Australian Collaborative Rangeland Information System, Reporting Change in the Rangelands – 2007

South Australian Information for the National Report

Fleming, M. and Brook, A.

Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation

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This is a technical report prepared for the ACRIS Management Committee to assist preparation of *Rangelands 2008 – Taking the Pulse* (Bastin and the ACRIS Management Committee 2008).

Knowledge and Information Division

Department of Water, Land and Biodiversity Conservation

25 Grenfell Street, Adelaide

GPO Box 2834, Adelaide SA 5001

Telephone	National	(08) 8463 6946
	International	+61 8 8463 6946
Fax	National	(08) 8463 6999
	International	+61 8 8463 6999
Website	www.dwlbc.sa.gov.au	

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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the State. It is critical that these resources are managed in a sustainable manner to safeguard them both for current users and for future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continues to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

Rob Freeman
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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SUMMARY

The Australian Collaborative Rangeland Information System (ACRIS) is a coordinating mechanism that should allow monitoring and other data reporting change to be widely disseminated amongst rangeland managers, advisors, administrators and those formulating policy.

Previous ACRIS reporting activity in South Australia focussed on one trial area, the Gawler Bioregion (Della Torre 2005). This was one of five pilot regions across Australia selected to test the quality of our information and our capacity to combine it into a national picture. The success and knowledge gained from the pilot activity have contributed to this latest iteration where we endeavour to report more broadly across the rangelands.

This report utilises existing data assembled from a variety of sources to report on recent change across the South Australian rangelands. Three of the six ACRIS themes for 2008 report (*Rangelands 2008 – Taking the Pulse*) are reported here. These are:

- Landscape Function
- Sustainable Management
- Land values component of the Social and Economic Change theme

As with the previous ACRIS activity, the objectives included not only the reporting of change, but also an assessment of our ability to report. The spatial extent of the biophysical and economic information used to inform this report is confined to land under Pastoral Lease. At the time the project was undertaken, no suitable data was available for the considerable area of the South Australian rangelands that lie outside of the Pastoral estate.

Analyses for the Landscape Function and Sustainable Management themes were conducted using the same data. These include grazing gradient analyses derived from satellite imagery, watered areas data from GIS analyses and field-based monitoring data from sequential visits to permanent photo-points. A Seasonal Quality Matrix adopted by ACRIS provides context when interpreting the field-based data. This approach allows change from causes other than seasonal effects to be highlighted.

Estimates of unimproved pastoral land values produced by the South Australian Valuer General were used in analyses for the Social and Economic Change theme.

The reporting period covers the 14 years between 1992 and 2005. During this period, rainfall was greater in quantity and more general in extent over the northern pastoral area than further south. The reporting period included two significantly dry years, 1994 and 2002. These events affected all pastoral areas in South Australia and were sufficiently severe in some places to cause extensive death of perennial plants.

Landscape Function is a theoretical framework used to explain biophysical changes in rangeland environments. Landscape function describes the ability of land to trap and store water and nutrients (Ludwig *et al*. 1997). Any reduction of this ability has negative consequences for biomass production and biodiversity.

In the northern, cattle-grazed rangelands, grazing gradient analysis was used to assess change in landscape function. This method reports the level of remotely-sensed vegetation cover with increasing distance from water. Loss of landscape function is inferred where a grazing gradient persists near waterpoints following much above-average rainfall (complete vegetation recovery expected at this time).

A reduction in landscape function was detected for all land types where grazing gradient analyses were carried out. The amount of this reduction varied between the different land types in both values for percentage cover production loss (the index used to specify landscape function) and in the spatial extent of the area affected. The percentage cover production loss varied from 1% (1989) and 1.5% (2002) for STP1 Mount Willoughby to 15.6% (1989) and 2.1% (2002) for STP6 Coongra. For most land types where rainfall was sufficient for maximum recovery of vegetation from grazing, thereby allowing grazing gradient analysis, values of the percentage cover production loss were in the order of 1-2% (implying minimal loss of landscape function). Nonetheless when the area of this loss is taken into account, a considerable area is affected.

Perennial plant density data from Jessup Transects was used to infer landscape function at various locations in the southern portion of the South Australian rangelands. Despite monitoring at 67% of sites occurring within periods of above average seasonal condition, 13% of sites showed some level of deterioration in landscape function

The estimates of unimproved pastoral land values used in analyses for the Social and Economic Change theme were CPI-adjusted to 2005 values in dollars per square kilometre. The Broken Hill Complex, the Murray Darling Depression and the Flinders Lofty Block had the highest unimproved values. Values in these regions increased by around 56% between 1998 and 2004. At the other end of the scale, the Finke Bioregion in 1998 was considered to have an unimproved value equivalent to 12% of that of the Broken Hill Complex or the Murray Darling Depression.

1. INTRODUCTION

1.1 ACRIS THEMES AND PRODUCTS

The Australian Collaborative Rangeland Information System (ACRIS) is in the final stages of compiling its national report of change in the rangelands for the period 1992 to 2005. The Australian Government will publish this report in 2008. The national report has been compiled from available jurisdictional and national datasets and this report describes the datasets and information contributed by South Australian agencies. Reporting is by IBRA bioregion (IBRA v 6.1).

The national report is based on a number of biophysical and socio-economic themes and related products. South Australian contributions to these themes include:

Table 1. South Australian contributions

Theme	Product	Datasets
Landscape function	Inferred Landscape function	DKCRC grazing gradient analyses DWLBC photo-point monitoring
Sustainable management	Inferred Landscape function	DKCRC grazing gradient analyses DWLBC photo-point monitoring DWLBC Watered areas information
Socio-economic	Land values	DWLBC unimproved values for pastoral leases
Supporting information	Photos	DWLBC Time-series photos of selected rangeland sites

1.1.1 LANDSCAPE FUNCTION AND SUSTAINABLE MANAGEMENT THEMES

As the results of the analyses for the Landscape function and Sustainable management themes were very similar, the results in this report have been presented in a combined form under the heading of biophysical themes.

For the purpose of reporting change for both of the biophysical themes within the specified period, there are two datasets that cover extensive areas of the South Australian rangelands. These are grazing gradient analyses conducted over a central-northern area and point-based vegetation monitoring data from a central-southern area. An additional product relevant to the sustainable management theme was identified subsequent to the ACRIS pilot project. This was the watered areas analysis for all areas held under pastoral lease in South Australia.

The grazing gradient analysis was completed as part of Rewards for Biodiversity, a Desert Knowledge Cooperative Research Centre (DKCRC) project. The analyses utilised satellite imagery to report changes in cover with distance from water on five dates between 1988 and 2002

Field measurements from 397 fixed belt transects formed the second set of monitoring data. The transects are located at permanent photo-point sites that were originally established by the Pastoral Program as part of South Australia's statutory pastoral lease monitoring requirements. The time-one field measurements were collected when the sites were established. The subsequent time-two field measurements are mainly comprised of data collected specifically for the pilot ACRIS reporting project. The remainder of the time-two field measurements were collected for inspection and opportunistic monitoring purposes. Consequently most field based data relates to the Gawler Bioregion where the pilot project was run.

Figure 1 below illustrates the spatial coverage of both the grazing gradient analysis and the photo-point monitoring data used to inform reporting of the biophysical themes.

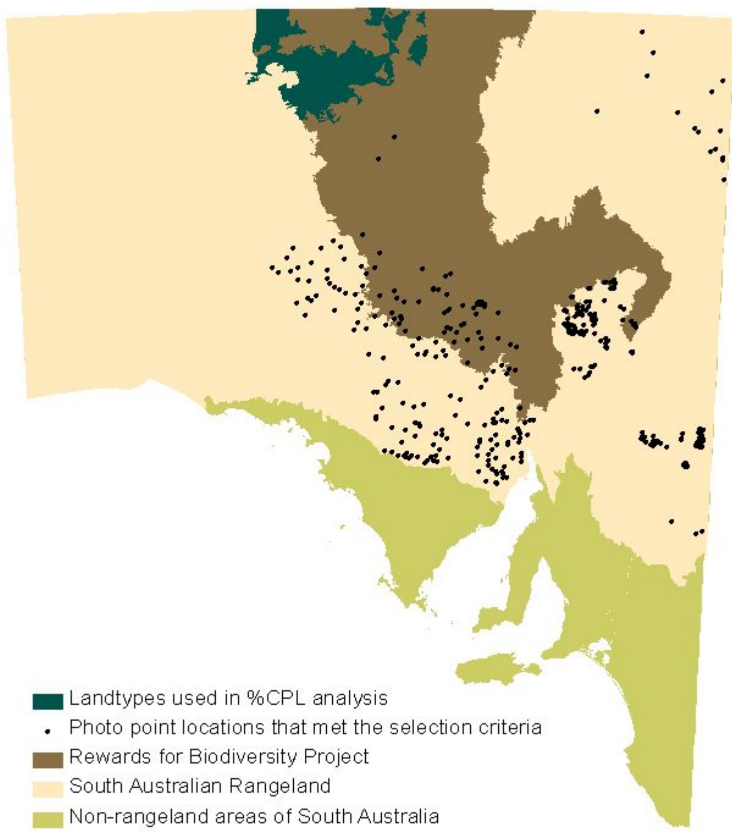


Figure 1. Areas with suitable monitoring data available for reporting on biophysical themes.

1.1.2 SOCIAL AND ECONOMIC CHANGE THEME

Several potential products were identified in *Rangelands - Tracking Changes* (NLWRA, 2001) as being suitable for reporting on social and economic change in the rangelands. These included changes in land values, land tenure and land use. Changes in land values across the South Australian rangelands were available for the regions under pastoral lease.

Unimproved value is used as a component in calculating the annual rental charged on pastoral leases. In recent years, the Pastoral Board has contracted the South Australian Valuer General to provide an unimproved value for each pastoral lease, based on recent sales. The data used for reporting are these valuations and has been provided by the South Australian Pastoral Board. The unimproved values for a station were used to calculate an average value (km^2) for each IBRA region.

1.1.3 EXTENT OF THE SOUTH AUSTRALIAN PASTORAL ESTATE

The greater part of the South Australian rangelands used for pastoral purposes is within the land under formal pastoral tenure and identified in Figure 2 below. Grazing of native vegetation by domestic stock occurs in other tenures within the rangelands but is not monitored to the same degree as the pastoral leases are. Other tenure types that are extensively grazed include Perpetual Leases, Regional Reserves and Aboriginal freehold land.

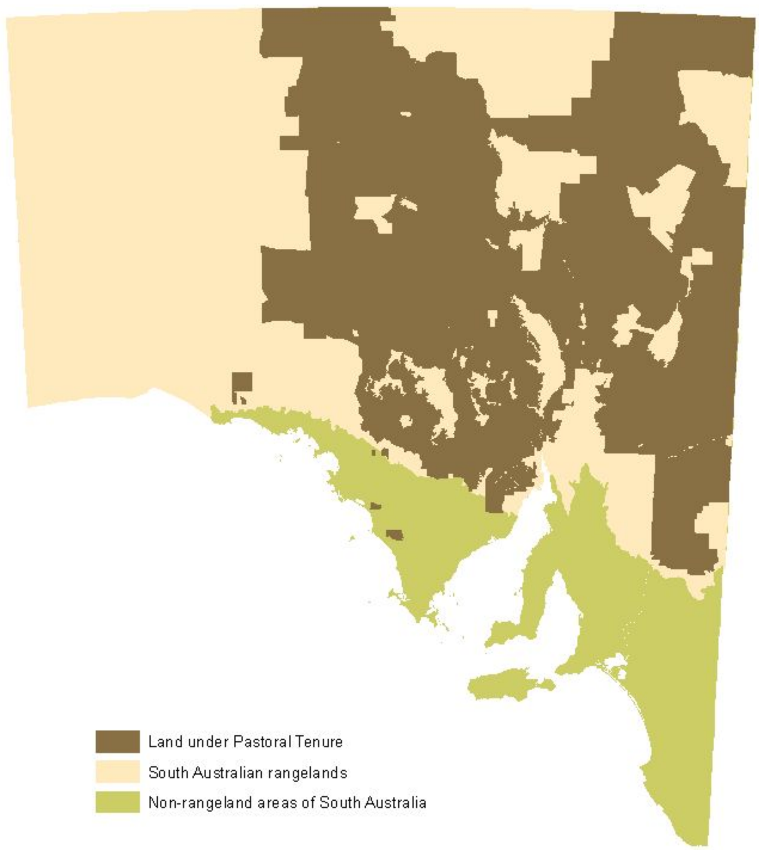


Figure 2. Land held as Pastoral Leases in South Australia.

The extent of the pastoral estate represented in Figure 2 is based on DWLBC fenced boundary data and may differ from cadastral boundaries. The extent of the South Australian rangeland is based on 2006 Environmental Resources Information Network (ERIN) data.

