetation Management	Pastoral Program Brendan Lay and Paul Gould GPO Box 1047 Adelaide 5001 Phone (08) 204 8860 Fax (08) 204 8859
Weed Control	John Pitt Rural Solutions SA Clare

REFERENCES

Bureau of Meteorology 1988. Climatic Atlas of Australia Australian Government Printing Service.

Bureau of Meteorology 1989. Drought in Australia Australian Government Printing Service.

Freddricks S (1862) An Account of the Colony of South Australia.

Fenner F and Ratcliffe FN (1965) Myxomatosis Cambridge University Press.

Gibbs W J and Maher J V (1967). Rainfall Deciles as Drought Indicators: Bulletin No 48. Australian Government Printing Service.

Graetz D and Wilson (1984) Ch 14 Saltbush and Bluebush in Management of Australia's Rangelands. EDS Harrington G.N., Wilson A.D., & Young M.D CSIRO Division of Wildlife and Rangelands Research.

Griffin GF. (1984) Ch 18 Hummock Grasslands in: Management of Australia's Rangelands. EDS Harrington G.N., Wilson A.D., & Young M.D. CSIRO Division of Wildlife and Rangelands Research.

Henzell R (1993) The Ecology of Feral Goats. Primary Industries SA, Goat Note May 1993.

Hodgkinson KC et al (1984) Ch 10 Management of Vegetation With Fire in: Management of Australia's Rangelands. EDS Harrington G.N., Wilson A.D., & Young M.D.. CSIRO Division of Wildlife and Rangelands Research.

Laut P, Heyligers P C, Keig G, Loffler E, Margules C, Scott R and Sullivan ME (1977) Environments of South Australia, Province 3 CSIRO.

Lay B.G (1976) Fire in the Pastoral Country Journal of Agriculture South Australia Vol 79 No. 1 Autumn 1976

Linton V and Cooke B (1992) Warren Destruction - The Key to Rabbit Control in Arid Lands. Animal and Pest Plant Commission. SA, Pastoral Lands Notes.

Linton V and Cooke B (1994) Rabbits - What They Really Cost You. Animal and Pest Plant Commission SA, Pastoral Lands Notes.

Morrisey JG (1984) Ch 19 Arid Mulga Woodlands in: Management of Australia's Rangelands. EDS Harrington G.N., Wilson A.D., & Young M.D CSIRO Division of Wildlife and Rangelands Research.

Noble I (1984) Ch 15 Mallee in: Management of Australia's Rangelands. EDS Harrington G.N., Wilson A.D., & Young M.D CSIRO Division of Wildlife and Rangelands Research.

Rolls E (1969) They All Ran Wild Angus and Robertson

Stodart E and Parer I (1988) Colonisation of Australia by the Rabbit CSIRO Division of Wildlife and Ecology Project Report No. 6.

Tongway D (1994) Rangeland Soil Condition Assessment Manual. CSIRO Division of Wildlife and Ecology, Canberra.

Tynan RT (1992) Maximum Stocking Rates For South Australian Pastoral Leases: Historical rationale and implications of the Pastoral Land Management and Conservation Act, 1989. Master of Applied Science (Natural Resources) Qualifying Paper, University of Adelaide. Unpublished.

Tynan RT (1995) Lease Assessment Overview Report: Gawler Ranges Soil Conservation District. Department of Environment and Heritage, Pastoral Program.

APPENDIX A

HOW ARE RAINFALL DECILES CALCULATED?

Rainfall deciles are based on long-term rainfall records and are hence location specific. The rainfall records, whether for a specified month, group of months or years, are sorted from lowest to highest amount of rainfall. The sorted records are divided into ten groups of equal number (hence decile, deci-meaning ten). The decile represents the division between two decile groups or the last value.