Although there are some Pastoral Program vegetation monitoring sites located within the other tenure types, the grazing status of these is generally not known and the site network too sparse for inclusion here.

1.1.4 RAINFALL DURING REPORTING PERIOD

The pattern of rainfall distribution through the reporting period (1992 - 2005), shown in Figure 3, saw considerably more rain in the northern portion than further south. Rainfall for the Gawler and Flinders Lofty Block Bioregions was consistently lower than that of other regions for the period. Note low rainfall for all bioregions in 1994 and 2002.

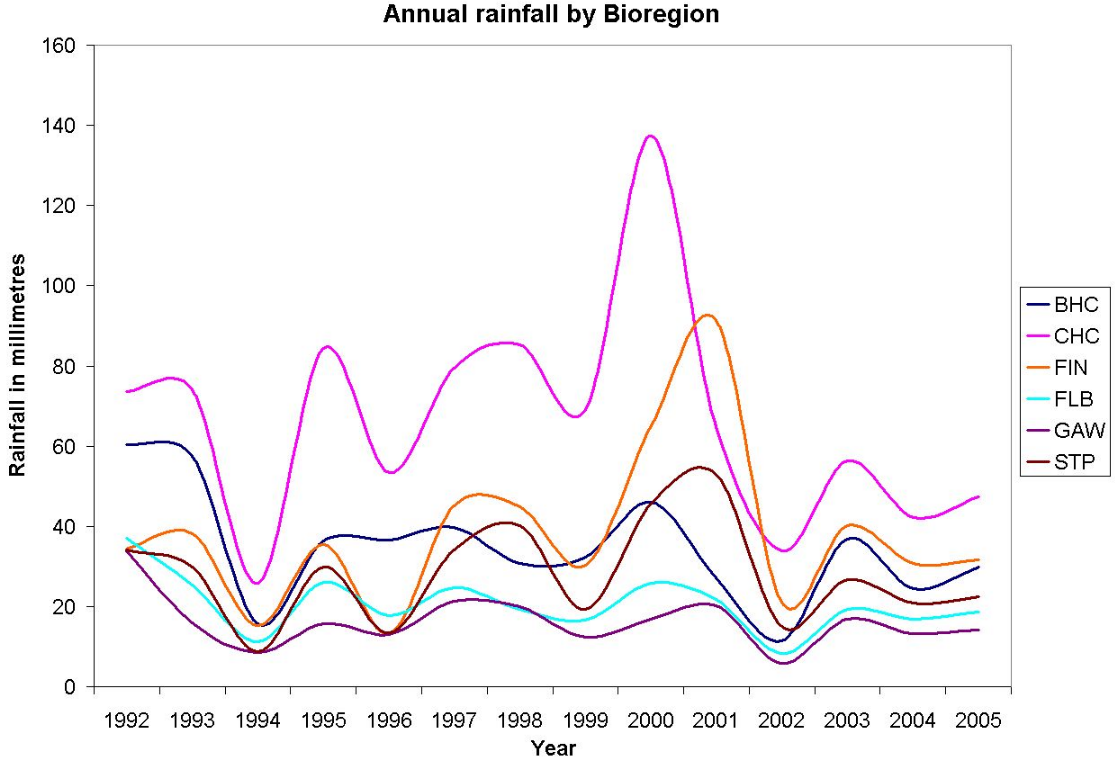


Figure 3. Annual rainfall by Bioregion for ACRIS reporting period 1992 – 2005.

1.1.5 COMPONENTS OF TOTAL GRAZING PRESSURE

Domestic stock numbers (sheep and cattle) are being sourced separately by the ACRIS Management Unit from the Queensland Department of Natural Resources and Water (QDNR&W) who use the data in its Aussie-GRASS simulations of pasture growth. The QDNR&W, in turn, obtains its data from the Australian Bureau of Statistics who conduct periodic assessments of domestic stock numbers via complete Agricultural Census (every five years) and sample surveys conducted in intervening years. The ABS report data by Statistical Local Area (SLA). Data were available to ACRIS for the period 1983-2004.

1.1.6 FIRE RECORD

Fire scars are mapped on a monthly basis from satellite imagery for most of Australia by the Western Australian Land Information Authority (Landgate, see http://www.dli.wa.gov.au/corporate.nsf/web/Fire+Scar+History+Maps).

This agency has provided the ACRIS Management Unit with statistics of the monthly and annual area of each rangeland bioregion (and sub IBRA) burnt between 1997 and 2005. The Department has also provided an indication of fire frequency based on the number of times an area was burnt over the reporting period 1997 to 2005. While wildfire and fire management are generally of minor importance in the areas under pastoral tenure in the South Australian rangelands, fire is a major factor in landscape and vegetation change in the far northwest of the state. Fire scars detected in 2002 are shown in red in Figure 4 below. A high incidence of fire through the Mann and Musgrave Ranges is apparent.

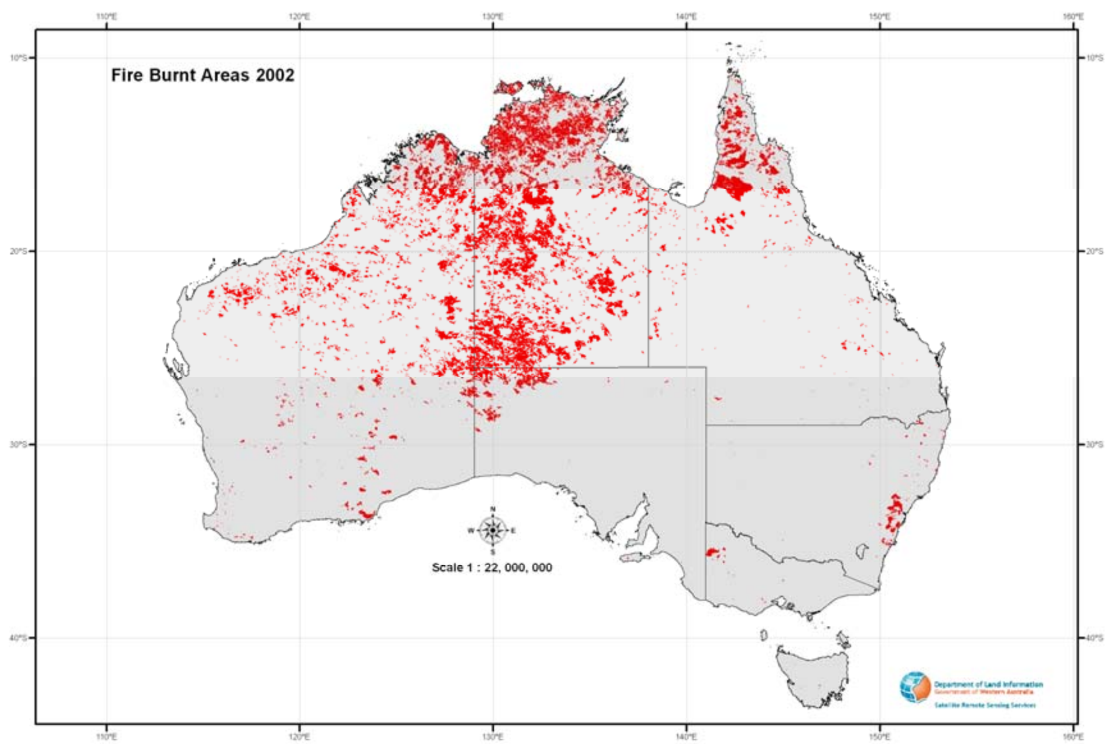


Figure 4. Map of fire burnt areas for 2002

2. METHODOLOGY

2.1 COMMONLY MONITORED PLANTS

A total of 96 perennial plant species were used in the analysis for the landscape function theme. This was all perennial plants recorded at all locations.

Data for the sustainable management theme required more specific criteria as only *palatable* perennial plants found at sites known to be *grazed* could be used. A total of 47 different plants met these criteria. However, the majority of records were confined to relatively few species.

The 47 plant species were reduced to 10 as most had too few records to be useful. One or more of these plants, listed in Table 2 below, are represented at 92% of the Jessup transects. These 10 most commonly monitored plants were adopted for use in reporting for the Sustainable Management theme.

Table 2. Ten most commonly monitored perennial shrubs in descending order

Plant Species Name	Sites	% of sites
Atriplex vesicaria ssp.	1931	67
Maireana sedifolia	1260	44
Maireana astrotricha	1223	42
Maireana pyramidata	1205	42
Maireana georgei	1077	37
Enchylaena tomentosa var.	871	30
Rhagodia spinescens	792	27
Ptilotus obovatus var.	764	26
Maireana appressa	371	13
Rhagodia ulicina	294	10

While grasses contribute substantially to the perennial pastures found in several South Australian bioregions, they are not consistently recorded at Jessup transects. The primary focus of these transects are the more common Chenopod low shrubs.

2.2 GRAZING GRADIENT ANALYSIS

The grazing gradient data and graphs used in this report were created in 2006 by DWLBC in conjunction with the CSIRO for the Desert Knowledge Cooperative Research Centre (DKCRC) project number 1.707, *Rewards for Biodiversity*. The spatial extent of this analysis is shown in Figure 5. The project area represented is 210,000 km^2.

Grazing gradient graphs were calculated using CSIRO software for selected land types and IBRA sub-regions for five mosaic dates (1988, 1989, 1997, 2000 and 2002). The 1988, 1989 and 1997 Landsat TM imagery were selected and acquired by DWLBC specifically for performing grazing gradient analysis. This was not the case for the 2000 or 2002 Landsat TM imagery. These images were available through the Australian Greenhouse Office and were not selected specifically for grazing gradient analysis. Consequently for a large proportion of the project area there was insufficient rainfall to report on %CPL.

The area shaded green at the top of Figure 5 represent the sub-regions that received sufficient rainfall to allow a potential full recovery of the perennial pasture component. A percent cover production loss (%CPL) figure was then calculated and used to estimate the degree of change in landscape function. The pattern of rainfall distribution through the reporting period saw considerably more rain in the northern portion than further south.

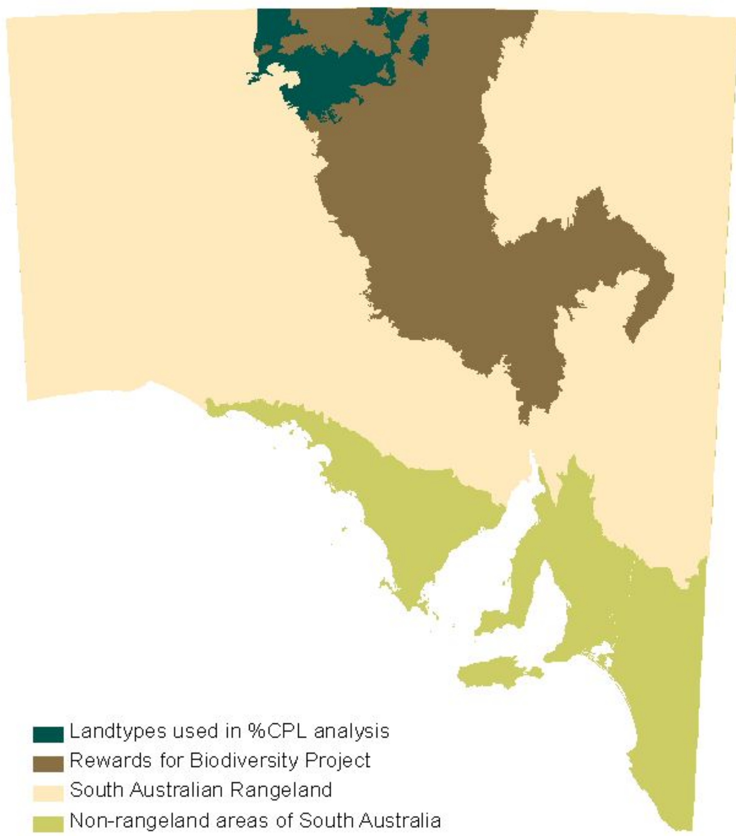


Figure 5. Location of sub-regions used in %CPL analysis

2.3 JESSUP TRANSECT ANALYSIS

There are approximately 5,800 permanently marked photo-points that have been established in the South Australian rangelands by the Pastoral Program since the 1970's. There are several types of sites that affect the information collected. While all sites share the common characteristic of a photo being taken at each visit, there are also many differences. Some site types require detailed soil, landform and plant species measurements to be collected. Others require only a photograph and brief comments. Table 3 shows the various site types and some of the related attributes.

Site type does not dictate the type of data recorded at a particular site on subsequent visits. For example, a site can be established as a quantitative site (e.g. QS) but on subsequent visits have only a photograph taken and a species list recorded (e.g. OB).

Of the site types listed below in Table 3, only the QS and RS sites are suitable for reporting change. These types indicate that some quantitative information has been collected. The more robust of the quantitative measurements is that of the Jessup Transect, a fixed belt-transect of 100 metres length and 4 metres width that is used to measure the density of perennial low shrubs and occasionally grasses. It is also the most widely and consistently implemented monitoring method across the South Australian rangelands. A Jessup transect is the minimum standard for quantitative sites.

Table 3. Site types

Site Type	Description	Grazed	Jessup Transect	Total
EX	Fenced exclosure	N	Y/N	10
OB	Observation only	Y/N	N	2235
OP	Opportune	Y/N	N	55
PC	Photographic Comparison	Y/N	N	3
QS	Quantitative	Y	Y	3184
RF	Rabbit Free (Project)	Y/N	Y	6
RG	Rabbit Grazed (Project)	Y/N	Y	6
RS	Reference	N	Y	90
TG	Total Grazing Pressure (Project)	Y	N	58
TS	Type Site	Y/N	N	155

The Jessup transect data may also have benefits for ACRIS in that it is compatible with the WARMS reporting for the shrublands of Western Australia.

The majority of QS sites were established as part of the initial round of Pastoral Lease assessments that began in the early 1990’s. This initial round of assessments was completed in December 2000. Under the Pastoral Land Management and Conservation Act 1989 (SA), all Pastoral Leases must be reassessed within 14 years of the previous assessment. There is currently no systematic program of site revisits between these assessments other than opportunistic monitoring by Pastoral Inspectors. It is assumed that some of the established QS sites will be monitored as part of subsequent Pastoral Lease assessments in a 14-year cycle. However, it should be noted that there is no legislative requirement to ever revisit these sites.

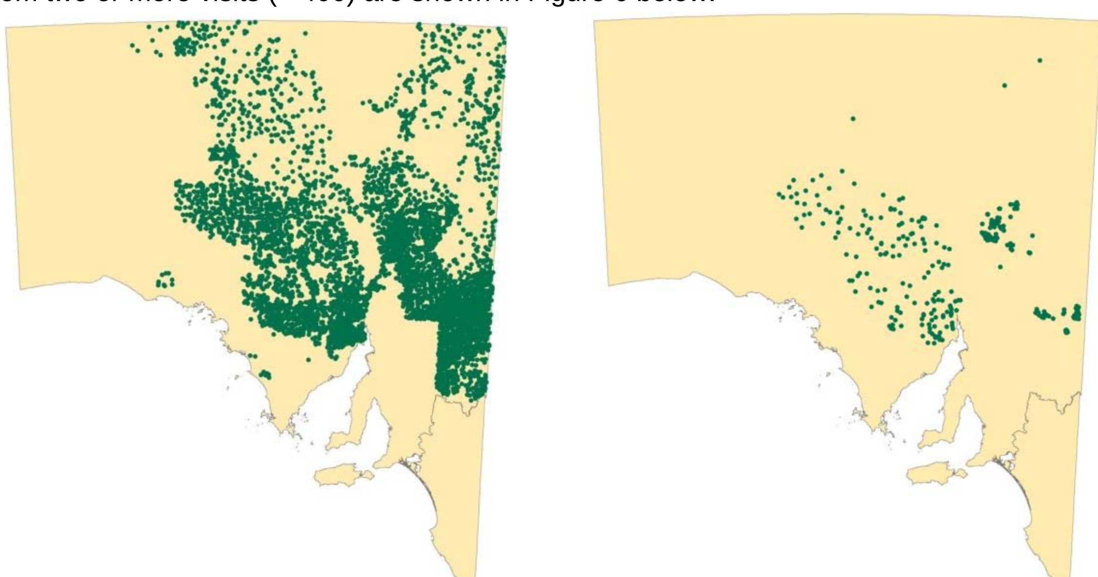
For reporting change, only sites with quantitative information from at least two visits are of value. With the exception of the Gawler Bioregion (which saw ~160 sites revisited in 2001 and 2002 as the South Australian component of the National Land and Water Resources Audit), site revisits between assessments have been opportunistic only. This has resulted in a variety of interval lengths between time 1 and time 2.

Table 4 shows the number of sites with more than one Jessup measurement and with a second set of Jessup transect measurements recorded between 1993 and 2004 by IBRA region and year.

Table 4. Number of sites per IBRA region by year of second Jessup transect measurement

IBRA	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
BHC	22										1	4	**27**
CHC					7	1			2				**10**
FLB		57	1	18	1		1	1		1	3	12	**95**
GAW		5	3	2		2	3	2	81	77	7	29	**211**
GVD									1	1			**2**
MDD		1	1				1					13	**16**
SSD					4				1				**5**
STP		3	3	1	1					13		10	**31**
Total	**22**	**66**	**8**	**21**	**13**	**3**	**5**	**3**	**85**	**93**	**11**	**68**	**397**

A comparison of the distribution of all sites (~ 5800) and those with Jessup transect data from two or more visits (~ 400) are shown in Figure 6 below.



(a) (b)

Figure 6. (a) All sites (b) Sites with Jessup transects with two or more visits in the past 14 years

The difference between the QS and RS site types is in the intensity of grazing. Generally, QS sites are located between one and three km from a functioning water point for the purpose of monitoring the grazing effects of sheep or cattle on perennial plants. RS sites are deliberately established at points remote from water for comparison purpose and are thus less likely to be grazed intensively. Both of these types of sites have been included in analysis for the

Landscape Function theme. Only sites known to be grazed (QS) were used for the Sustainable Management theme.

2.4 STEP-POINT DATA

In addition to perennial plant density measurements recorded using Jessup transects, the other quantitative measurement recorded at QS and RS sites is cover from a step point method. A potential use of these step-point data are as part of a modified Richards-Green index of landscape function. This requires the input of both density data from a Jessup transect and cover data from step-point measurements for each site.

Of the 397 sites with Jessup transect measurements, only 218 (55%) also have step-point measurements. Of the 218 sites with both types of data, 184 are located in the Gawler Bioregion. See Table 5 below. A second table showing the same information by sub-region is included as Appendix B.

Table 5. Sites with multiple visits and both Jessup and step-point data by IBRA

IBRA	Jessup	Step-point	Jessup & Step-point
BHC	27	20	16
FIN	0	4	0
CHC	10	0	0
FLB	95	40	4
GAW	211	213	184
GVD	2	2	2
MDD	16	0	0
SSD	5	0	0
STP	31	19	12
Total	**397**	**298**	**218**

Apart from the Gawler Bioregion where data exists for both density and cover at 87% of the quantitative sites, there are few sites with these measurements available for the remainder of the South Australian rangelands.

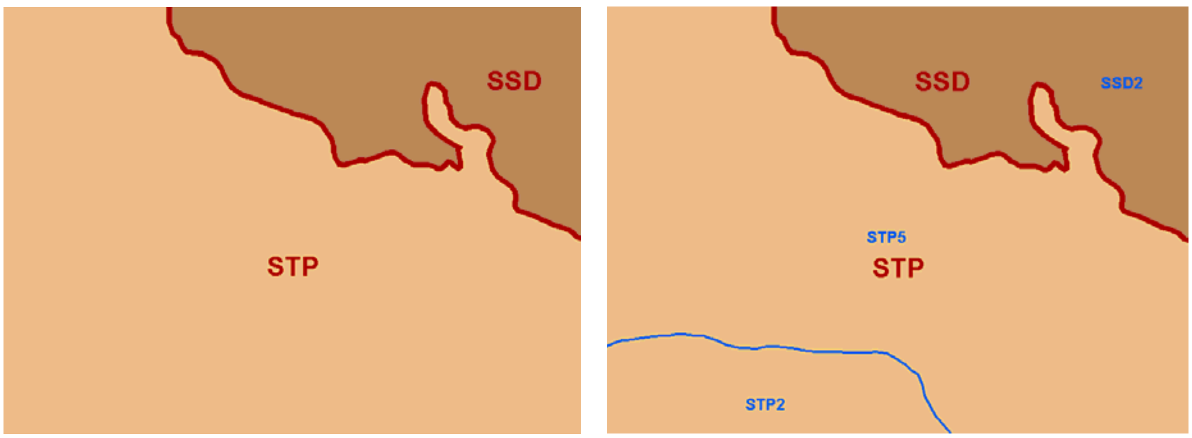
The Richards-Green Functionality Index, as proposed, has a trend component that can’t be objectively determined from available data. ACRIS and state agencies therefore have to modify it in order to implement it. Although trialled in the ACRIS pilot reporting activity, no consistent or agreed form of a suitably modified index has emerged. Therefore this approach has not been used in this report.

2.5 REVISED IBRA SUB-REGIONS

IBRA regions and subregions

The Interim Biogeographic Regionalisation of Australia (IBRA) V6.1 divides the Australian continent into 85 bioregions. Each region has a unique 3-letter code. For example, in Figure 7(a), the Stony Plains Bioregion has a code of STP.

There are 404 sub-regions that have been defined in Australia, based on major geomorphic features in each bioregion. IBRA sub-region boundaries coincide with and sub-divide IBRAs. They are identified by a number prefixed with the bioregion 3-letter code. See blue annotation and lines in Figure 7(b) below.



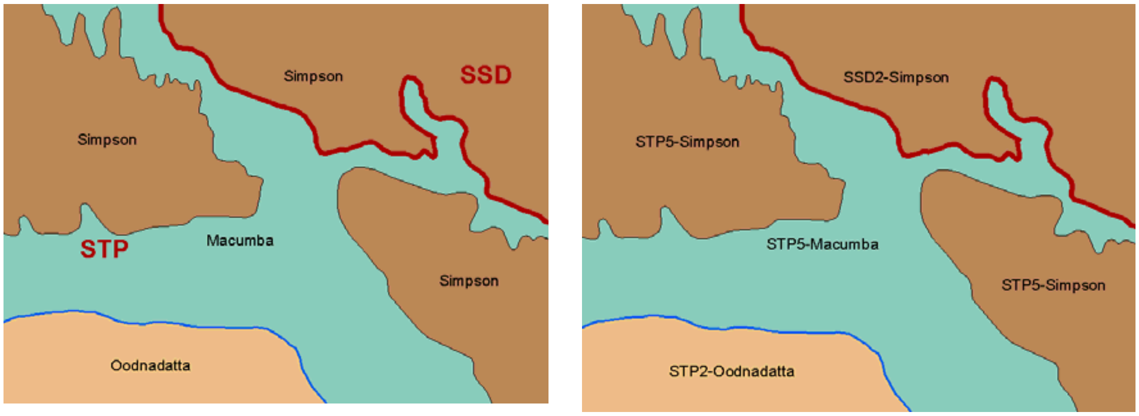
(a) (b)

Figure 7. (a) IBRA region codes and boundaries, (b) IBRA sub-region codes and boundaries.

Relationship between IBRA, IBRA sub-regions, land systems and land types.

South Australia has recently completed the revision of a large portion of its Interim Biogeographical Regionalisation of Australia (IBRA) sub-region boundaries within the rangelands. The boundaries have been updated using Landsat TM satellite images overlain with geology, vegetation communities and other biogeographical stratification information, including district land systems boundaries. The land systems boundaries now provide the IBRA region and sub-region boundaries with land types creating a fourth level of land stratification.

Figure 8a shows the land systems boundaries with IBRA regions and sub-regions displayed. Figure 8b shows the combination of IBRA sub-regions and land systems to create land types; IBRA sub-regions and land types are merged to create land types. For example, the Simpson land system in the SSD2 subregion is a different land type than the Simpson land system in the STP5 sub-region.



(a) (b)

Figure 8. (a) Land systems and IBRA region codes, (b) land type names.

The revised IBRAs, IBRA sub-regions and land types have been used for analysis for reporting of the biophysical themes. There are some slight changes to the IBRA boundaries compared to the current version (IBRA 6.1). These consist of relatively minor realignments, as illustrated in Figure 9. The IBRA region boundaries generally remain very similar.