The following example describes how deciles are derived and how to interpret rainfall decile values. The July total monthly rainfall records for all years (90 in total) for Nonning are ranked in order from lowest to highest. These are then marked off into ten equal groups. The group of lowest rainfall is decile range 1 (lowest 10% of all records), the next group is decile range 2, and so on up to the highest 10% group of all records, called decile range 10. The highest value in a decile range can be used as a rough indication on the value of the decile. For example, decile 4 is 18 mm and is the division between the lowest 40% and the highest 60% of records.

Decile 5 is also known as the **median** - the value that 50% of the records are less than, and 50% are greater than. Note that the median is not the same as the mean of average.

These decile ranges, as shown in tables, charts or maps, indicate how dry or wet a certain month, season or year has been by comparison with historical ranges of values and is a more meaningful comparison than averages or mean values.

DECILE RANGE	EXTENT OF RANGE	DESCRIPTIVE RANGE
1st	Lowest 10% of records	Very much below average
2nd	2nd Lowest 10% of records	Much below average
3rd	3rd lowest 10% of records	Below average
4th, 5th, 6th, 7th	Middle 40% of records	Average
8th	3rd highest 10% of records	Above average
9th	2nd highest 10% of records	Much above average
10th	Highest 10% of records	Very much above average

The decile can be equated with the probability of exceeding the rainfall value at that decile. For example, at decile 1 for Nonning in July there is a 90% chance of exceeding 7mm, ie based on historical records the July rainfall will exceed 7mm 9 years in 10 (see graph). At decile 7 there is only a 30% chance of exceeding 27mm in the month of July, i.e. based on historical records only 3 years in 10 will exceed 27mm.

FROM: Crosby D and J Egan 1994 "Climate Risk Management in Agriculture" in: Notes for Managing Climate Variability Workshop. Bureau of Meteorology and South Australian Research and Development Institute.

APPENDIX B

TEMPERATURE DATA FOR WOOMERA, PORT AUGUSTA AND NONNING

Woomera

	Minimum(°C)		Maximum(°C)		Average number of days				
	Extreme	Mean	Mean	Extreme	>40°C	>35°C	>30°C	<2.3°C	<=0°C
Jan	8.3	19.1	34.1	47.6	4	14	24	0	0
Feb	10.3	19.1	33.4	45.6	3	11	21	0	0
Mar	8.4	16.8	30.4	43.0	1	6	17	0	0
Apr	4.9	12.9	25.3	38.4	0	0	5	0	0
May	-0.3	9.3	20.3	30.7	0	0	0	0	0
Jun	0.0	6.7	17.3	27.1	0	0	0	1	0
Jul	-0.9	5.8	16.7	28.6	0	0	0	2	0
Aug	-1.4	6.6	18.5	32.3	0	0	0	1	0
Sep	1.8	9.1	22.1	37.0	0	0	2	0	0
Oct	4.4	12.2	26.0	41.2	0	2	7	0	0
Nov	6.2	15.0	29.4	44.4	1	5	13	0	0
Dec	8.8	17.4	32.1	45.4	2	10	20	0	0

Port Augusta

	Minimum(°C)		Maximum(°C)		Average number of days				
	Extreme	Mean	Mean	Extreme	>40°C	>35°C	>30°C	<2.3°C	<=0°C
Jan	9.7	19.5	31.9	46.4	4	9	18	0	0
Feb	9.4	19.7	31.7	45.6	3	8	16	0	0
Mar	9.6	17.6	29.2	44.0	1	5	13	0	0
Apr	6.4	14.3	25.0	38.4	0	0	5	0	0
May	3.3	11.0	20.5	30.6	0	0	0	0	0
Jun	1.7	8.0	17.4	25.4	0	0	0	0	0
Jul	-0.6	7.3	16.8	28.0	0	0	0	0	0
Aug	1.4	8.2	18.4	31.2	0	0	0	0	0
Sep	3.0	10.4	21.5	36.3	0	0	1	0	0
Oct	5.0	13.2	25.0	40.3	0	1	6	0	0
Nov	5.8	16.0	28.3	44.4	1	5	11	0	0
Dec	8.9	18.0	30.2	45.1	2	7	14	0	0