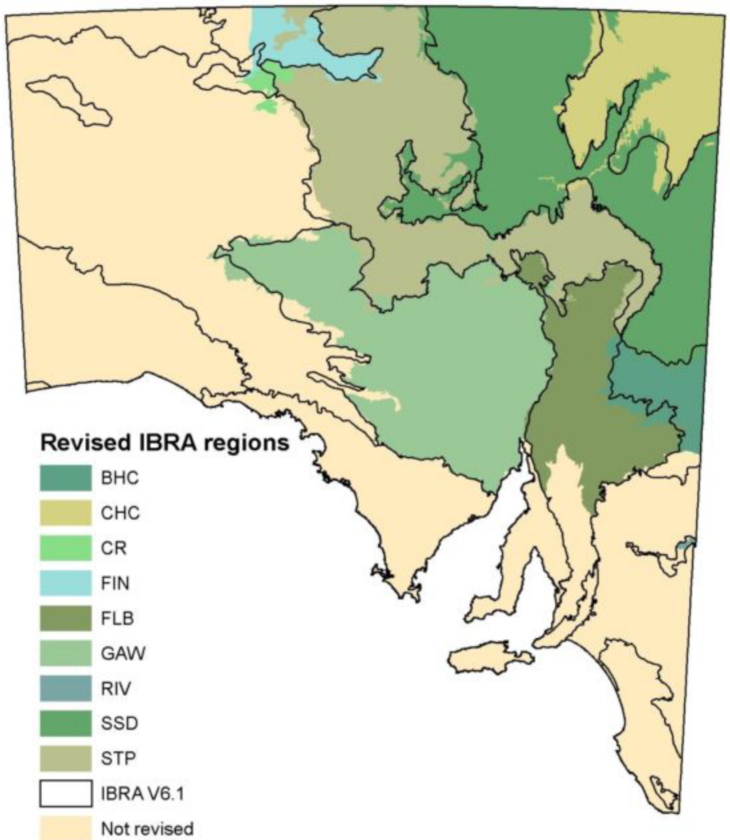


Figure 9. Revised IBRA regions and IBRA V6.1

2.6 SCALE OF LANDSCAPE STRATIFICATION UNITS USED FOR REPORTING.

Typically ACRIS reporting has been at the IBRA Bioregion level. For field-based data, reporting by IBRA was feasible only where there were sufficient monitoring data with even dispersal. Where the data represented part of an IBRA, smaller land stratification units were used. The regions reported upon therefore include IBRAs, sub regions and land types. For grazing gradient analysis, reporting was at the land type scale. Previous work has shown the land type scale to be most informative for reporting – analysis shows that the patterns of seasonal cover responses and grazing impacts vary between land types. Analysis at the IBRA and sub-region scale can hide this.

Figure 10 identifies the regions used for reporting with bold text and borders. It also shows where the various reporting regions are situated within a three-tiered hierarchy. The field-based data was reported at either the IBRA Bioregion (top row) or IBRA Sub-region levels second row), depending upon the quantity and dispersion of the monitoring sites. The grazing gradient information was reported at the land type level (bottom row of Figure 10).

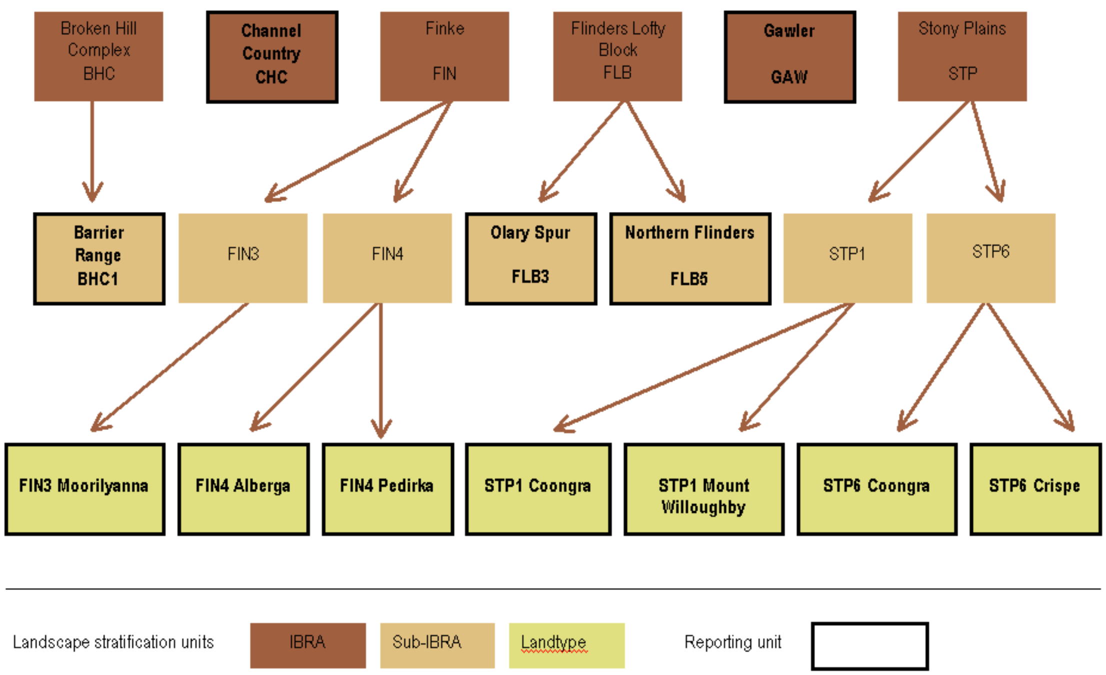


Figure 10. Landscape stratification units used for reporting

2.7 SITE SEASONAL QUALITY

In order to separate changes in vegetation due to seasonal conditions from management-induced change, ACRIS uses an index of seasonal quality. The index provides context to trends indicated by change data. For example, an increase in cover indicated by vegetation measurements during above average seasons is to be expected and a decrease in cover is expected during below average seasons. Where the vegetation measurements indicate change that is contrary to the seasonal conditions, other causes of change are implicated.

Site Seasonal Quality (SSQ) is based on the amount and timing of rainfall in relation to the growth season during the three years prior to the second monitoring visit compared with long-term records. The growth season was either summer (October to March) or winter (April to September.) SSQ for areas with chenopod shrubs as the major pasture component were calculated using “Winter” as the growth season.

The final product is a relatively simple ‘quality of preceding seasons’ by ‘direction of change’ matrix used to present change data in the context of seasonal condition. An example of the matrix is shown in Table 6 below. The red cell in the example shows the percentage of sites with a declining trend in the reporting period, despite being monitored in above average seasonal conditions. (As seasonal change has been eliminated as the cause of the decline, grazing is implicated.) Conversely, the green cell shows the percentage of sites with a increasing trend despite being monitored in a below average season.

Table 6. Example of Site Seasonal Quality (SSQ) matrix showing quality of preceding seasons by direction of change.

Seasonal Quality	No sites	Percent of monitoring sites		
		Decline	No change[1]	Increase
Above average	123	18%	21%	61%
Average	82	21%	23%	56%
Below average	6	50%	17%	33%

1 A tolerance of +/- 10% in perennial density used to categorise “No change”

The rainfall data used was the national SILO dataset of five-km grid-cells interpolated from rainfall records from 1890 onwards. Jeffrey *et al*. (2001) describes the methods used to produce these surfaces and an assessment of their accuracy. In general, rainfall interpolated in regions with a very sparse distribution of recording stations will be less accurate than that interpolated from regions where the recording stations are relatively abundant.

The process used in South Australia for creating the index is the same as that developed by Ian Watson and Vanessa Chewings for the WARMS data and consists of:

- Extracting raw monthly rainfall data by site location as two separate datasets (summer and winter)
- Using the months October to March as summer, April to September as winter.

- Calculating terciles from raw monthly rainfall data for the years 1900 to 2004 for both the summer and winter datasets
- Calculating the tercile rank for each site for each year against the long-term record for both the summer and the winter datasets
- Calculating an aggregate (summer + winter) score for each site for each year using either a winter-dominant or summer-dominant rainfall pattern, depending upon site location.
- Calculating terciles for the aggregate scores 1900 to 2004.
- Determining the monitoring interval for each site (Time 1 to time 2).
- Selecting the relevant scores within the individual monitoring interval for each site and calculating a seasonal quality ranking for each site.

For the reporting period, more than 60% of the suitable field based monitoring data was collected during above average seasonal conditions. The following table (Table 7) shows the number of sites in each seasonal quality rank by IBRA.

Table 7. Jessup site seasonal quality ranking by IBRA

	Sites by seasonal quality ranking				% of sites by seasonal quality ranking		
IBRA Code	**Above average**	**Average**	**Below average**	**Total**	**1**	**2**	**3**
BHC	22	1	4	27	81	4	15
CHC	4	6		10	40	60	0
FLB	74	19	2	95	78	20	2
GAW	123	82	6	211	58	39	3
GVD	1		1	2	50	0	50
MDD	0	14	2	16	0	88	13
SSD	5			5	100	0	0
STP	17	3	11	31	55	10	35
Total	**246**	**125**	**26**	**397**	**62**	**31**	**7**

2.8 SITE SELECTION CRITERIA

A set of rules had to be developed to enable the consistent and objective processing of the photo point site data. These rules included some thresholds that were set with the intention of maximising the number of sites that could be analysed while excluding those that were not appropriate. The rules used for the Landscape Function theme are as follows:

- Site has Jessup data
- Compare only same site time one to time two.
- Select only sites where the time one to time two interval overlaps the ACRIS reporting period by 50% or more. (50% threshold adopted to maximise available data.)

- Include a plant species only if the count is five or more per transect on both time one and time two. (threshold adopted to reduce potential errors associated with small samples)
- Use perennial plant species only
- Select only sites within rangelands

Further filtering was required for the Sustainable Management theme as it only utilised those data relevant to inform reporting on grazing induced change. The additional site selection criteria were:

- Select only perennial plant species that are palatable to stock.
- Select only sites within pastoral tenure
- Use only sites known to be grazed (QS)

The selection criteria were applied in the sequence outlined above. Table 8 shows the effects of the application of these rules in successively reducing the number of sites available for analysis. At the time of preparing this report, after applying the criteria, only 5.33% of all sites could be used in the quantitative analysis of palatable plant density in the pastoral estate within a recent 14-year period. This figure may increase for future reporting as new data is added.

Table 8. Effect of selection criteria on site numbers

Theme	Criteria	Sites	Percentage of total
	Total sites	5779	100
Landscape Function	Jessup transect data	2893	50
	Two or more visits	624	11
	Time one and time two dates relevant to report	463	8
	Plant density >4 per transect	413	7.15
	All perennial plant species	400	6.92
	Within rangelands region	397	6.87
Sustainable Management	Palatable perennial plant species	352	6.09
	Within pastoral estate	341	5.90
	Grazed sites with relevant data (QS sites)	308	5.33

Table 9 shows the QS and RS site types with Jessup data for each IBRA. A table showing the same information by Sub-IBRA is included as Appendix A.

Table 9. QS and RS site types with Jessup data by IBRA

IBRA Region	QS	RS	Total
BHC	27		27
CHC	10		10
FLB	94	1	95
GAW	200	11	211
GVD	2		2
MDD	16		16
SSD	5		5
STP	30	1	31
Total	**384**	**13**	**397**

After applying site selection criteria to individual reporting units there was little difference in the sites selected except for the Gawler Bioregion. Therefore, it was decided to present site data for the Sustainable Management theme in all cases except the Gawler Bioregion where data for the Landscape Function theme are also presented.

2.9 LANDSCAPE FUNCTION

2.9.1 INFERRING LANDSCAPE FUNCTION FROM GRAZING GRADIENT ANALYSES

The grazing gradient method (Bastin *et al*. 1993) provides information on vegetative cover change with distance from water points. Using the framework described by Ludwig *et al*. (1997), these changes in vegetative cover are related to specific landscape function processes. For example, cover reduction affects the ability of the landscape to trap and store essential plant nutrients. As the effectiveness of the physical structures that obstruct and slow the passage of water during rainfall events is lost, less infiltration and increased overland flows occur. Unincorporated nutrients are flushed out of the system and lost. The change in the water budget (infiltration versus overland flow) also affects the amount of water retained in the soil profile, further reducing the ability of the landscape to respond to rainfall. At a minimum, sequential grazing gradient analyses show the direction of change in landscape function due to grazing and indicates the distance from water that the change has occurred in.

A measure of the amount of change in landscape function can also be calculated, providing there has been sufficient rainfall for full potential vegetation recovery. The Percentage Cover Production Loss (%CPL) can be used to quantify the extent to which a grazing gradient persists after good rainfall, and thereby provide an inferred value of loss of landscape function. The index is explained in Bastin *et al*. (1993).

2.9.2 INFERRING LANDSCAPE FUNCTION FROM FIELD BASED SITE DATA

Perennial plant density data collected from fixed belt-transects at permanent vegetation monitoring points has also been used to infer changes in landscape function. For example, an increase in perennial plant density is assumed to indicate an improvement in landscape function through better soil stability and an increase in the obstacles to the overland movement of water.

The data used to report on landscape function was the total density of all perennial plants found within a standard 400-m^2 Jessup belt-transect. This was the most complete dataset available.

2.10 SUSTAINABLE MANAGEMENT

2.10.1 FORAGE QUALITY

Forage quality in this report is defined as the accessibility and density of specific palatable perennial plant species within the pasture. Ten of the most commonly monitored perennial plants were chosen as being suitably representative for reporting on change in forage quality for the sustainable management theme. As analyses were restricted to these ten species, a change in perennial plant density is synonymous with a change in forage quality.

The underlying assumption made when using forage quality as a measure of sustainable management is that maintenance of forage quality to a high standard indicates the use of sustainable management practises. Conversely, a decline in forage quality indicates the use of un-sustainable management practises.

2.10.2 PHOTOGRAPHIC RECORD

The photographs in this report have been chosen to illustrate landscape change over time. These include historic photos of various landscapes that have since been revisited and of sites that were deliberately installed for the purpose of taking sequential photographs. Much of the change can be directly related to the influence of grazing upon natural systems.

Figure 11. Left photo taken in 1994, right in 2006. Sequence shows growth of woody shrubs, mainly *Dodonaea* sp. and *Hakea leucoptera.*

2.10.3 WATERED AREAS ANALYSIS

A raster layer where each cell has a distance-from-water value is required as a component for grazing gradient analyses. This layer is created as output from a GIS analysis that calculates the distance each cell is from the nearest known water point within a paddock. The Watered Areas information used in this report was produced as part of the grazing gradient work for the DKCRC *Rewards for Biodiversity* project. Maps showing distance from water graduations are used to illustrate the relative density of and distribution of water points for each region reported upon. Summary tables derived from the distance-from-water layer are used to show the area and proportion of the various distance classes within a region.

2.11 SOCIAL AND ECONOMIC CHANGE

Unimproved value is used as a component in calculating the annual rental charged on South Australia's pastoral leases. Only the areas under pastoral tenure within each IBRA were used in the analysis. Bioregions with less than 50% pastoral tenure were excluded, except the Simpson Strzelecki Desert Bioregion with 49%. Also excluded were bioregions with less than 5 stations. The bioregions used are listed in Table 10 together with the number of stations and the percentage area under pastoral tenure.

Table 10. %Pastoral tenure within bioregions

IBRA Name	Number of stations	% Pastoral tenure
Broken Hill Complex	32	99
Channel Country	11	78
Finke	7	70
Flinders Lofty Block	84	62
Gawler	74	81
Murray Darling Depression	25	57
Simpson Strzelecki Dunefields	28	49
Stony Plains	57	90

There are several stations that overlap two or more bioregions, particularly the larger cattle stations north of the dog fence. Thus the column headed Number of stations in the above table shows stations with some land within the respective IBRAs and does not represent whole stations. For example, Witchelina counts once each for the Gawler, Flinders Lofty Block and Stony Plains bioregions.

The unimproved values for a station were used to calculate an average value (km^2) for each IBRA region. Firstly, the total unimproved value for each station was divided by station area in square kilometres to give a value per square kilometre. The area of each station within the respective IBRAs was then calculated, multiplied by its value per square kilometre and summed. The total value per IBRA was the divided by the total area under pastoral lease within that IBRA to provide an average value per square kilometre.

Consumer Price Index (CPI) information was provided by Melissa Schliebs of CSIRO in Alice Springs for use in this analysis. This was modified from Australian Bureau of Statistics (ABS) data to use 2005 as a base for calculating the CPI.

3. RESULTS

3.1 BIOPHYSICAL THEMES

After applying site selection criteria to individual reporting units there was little difference in the sites selected for the landscape function and sustainable management themes, except for the Gawler Bioregion. Therefore, it was decided to present site data for the sustainable management theme in all cases except the Gawler Bioregion where data for the landscape function theme are also presented.

3.1.1 BROKEN HILL COMPLEX

Within South Australia, the Broken Hill Complex Bioregion (BHC) is located on the eastern side between the Flinders Ranges and the New South Wales border (Figure 12). This bioregion extends into the Broken Hill region of New South Wales (33% of this bioregion is in South Australia). It consists of flat to undulating plains with chenopod shrublands and patches of low forest and closed shrubland.

Figure 12. Location of the Broken Hill Complex Bioregion in SA

Table 11 shows that data from 22 sites could be used for the sustainable management theme. As these sites were all within the Barrier Range IBRA Sub-region, palatable perennial plant density data has been presented separately for that region.

Table 11. Broken Hill Complex Bioregion

Attribute	Description
Name	Broken Hill Complex (BHC)
Area km^2	18,790
Reporting unit	1 sub-region: Barrier Range IBRA Sub-region
Data used to report	Sustainable management: Palatable perennial plant density from 22 Jessup transects

Land tenure for most of this bioregion is Pastoral Lease. Figure 13 shows the pattern of distribution of stock watering points across the BHC Bioregion for areas under pastoral lease.

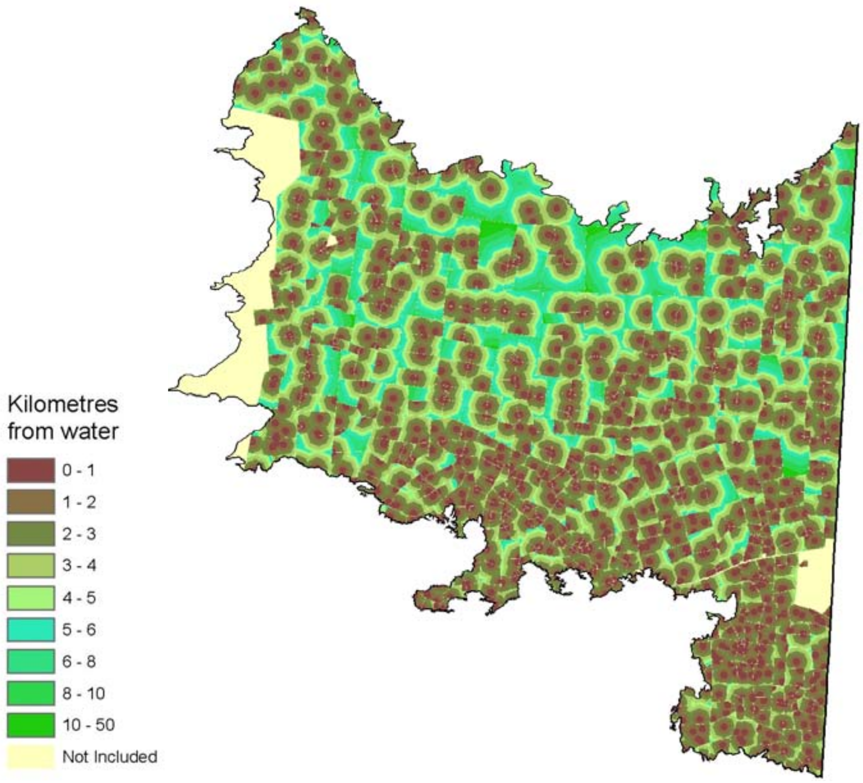


Figure 13. Distribution of stock watering points across the BHC Bioregion

Table 12 below shows the area and proportion of land for distance from water in 1 km increments. Within South Australia, this bioregion is typically grazed by sheep. Assuming 5km as the maximum distance that sheep range out from water, Table 12 shows 87% of the land area analysed as being within grazing range. This leaves 13% beyond the usual grazing range of sheep.

Table 12. Distance from water zones by area and proportion

Distance km	km^2	% Area	Cumulative %
0-1	2167	12	12
1-2	4173	24	36
2-3	4009	23	59
3-4	2942	17	76
4-5	1835	11	87
5-6	1044	6	93
6-7	592	3	96
7-8	334	2	98
8-9	185	1	99
9-50	86	<1	100

The following photo sequence in Figure 14 is from an area where the sand-over-clay soil profile ensures a landscape that is highly susceptible to wind erosion when the protective vegetation is removed.

Figure 14. Left photo taken in 1981, right in 1993. The photo sequence shows change from a landscape of drifting sandy soil with little cover to a more stable landscape with both ephemeral and perennial cover.

Summary

A considerable proportion of this bioregion is within the usual grazing range of sheep. Seventy-six percent is within four kilometres of water. Grazing is likely to influence landscape function to some degree in these areas.

There is insufficient Jessup data available to inform reporting on plants density for the South Australian portion of the Broken Hill Complex Bioregion as a whole. However, it was possible to report for the Barrier Range sub-region.

3.1.2 BARRIER RANGE IBRA SUB-REGION

Field based monitoring data were available for one sub-region within the Broken Hill Complex Bioregion. This was Jessup transect data from 22 sites visited in1989 and again in 1993. The sites are not evenly distributed, being concentrated in the centre of the sub-region as shown in Figure 15. Landforms include low shrubland, low stony rises and pattern plains of bladder saltbush and low bluebush or blackbush; plains and watercourses of blackbush and nitrebush with prickly wattle.

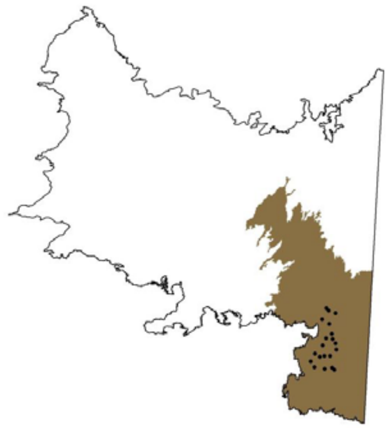


Figure 15. Distribution of monitoring sites within the Barrier Range sub-region.

Table 13 shows data from 22 sites could be used for analysis. The ratio of sites to square kilometres is thus around 1:174 km^2.

Table 13. Barrier Range sub-region

Attribute	Description
Name	Barrier Range (BHC1)
Area km^2	3,818
Reporting unit	IBRA Sub-region
Data used to report	Sustainable management: Palatable perennial plant density from 22 Jessup transects

Table 14 shows that the monitoring data available for this sub-region was at the very beginning of the ACRIS reporting period. The time 1 and time 2 visits were relatively close together with an interval of four years.

Table 14. BHC1 sub-region sites with Jessup visited by year

	Year																
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Visit 1	22																
Visit 2					22												

There has been an overall increase in perennial plant desity between time 1 and 2 with plant density increasing at 59% of sites and decreasing at 14%, all in above average seasonal conditions (See Table 15). Figure 16 shows perennial plants counted at time 2 plotted against time 1 counts. The points appearing above the diagonal line represent an increase at time 2 and points below a decrease.

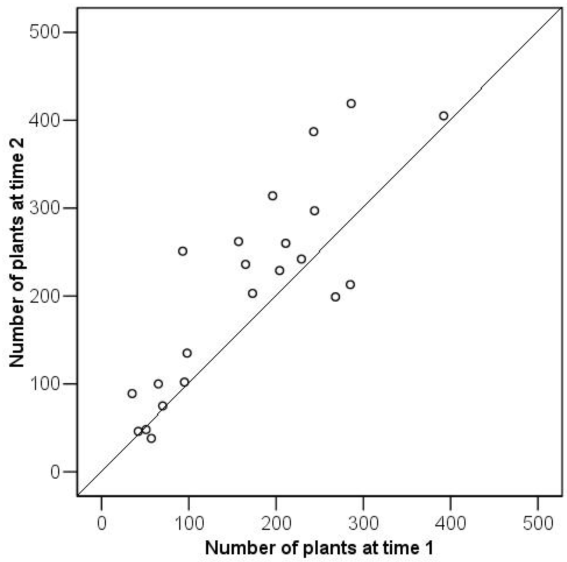


Figure 16. Change in perennial plant density for the BHC1 sub-region.

Change matrix.

- All 22 sites were monitored during above average seasonal conditions.
- 14% of the sites showed a decline in plant density despite being monitored during above average seasons, indicating management (grazing) as a causal factor. Pasture utilisation appears to be exceeding production and regeneration. Landscape function may be moving towards a dysfunctional state at these sites.
- Significantly more sites had an increase in plant density than had a decrease.

Table 15. Change matrix for the BHC1 sub-region.

Seasonal Quality	No sites	Percent of monitoring sites		
		Decline	No change[1]	Increase
Above average	22	14%	27%	59%
Average	0	0%	0%	0%
Below average	0	0%	0%	0%

The photo sequence in Figure 17 below illustrates the growth of a cohort of woody shrubs in the background and the loss of definition between patches in the landscape through grazing impact. The later photo shows a homogenised landscape.

Figure 17. Left image taken in 1978, right in 1994. Sequence shows the homogenisation of the previously fully-functioning landscape evident in the 1978 photo. By 1994 the cohort of woody shrubs evident in the earlier photo dominate a homogenised landscape. The crisp definition between patches has been lost, indicating changes in the ability to trap and store water and nutrients.

Summary

Land tenure within the South Australian portion of the Broken Hill Complex Bioregion is almost exclusively Pastoral Lease. Development of sheep grazing enterprises on this land has resulted in 87%. of the area analysed being less than 5 km from water. Land close to water is particularly susceptible to management-induced change as it is there that most grazing activity occurs.

The clustered location of the sites provides data that is only representative of part of the Barrier Range sub-region. Additionally, the monitoring period is relatively short and confined to the earlier part of the ACRIS monitoring period.

Within the small section represented by monitoring data in the Barrier Range sub-region, 14% of the sites showed a decline in palatable perennials despite being monitored in above average seasons. This suggests that grazing intensity at these sites has been too high and is not sustainable.