Nonning

	Minimum(°C)		Maximum(°C)		Average number of days				
	Extreme	Mean	Mean	Extreme	>40°C	>35°C	>30°C	<2.3°C	<=0°C
Jan	5.8	16.3	32.9	45.8	3	11	21	0	0
Feb	7.5	16.6	32.7	44.9	2	11	18	0	0
Mar	3.8	14.4	29.4	42.6	0	4	13	0	0
Apr	1.0	10.9	24.7	38.0	0	0	4	0	0
May	-2.6	7.2	20.0	29.4	0	0	0	3	1
Jun	-4.5	4.4	16.6	25.6	0	0	0	9	3
Jul	-5.6	3.8	16.3	28.5	0	0	0	10	4
Aug	-4.3	4.5	17.8	31.0	0	0	0	9	3
Sep	-1.6	6.6	21.0	35.6	0	0	1	3	0
Oct	0.7	9.5	24.7	40.0	0	1	5	0	0
Nov	2.8	12.4	28.3	42.9	0	4	11	0	0
Dec	5.5	14.7	31.2	44.0	1	8	17	0	0

Data from these tables were used to produce fig 9. The figures in the last 5 columns refer to the average number of days per month for which maximum temperatures exceed 40°C, 35°C and 30°C, and the average number of days for which the minimum temperature falls below (or equals) 2.2 °C and 0oC

APPENDIX C

RELATIONSHIP BETWEEN THE LAND SYSTEMS AS DEFINED BY THE SOIL CONSERVATION BOARD AND PASTORAL PROGRAM

SCB	PMB	DESCRIPTION
Gawler Ranges	Centre	Mallee woodland on hills; mixed shrubland on dunes and sand spreads.
	Ebunbanie	Mulga woodland with Tarcoola wattle and porcupine grass on hills; valleys with mallee woodland over shrubland.
	Eucarro	Mallee low woodland on hills; valleys with mallee woodland over shrubland.
	Granite	Mallee woodland on hills; mixed woodland on sand plains; shrubland on dunes.
	Horseshoe	Plains; Western myall woodland over black bluebush and bladder saltbush; mixed chenopod shrubland.
	Kolendo	Plains with blackbush and bladder saltbush shrubland; with mulga woodland on hills.
	Yudnapinna	Tableland; bladder saltbush, samphire and bush minuria shrubland.
Moonaree	Ebunbanie	Mulga woodland with Tarcoola wattle and porcupine grass on hills; valleys with chenopod shrublands and grasslands.
	Waulalumbo	Mixed woodlands on dunes; mulga and Tarcoola wattle tall open shrubland.
Glyde Hill	Yarna	Plains; pearl bluebush shrubland with patches of western myall woodland; bladder saltbush shrubland.
	Corrobinnie	Dune field; mallee woodland over shrubland.
	Mendea	Mixed woodland of pine, mallee and blackoak; on sandplains and dunes.
Buckleboo	Bittali	Plains; mallee woodland over diverse shrubland including bluebush daisy; mixed woodland over pearl bluebush shrubland.
	Corrobinnie	Dune fields with mallee woodland over shrubland.
	Jungle Dam	Sand plains with mixed woodland and dense midstorey of cassia and pinbush wattle.
	Oxys	Plains with mallee woodland over bluebush daisy.
	Peter Pan	Plains with mallee woodland; western myall woodland; bladder and bitter saltbush shrubland.
	Peterlumbo	Mixed woodland of western myall/mallee and blackoak.
	Pinkawillinie	Dune fields; mallee woodland.
	Weednanna	Hills with mallee woodland over shrubs and heath; plains with mixed woodland over shrubs.
	Yarlerberrie	Plains; Mallee woodland; open grassland; mixed woodland over sparce pearl bluebush.
	Thurlga	String of saltlakes fringed with woodland and bladder saltbush shrubland.