3.1.3 CHANNEL COUNTRY

The South Australian part (18%) of the Channel Country Bioregion (CHC) is located in the far northeast corner of the State. The location and extent is shown in Figure 18. The bioregion extends beyond the border into Queensland, the Northern Territory and New South Wales. The greater part lies in Queensland's channel country, from which it takes its name. The CHC bioregion also It is characterised by gibber plains with Mitchell grass, low rocky hills and mesas. It includes Sturt's Stony Desert of extensive flat gibber plains with very sparse vegetation, scattered dunes and sand mounds.

Sections of the Eyre Creek, Cooper Creek and Diamantina River consist of braided watercourses and flood plains with coolibah, lignum and Queensland bluebush.

Figure 18. Location of the Channel Country Bioregion in SA

Table 16 shows the number of sites able to be used in the biophysical themes and the area represented. There were insufficient data to inform reporting of the sustainable management theme. At 10 sites for the landscape function theme, the ratio of sites to square kilometres was near to 1:5,000.

Table 16. Channel Country Bioregion

Attribute	Description
Name	Channel Country (CHC)
Area km^2	51,624
Reporting unit	IBRA Bioregion
Data used to report	Landscape or ecosystem change: Perennial plant density from 10 Jessup transects

Table 17 shows the distribution of the monitoring dates for the relevant sites in the Channel Country Bioregion. The average interval between time 1 and time 2 was about 6 years.

Table 17. Channel Country Bioregion sites with Jessup visited by year

	Year																
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Visit 1			6	1		2		1									
Visit 2									7	1			2				

Figure 19 shows no significant change in plant numbers over time.

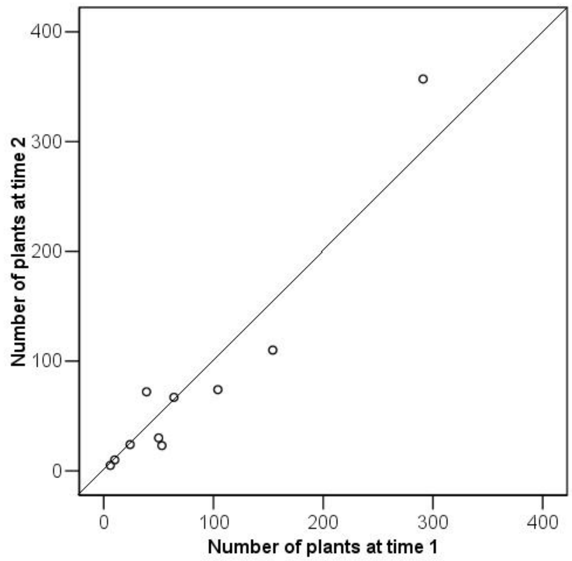


Figure 19. Change in perennial plant density for the Channel Country Bioregion.

Change matrix.

- 4 sites monitored during above average seasonal conditions.
- 6 sites monitored during average seasonal conditions.
- No monitoring occurred during below average seasonal conditions.
- Fifty % of sites monitored during above average seasons showed a decline in plant density.
- Fifty % of sites monitored during average seasons showed a decline in plant density.

Table 18. Change matrix for the Channel Country Bioregion

Seasonal Quality	No sites	Percent of monitoring sites		
		Decline	No change[1]	Increase
Above average	4	50%	25%	25%
Average	6	50%	33%	17%
Below average	0	0%	0%	0%

The distribution of stock watering points can be seen in Figure 20 below.

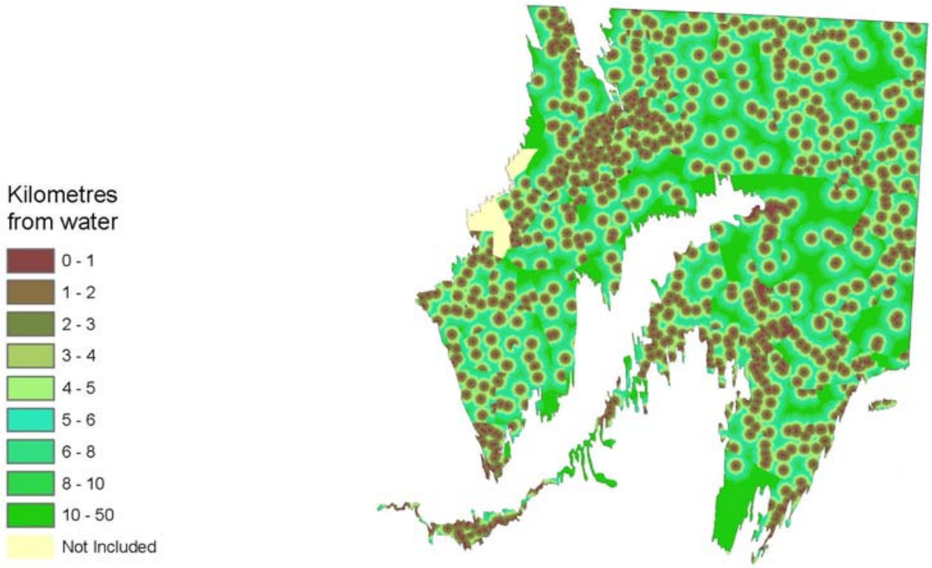


Figure 20. Distribution of stock watering points in the CHC Bioregion

Table 19 below shows the area and proportion of land for distance from water in 1 km increments. Within South Australia, the predominant grazing species in this bioregion is cattle. Assuming 8 km as the maximum distance that cattle usually range out from water, Table 19 shows 80% of the land area analysed as being within grazing range. This leaves 20% beyond the usual grazing range of cattle.

Table 19. Distance from water zones by area and proportion

Distance km	km^2	% Area	Cumulative %
0-1	2302	5	5
1-2	5367	11	15
2-3	6930	14	29
3-4	7045	14	43
4-5	6362	13	55
5-6	5329	11	66
6-7	4220	8	74
7-8	3185	6	80
8-9	2412	5	85
9-10	1818	4	89
10 +	5692	11	100

A lone saltbush clings to the side of a dune in the fore ground of the earlier photo in Figure 21. The strong recruitment of coolibah and *Acacia* species between 1976 and 1999 supports common anecdotal evidence in this region of previously treeless watercourses becoming densely vegetated over time.

Figure 21. Left photo taken in 1976, right in 1999. Sequence shows the colonisation of a bare interdune area by coolibah and *Acacia* species.

Summary

The change matrix indicates a decline in plant density despite favourable conditions. However, given the limited number of samples used, any results should be treated cautiously.

Landscapes in this region can be very dynamic, as illustrated in the photo sequence in Figure 21.

3.1.4 FINKE

The South Australian portion of the Finke Bioregion (28%) is located on the Northern territory border. The location and extent is shown in Figure 22. The northwest part has scattered granite outcrops, open woodlands and generally pale red sand. The bioregion also includes the Pedirka Desert that has deep-red coloured sand and dense mulga woodlands.

Figure 22. Location of the Finke Bioregion in SA

Table 20 refers to three land types used to inform reporting for this bioregion. These are the FIN3 Moorilyanna, FIN4 Alberga and FIN4 Pedirka land types. FIN3 Moorilyanna is the most productive of the three, FIN4 Alberga consisting of nutrient-poor mulga sand plains and FIN4 Pedirka of dunefields.

Table 20. Finke Bioregion

Attribute	Description
Name	Finke (FIN)
Area km^2	13,668
Reporting units	3 Land Types
Data used to report	Grazing gradient over three Land Types;
	FIN3 Moorilyanna
	FIN4 Alberga
	FIN4 Pedirka

Figure 23 illustrates the distribution of stock watering points across the Finke Bioregion. The higher density of water points on the left side of Figure 23 reflect the higher level of pastoral infrastructure development in the FIN3 Moorilyanna land type compared to the sparse and peripheral development of the FIN4 Alberga and FIN4 Pedirka land types.

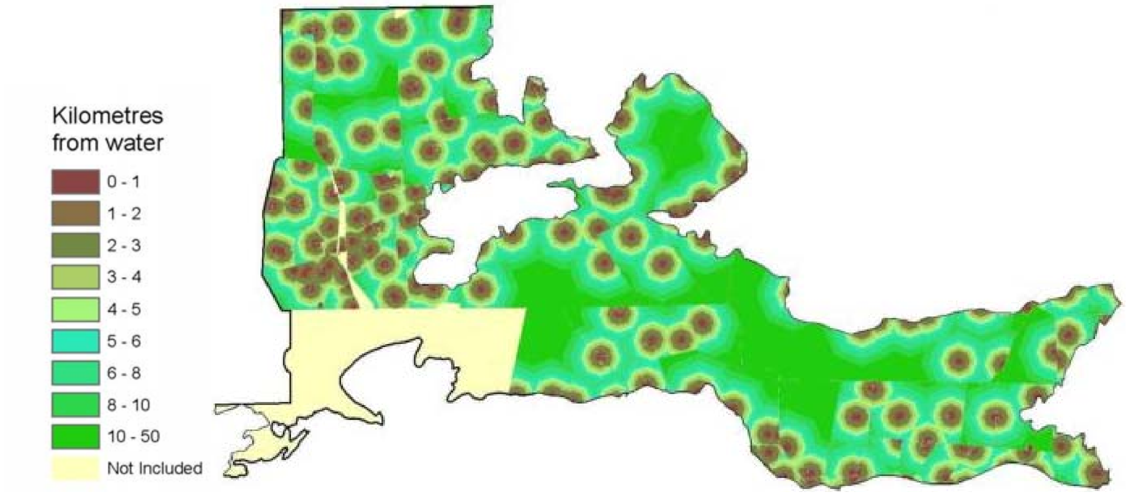


Figure 23. Distribution of stock watering points across the Finke Bioregion

Table 21 below shows the area and proportion of land for distance from water in 1 km increments. Within South Australia, the predominant grazing species in this bioregion is cattle. Assuming 8 km as the maximum distance that cattle usually range out from water, Table 21 shows 74% of the land area analysed as being within usual grazing range of cattle. This leaves 26% beyond grazing range of cattle.

Table 21. Distance from water zones by area and proportion

Distance km	Km^2	% Area	Cumulative %
0-1	400	3	3
1-2	906	7	11
2-3	1301	11	21
3-4	1494	12	34
4-5	1516	12	46
5-6	1381	11	58
6-7	1126	9	67
7-8	879	7	74
8-9	672	6	80
9-10	512	4	84
10 +	1961	16	100

Figure 24 shows an open mulga sand plain typical of FIN3 Moorilyanna. While there is increased cover apparent on the ground in the 2000 photo, this is a seasonal response. Longer-term change is reflected in the growth of woody shrubs that obscure the background.

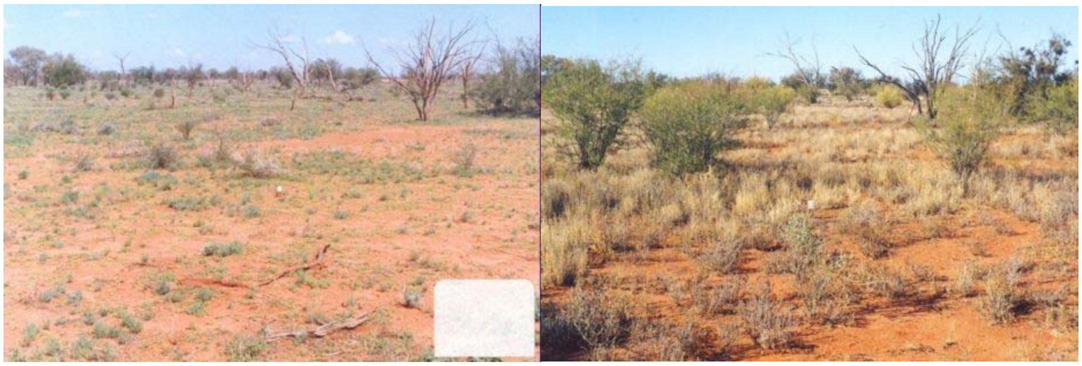


Figure 24. Left photo taken in 1988, right in 2000. Sequence shows growth of woody shrubs in open mulga woodland.

Grazing gradient analyses were conducted for the Finke Bioregion using South Australia's revised IBRA sub-region boundaries and land types. Reporting for the Finke Bioregion has been done at the individual land type level. These are FIN 3 Moorilyanna, FIN 4 Alberga and FIN 4 Pedirka. The relationship between these three land types, the sub-regions and the Finke Bioregion is shown in Figure 10. Descriptions and grazing gradient results for the three land types that represent the Finke Bioregion follow.

3.1.5 FIN3 MOORILYANNA

FIN3 Moorilyanna is comprised of open mulga plains of pale red sands with often-dense grass cover relative to other sand plain land types. Calcareous patches with sparser grass cover supporting saltbush. Patches of low bluebush with isolated patches of mallee also occur. The natural fire regime has probably been altered through grazing effects. The reduced frequency of fire results in the thickening of woody shrubs, particularly mulga. This land type is highly developed in respect of water points and fencing relative to neighbouring land types.