SCB	PMB	DESCRIPTION
Saltia	Saltia	Plains with low bluebush and bladder saltbush shrubland.
	Buckaringa	Hills with blackoak and native pine woodland and silvertails and porcupine grass understorey.
	Wyacca	Hills with mallee woodland and yacca.
Acraman	Beacon	Sand plains with western myall woodland over pearlbluebush and daisy bluebush; dunes with horse mulga and mallee tall shrubland.
	Carpentria	Mallee woodland over diverse shrubland on hills; dunes with mallee woodland over porcupine grass and shrubs.
	Acraman	Saltlake fringed by chenopod shrubland and blackoak/western myall woodland.
	Mendea	Dunefields and sand plains with mixed woodland of native pine, mulga and blackoak.
	Narlaby	Network of small salt lakes fringed by sparse shrubland and chenopod shrubland.
	Yarna	Pearl bluebush shrubland with patches of western myall woodland, bladder saltbush shrubland
Hesso	Arcoona	Tableland, bladder saltbush and samphire shrubland.
	Glendambo	Western myall low open woodland over pearl bluebush and bladder saltbush.
	Hesso	Sand plains with western myall/sugarwood woodland over pearl bluebush and bladder saltbush.
	Bowen	Tableland; bladder saltbush/samphire shrubland; scattered mulga and western myall over pearl bluebush/bladder saltbush shrubland.
	Yorkey	Sand plains with mixed woodland on dunes; interdunes with bladder saltbush/blackbush and samphire with scattered western myall.
	Vivian	Dune fields with mulga woodland over grasses.
	Roxby	Dune field; Native pine woodland or mulga woodland over grasses; western myall woodland over chenopods.
Pandurra	Pandurra	Sandstone hills with mulga & mallee woodlands over diverse shrub understorey; low bluebush/bladder saltbush shrubland.
	Yudnapinna	Tableland with bladder saltbush, samphire and bush minuria shrubland.
	Iron Knob	Plains with mallee woodland aver diverse shrubland including bluebush daisy; mixed woodland over pearl bluebush shrubland.

SCB	PMB	DESCRIPTION
Middleback	Iron Knob	Plains with mallee woodland aver diverse shrubland including bluebush daisy; mixed woodland over pearl bluebush shrubland.
	Yudnapinna	Tableland with bladder saltbush, samphire and bush minuria shrubland.
	Bittali	Mallee woodland over diverse shrubland including bluebush daisy; mixed woodland over pearl bluebush shrubland.
	Pandurra	Sandstone hills with mulga & mallee woodlands over diverse shrub understorey; low bluebush/bladder saltbush shrubland.
Tent Hill	Arcoona	Tableland, bladder saltbush and samphire shrubland.
	Tent Hill	Tableland with bladder saltbush/samphire shrubland; low bluebush/bladersaltbush shrubland.
	Douglas	Granite hills with western myall/blackoak woodland and plains with bladder saltbush/blackbush shrubland.
	Yorkeys	Mixed woodland on dunes and interdunes with bladder saltbush, black bluebush and samphire with scattered western myall.
	Hesso	Sand plains with western myall and sugarwood over pearl bluebush and bladder saltbush.

APPENDIX D

PLANT LIST: COMMON NAME - SCIENTIFIC NAME

The species list below provides the scientific name for the plants identified in this plan. This list is not a complete list of the plants occurring in the District.
* Indicates introduced species.