Figure 25. Location of the FIN3 Moorilyanna land type within the Finke Bioregion.

Table 22 provides some seasonal information relating to the image dates used in the Grazing gradient analysis for this region.

Table 22. FIN3 Moorilyanna land type

Attribute	Description
Name	FIN3 Moorilyanna
Area km^2	4,359
Reporting unit	Land type
Image dates	2000 dry (16/09/99) 2002 wet (16/03/02)
Seasonal context	2000 dry - Minor rain in month prior to image acquisition in mid-September 1999, prior to this, dry conditions through winter 2002 wet - Several high summer rainfall events (December 2001, February 2002) preceding image acquisition in mid-March 2002.
99-02 Rainfall Station	De Rose Hill

Comments

- The gradient shows reduced cover near to water for both dates that can be attributed to grazing.
- Much higher cover evident in the 2002 wet.
- Persistent gradient to 3 km for the 2002 wet. This means that despite adequate rainfall, regions within 3 km of water have failed to respond to the same degree as those regions further from water, indicating a loss of productive capability.
- Most areas are within 8 km from water.
- Low cover in the 2000 dry period contrasts strongly with the high cover in the 2002 wet period. The 2000 dry has a consistent gradient to 4 km, beyond which cover levels off.
- Cattle could be expected to range easily across most of this flat and sandy land type, resulting in a uniform pattern of grazing around water points and the potential for grazing effects on vegetation to extend beyond 8 km from water.

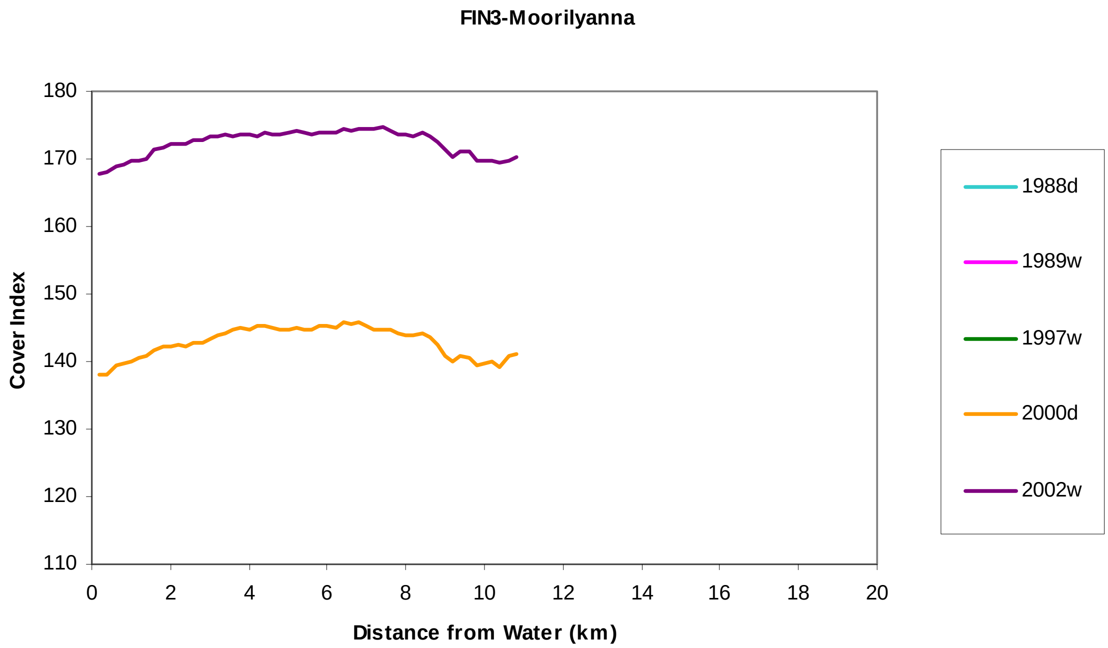


Figure 26. Grazing gradient for FIN3 Moorilyanna land type

Percentage Cover Production Loss

A minor loss in production across this land type is indicated by the %CPL for summer 2002. See Table 23 below

Table 23. %CPL for FIN3 Moorilyanna land type

Year	Distance in km.	% CPL	km^2
2002	3.4	2.0	1,530

Summary

FIN3 Moorilyanna is characterised by its highly resilient and productive grassy woodlands. However, landscape function across this land type has declined within 3 km of water resulting in loss of water and nutrients to a greater degree than areas beyond grazing range. This change is evident in the persistent 2002 wet gradient. Despite adequate rainfall, regions within 3 km of water have failed to respond to the same degree as those further from water. This loss in production is quantified by the %CPL as being in the order of 2% for the areas inside of 3.4 km from water (35% of the FIN3 Moorilyanna land type).

3.1.6 FIN4 ALBERGA

Figure 27 shows the location of the FIN4 Alberga land type. It is comprised of sand plains with often dense stands of mulga. Tree shrub species include narrow and broad-leaf mulga, horse mulga, grevillea , cassia and emubushes. Dense grass cover occurs seasonally, consisting of a high proportion of woolybutt. This land is generally acknowledged to be of little pastoral value. Deep, loose red sand flanking the Alberga Creek commonly supports tall kerosene grass.

Figure 27. Location of the FIN4 Alberga land type within the Finke Bioregion.

There were five image dates able to be used in this region. These dates and the seasons they were acquired in are detailed in Table 24.

Table 24. FIN4 Alberga land type

Attribute	Description
Name	FIN4–Alberga
Area km^2	2,448
Reporting unit	Land type
Image dates	1988 dry (October 1988)
	1989 wet (July 1989)
	1997 wet (April 1997)
	2000 dry (16/09/99)
	2002 wet (16/03/02)
Seasonal context	1988 dry image acquired during dry conditions following period of low rainfall.
	1989 wet image acquired following high rainfall events in December 1988 and March 1989, plus several smaller events
	1997 wet image acquired following series numerous small rainfall events from June 96 to February97
	2000 dry - Minor rain in month prior to image acquisition in mid-September 1999, prior to this dry conditions through winter
	2002 wet - Several high summer rainfall events (December 2001, February 2002) preceding image acquisition in mid-March 2002.
99-02 Rainfall Station	De Rose Hill

Comments

- The grazing gradient analysis for dates 1988 and the 1989 wet were conducted over a smaller region (71% of FIN4 Alberga) than the later dates.
- The majority of FIN4 Alberga is less than 7 km from water

- Lowest cover in the 1988 dry.
- Highest cover in 2002 wet, notably higher than that of the 1989 wet. This may be a result of a denser cover of grasses following summer rainfall event or an increase in woody canopy cover.
- Increase in cover across this land type in 2002 wet is possibly due to an increase in density of woody vegetation cover (mulga, sennas and other shrubs) - as a result of recruitment following the 1989 rains. Note that the 2000 dry image also has much higher cover values than that of the 1988 dry image.
- Cover levels in the 1989 wet, 1997 wet and 2000 dry are very similar
- Consistent gradients in the1988 dry, 1997 wet and 2000 dry to 10 km from water.
- The Gradient in the wet extends to only two km from water.
- Lack of distinct gradient in 2002 wet contrasts with gradient evident in 2000 dry. No persistent gradient.
- Natural fire regime probably altered through grazing, not frequently burnt, resulting in thickening of woody shrubs, particularly mulga.
- As low value grazing country, this land type is generally one of the last to be developed on most stations.

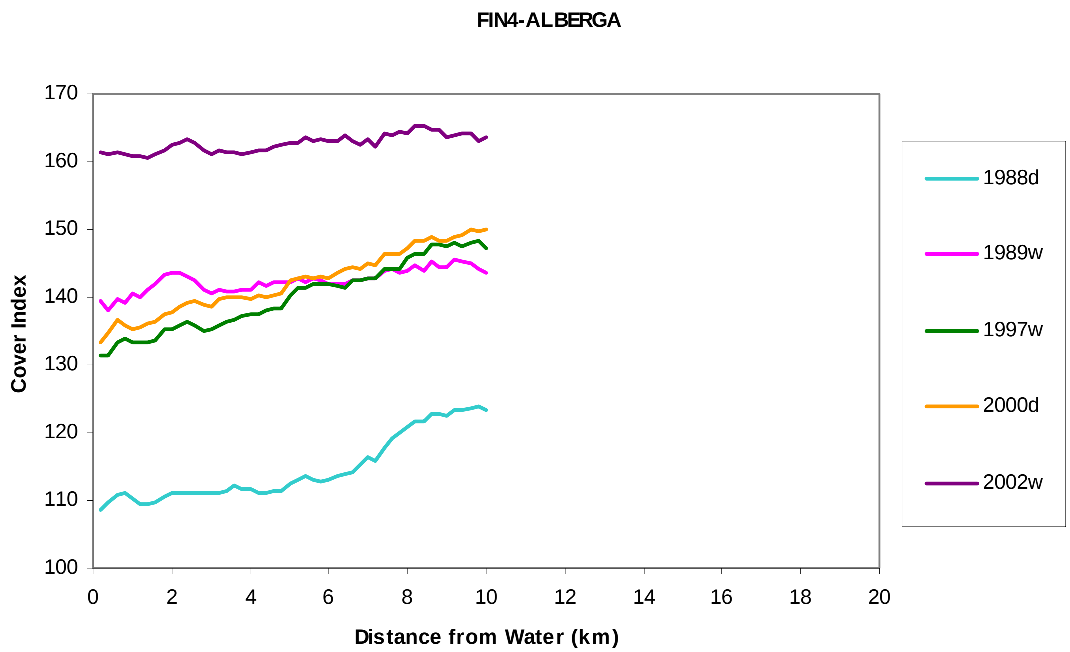


Figure 28. Grazing gradient for FIN4 Alberga land type

Percentage Cover Production Loss

A minor but consistent level of production loss across this land type is indicated by the %CPL values for 1989 and 2002 in Table 25 below.

Table 25. %CPL for FIN4 Alberga

Year	Distance in km.	% CPL
1989	2.0	1.0
2002	2.4	1.2

Figure 29 shows a typical mulga woodland on the deep red sands of the FIN4 Alberga land type. The sequence shows a change that is also quite typical in this region – the growth of distinct cohorts of mulga contributing to the increasing density of the upper storey vegetation cover.

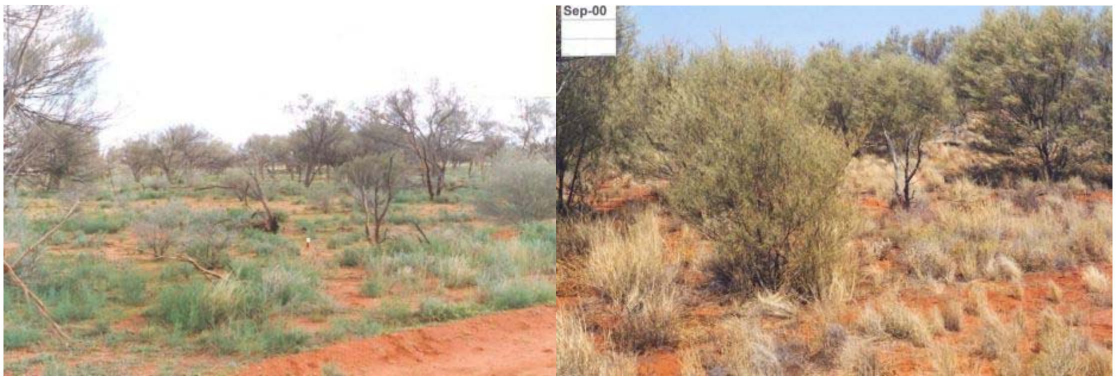


Figure 29. Left photo taken in 1988, right in 2000. Sequence shows the growth of a mulga cohort that germinated in the wet years during the 1970s. In 1988, the mulga woodland was quite open, but is becoming closed as the cohort matures.

Summary

FIN4 Alberga is characterised by mulga woodlands on red sand plains of low pastoral value. The grazing gradient graphs indicate that there has been a reduction in cover and that some loss in production has occurred close to water as a result of grazing pressure. This loss is quantified by the %CPL as being in the order of 1% for both dates for the regions inside of two km from water.

3.1.7 FIN4 PEDIRKA

Figure 30 shows the location of this land type, named after the Pedirka Desert of which it is part. The sand plains with often-dense stands of mulga are similar to the adjoining Alberga land type but with the addition of low, eroded and widely spaced parallel dunes. FIN4 Pedirka supports a high diversity and density of woody plants relative to other sand plain land types in the Finke Bioregion. These include narrow and broad-leaf mulga, horse mulga, *Grevillea* sp. *Senna* and *Eremophila* sp. Dense seasonal grass cover, often consisting of a high proportion of woolybutt, particularly where heavily grazed. This land is generally of little pastoral value. However, it is increasingly being developed and utilised.

Figure 30. Location of the FIN4 Pedirka land type within the Finke Bioregion.

Table 26 lists the dates and the seasons the five images used in this region were acquired.