COMMON NAME	SCIENTIFIC NAME
Bindii	*Sclerolaena spp.*
Bitter saltbush	*Atriplex stipitata*
Black bluebush	*Maireana pyramidata*
Black oak	*Casuarina cristata*
Bladder saltbush	*Atriplex vesicaria*
Bullock bush	*Alectryon oleifolius*
Bush minuria	*Minuria cunninghamii*
Cannonball	*Dissocarpus paradoxus*
Cassia	*Senna spp.*
Copperburr	*Sclerolaena spp.*
Desert lime	*Eremocitrus glauca*
Emu bush	*Eremophila spp.*
Geranium	*Erodium spp.*
Gilja	*Eucalyptus brachycalyx*
Granite wattle	*Acacia tarculensis*
Hopbush	*Dodonaea spp.*
Horse mulga	*Acacia ramulosa*
Kerosene grass	*Aristida contorta*
Low bluebush	*Maireana astrotricha*
Mallee cypress pine	*Callitris verrucosa*
Medic	*Medicargo spp.*
Mulga	*Acacia aneura*
Needle wattle	*Acacia rigens*
Northern cypress pine	*Callitris glaucophylla (previously columellaris)*
Pearl bluebush	*Maireana sedifolia*
Pinbush wattle	*Acacia burkittii*
Plover daisy	*Ixiolaena spp.*
Pointed mallee	*Eucalyptus socialis*
Porcupine grass, spinifex	*Triodia irritans*
Poverty bush	*Sclerolaena divaricata*
Quondong	*Santalum acuminatum*
Red mallee	*Eucalyptus oleosa, E. socialis.*
Sandhill wattle	*Acacia ligulata*
Scrubby cypress pine	*Callitris canescens*
Silver cassia	*Senna artemisioides ssp artemisioides*
Silver tails	*Ptilotus obovatus*
Southern native pine	*Callitris preissii*
Spinifex	*Triodia irritans*
Sugarwood	*Myoporum platycarpum*
Tarcoola wattle	*Acacia tarculensis*
Wallaby grass	*Danthonia caespitosa*
Wards weed	*Carrichtera annua*
Western myall	*Acacia papyrocarpa*
White mallee	*Eucalyptus dumosa*
Wild lime	*Eremocitrus glauca*
Wild oats	*Avena spp.*
Witchetty bush	*Acacia kempeana*
Yanga bush	*Maireana brevifolia*
Yorrell	*Eucalyptus gracilis*

APPENDIX E

PLANT LIST: SCIENTIFIC NAME - COMMON NAME

This list provides the common names for the plants identified in this plan.

SCIENTIFIC NAME	COMMON NAME
Acacia aneura	Mulga
Acacia burkittii	Pinbush wattle
Acacia kempeana	Witchetty bush
Acacia ligulata	Sandhill wattle
Acacia papyrocarpa	Western myall
Acacia ramulosa	Horse mulga
Acacia rigens	Needle wattle
Acacia tarculensis	Granite wattle
Acacia tarculensis	Tarcoola wattle
Alectryon oleiofolius	Bullock bush
Aristida contorta	Kerosene grass
Atriplex vesicaria	Bladder saltbush
Atriplex stipitata	Bitter saltbush
Avena spp.	Wild oats
Callitris preissii	Southern native pine
Callitris verrucosa	Mallee cypress pine
Callitris canescens	Scrubby cypress pine
Callitris columellaris	Northern cypress pine
Carrichtera annua	Wards weed
Casuarina cristata	Black oak
Danthonia caespitosa	Wallaby grass
Dissocarpus paradoxus	Cannonball
Dodonaea spp.	Hopbush
Eremocitrus glauca	Desert lime
Eremophila spp.	Emu bush
Erodium spp.	Geranium
Eucalyptus brachycalyx	Gilja
Eucalyptus dumosa	White mallee
Eucalyptus gracilis	Yorrell
Eucalyptus oleosa	Red mallee
Eucalyptus socialis	Pointed mallee, red mallee.
Ixiolaena spp.	Plover daisy
Maireana astrotricha	Low bluebush
Maireana brevifolia	Yanga bush
Maireana pyramidata	Black bluebush
Maireana sedifolia	Pearl bluebush
Medicargo spp.	Medic
Minuria cunninghamii	Bush minuria
Myoporum platycarpum	Sugarwood
Ptilotus obovatus	Sliver tails
Santalum acuminatum	Quondong
Sclerolaena divariacata	Poverty bush
Sclerolaena spp.	Bindii, Copperburr
Senna artemisioides ssp artemisiodes	Silver cassia
Stipa nitida	Annual spear grass
Triodia irritans	Porcupine grass, spinifex