Table 26. FIN4 Pedirka land type

Attribute	Description
Name	FIN4-Pedirka
Area km^2	4934
Reporting unit	Land type
Image dates	1988 dry (October 1988)
	1989 wet (July 1989)
	1997 wet (April 1997)
	2000 dry (16/09/99, 14/12/99, 31/01/00)
	2002 wet (9/03/02, 16/03/02)
Seasonal context	1988 dry image acquired during dry conditions following period of low rainfall
	1989 wet image acquired following high rainfall events in December 1988 and March 1989, plus several smaller events
	1997 wet image acquired following series numerous small rainfall events from June 96 to February 97
	2000 dry image consists of three dates spread over 4.5 months. Several months of very dry conditions precede first date, the second coincides with summer rainfall and the third is at least a month after rainfall.
	2002 wet. Rainfall in October and December 2001. High rainfall in February 2002 prior to image acquisition in mid-March 2002.
99-02 Rainfall Station	Todmorden

Comments

- The grazing gradient analysis for dates the 1988 dry and the 1989 wet were conducted over a smaller region (86.3% of FIN4 Pedirka) than the later dates.
- The majority of FIN4 Pedirka is less than 10 km from water.
- Lowest cover in the 1988 dry.
- The 1988 dry has a gradual gradient to 11 km, cover then levels out.

- Increase in cover in both the 1997 wet and 2000 dry.
- Gradient in 2000 dry is the steepest and continues to 9 km.
- Gradient in the 1997 wet is flatter and continues to 6-7 km
- Cover levels in the 1989 wet are similar to 1997 wet and 2000 dry however inverse gradient to 3 km
- Highest cover in 2002 wet with a gradual increase in cover to 6 km from water
- Overall persistent gradient to 6 km
- Increase in cover across this land type in 2000 dry and 2002 wet relative to earlier dates is likely due to increase in woody vegetation (mulga, senna and other shrubs) as a result of recruitment following the 1989 rains.

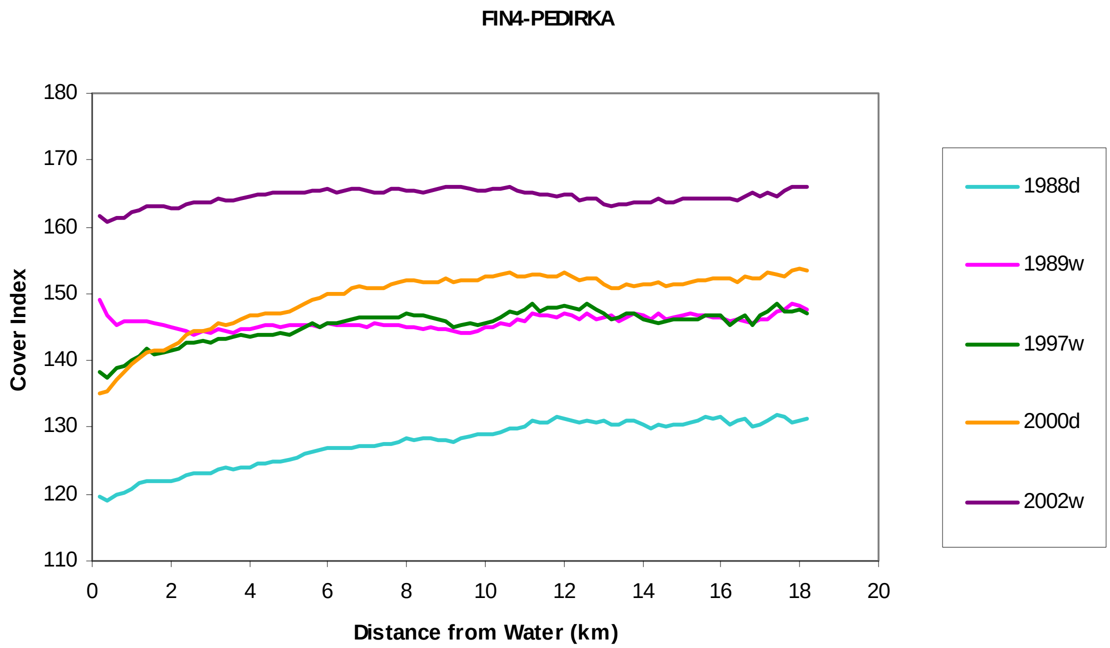


Figure 31. Grazing gradient for the FIN4 Pedirka land type

Percentage Cover Production Loss

The %CPL for the 1989 wet is relatively high at 8.1% (See Table 27 below). The region this loss occurs in extends to over 11 km from water. These measures are substantially greater than the later %CPL and distance measures for 2002. Some difference in measures is to be expected as the different dates represent slightly different areas of land (the 1989 region is 86.3% of the 2002 region).

Table 27. %CPL for FIN4 Pedirka

Year	Distance in km.	% CPL	km^2
1989	11.2	8.1	3902
2002	6.0	3.9	2186

The discrepancy may be partially explained by the timing of the different image dates of the wet scene acquisitions. The sand plains and low dunes of FIN4 Pedirka support mulga woodlands with shrub understorey and grasses. Seasonally, summer-germinated grasses probably contribute more than winter herbage in terms of short-term biomass and soil cover. More cover production could be expected from the grass growth stimulated by the 2002 summer rainfall than could be expected from the 1989 winter rainfall in this land type.

Other explanations include the masking effect of a greater contribution to cover levels from an increased woody component or the presence of recently established water points in the later image dates.

The 2002 %CPL figure of near 4% is significant given that this effect extends to 6 km from water. This represents 44% of the total area of FIN4 Pedirka.

Summary

A slight but consistent gradient to 11 km from water in the 1988 dry indicates the distance that grazing effects can extend to in dry times within this land type. This was the lowest cover level of all the dates. The gradient disappears in the subsequent 1989 wet period, indicating a full recovery. There is a conspicuous inverse gradient near to water in the 1989 wet that is absent for the other dates. This may be explained by the presence of winter herbage in the 1989 image and the absence of this type of cover for the other wet images.

Comparison of the sequence of dates indicates an overall increase in cover over time at all distances from water. This effect may relate to an increase in woody shrub density and increased canopy cover. A continuing increase in woody vegetation cover is in the mulga woodlands in this region is evident in photographic records. Much of this increased cover appears to be comprised of a cohort that germinated as a result of rainfall events in the 1970s. There may have also been recruitment of mulga, *Senna*, *Eremophila* and other shrubs as a response to the 1989 rainfall.

Some deterioration in landscape function near water can be inferred from the %CPL for both the 1989 wet and 2002. The land near water has failed to produce cover to the same extent as land further from water following adequate rainfall on two separate occasions. While a trend of improvement over time could be taken from the sequential distance and %CPL measures, this may alternatively only reflect seasonal differences. Subsequent analysis should be able to determine if this is the case.

3.1.8 FLINDERS LOFTY BLOCK BIOREGION

The Flinders Lofty Block Bioregion, shown in Figure 32, lies entirely within South Australia and includes the Flinders and Olary Ranges. A very diverse range of geology and landforms occur within this bioregion. Abrupt changes vegetation associations, related to the underlying geologic formations, are a common characteristic. Landforms include steep ranges of hills, gorges, intricate drainage patterns, outwash areas and open plains.

Figure 32. Location of the Flinders Lofty Block Bioregion in SA.

Table 28 shows the data from 75 sites was used to inform reporting for the sustainable management theme. The ratio of sites to square kilometres is thus around 1:700.

Table 28. Flinders Lofty Block Bioregion

Attribute	Description
Name	Flinders Lofty Block (FLB)
Area km^2	52,823
Reporting unit	2 IBRA sub-regions: Olary Spur (FLB3) and Northern Flinders (FLB5)
Data used to report	Sustainable Management: Palatable perennial plant density from 75 Jessup transects.

Fence line contrasts are a commonly photographed theme among rangeland organizations. Often the removal of all perennial vegetation within grazing reach becomes a permanent feature of the landscape. There appears to be a strong recovery of bladder saltbush in the photo sequence shown as Figure 33.

Figure 33. Left photo taken in 1965, right in 1996. Sequence shows the recovery of landscape function through recruitment of perennial saltbush in an area previously grazed bare. Land to the left of the fence in the earlier photo is much less able to retain rainwater and nutrients than the densely vegetated landscape apparent in the later photo.

Summary

The distribution of monitoring sites through the Flinders Lofty Block Bioregion is inadequate to allow conclusions to be drawn about the bioregion as a whole. The same situation is evident for the two sub-regions examined.

3.1.9 OLARY SPUR IBRA SUB-REGION

Figure 34 shows the very clustered location of the Jessup sites within the Olary Spur sub-region. The sub-region consists of calcareous plains with low shrubland of pearl bluebush; plains of sugarwood open woodland over bladder saltbush or bladder saltbush low shrubland with bitter saltbush; low hills of bladder saltbush low shrubland; watercourse plains of nitrebush and blackbush with river red gum creeks.

Figure 34. Distribution of monitoring sites within the Olary Spur sub-region.

Table 29 shows there are data from 19 sites to inform reporting on an area of 17,455 km^2. The ratio of sites to square kilometres for the sustainable management theme is thus around 1:900.

Table 29. Olary Spur sub-region

Attribute	Description
Name	FLB3 Olary Spur
Area km^2	17,455
Reporting unit	IBRA Sub-Region
Number of sites	Palatable perennial plant density from 19 Jessup transects (Sustainable management)

Most sites were monitored within the first half of the ACRIS monitoring period (See Table 30 below). The average interval between time 1 and time 2 was 6 years.

Table 30. Olary Spur sub-region sites with Jessup visited by year.

	Year																
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Visit 1	16					1		2									
Visit 2							1	16	1			1					

Plant density increased at 62% of the sites and declined at 10% of the sites. Figure 35 shows that there was a large increase for some sites.

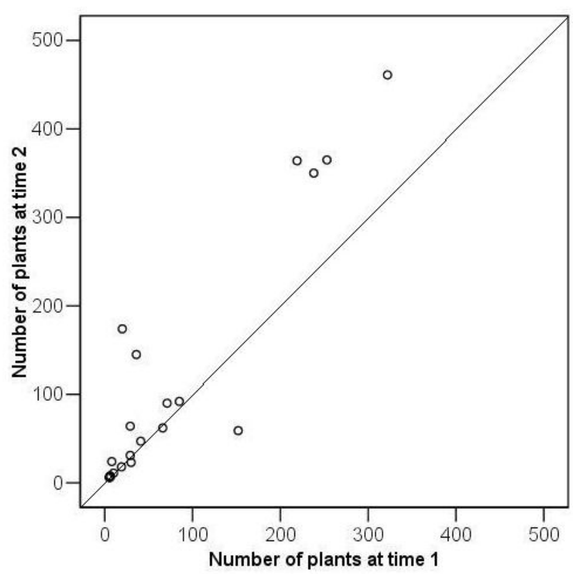


Figure 35. Change in perennial plant density for the Olary Spur sub-region.

Change matrix.

- 70% of the sites were monitored during above average seasonal conditions.
- 20% of the sites were monitored during average seasonal conditions.

- No sites were monitored during below average seasonal conditions.
- 7% of the sites monitored during above average seasonal conditions showed a decline in plant density, indicating management (grazing) as a causal factor.

Table 31. Change matrix for the Olary Spur sub-region.

Seasonal Quality	No sites	Percent of monitoring sites		
		Decline	No change[1]	Increase
Above average	15	7%	20%	73%
Average	4	25%	25%	50%
Below average	0	0%	0%	0%

The bare plain shown in the foreground of the earlier photo in Figure 36 gives no indication of supporting perennial vegetation. Change has occurred, but the catalyst is not obvious.

Figure 36. Left photo taken in 1955, right in 1995. Sequence shows a bare plain that has been colonised by nitrebush.

Summary

The change matrix clearly shows a 7% decline in palatable perennial plant density at sites monitored during above average seasonal conditions. As the seasonal context has been established as being conducive to plant growth, grazing is implicated as the other major factor influencing plant density.

3.1.10 NORTHERN FLINDERS IBRA SUB-REGION

This region has been classified into numerous land systems due to the diverse geology. Landforms include rolling hills, steep rocky slopes and numerous drainage lines. Figure 37 shows the distribution of monitoring sites through the region. Most are sites located on alluvial plains in valleys that commonly support elegant wattle, river red gum, bladder saltbush and bluebushes.

Figure 37. Distribution of monitoring sites within the Northern Flinders sub-region.

Table 32 shows there are data from 56 sites to inform reporting on an area of 18,468 km^2. The ratio of sites to square kilometres for the sustainable management theme is thus around 1:300.

Table 32. Northern Flinders sub-region

Attribute	Description
Name	Northern Flinders (FLB5)
Area km^2	18,468
Reporting unit	IBRA Sub-region
Data used to report	Palatable perennial plant density from 56 Jessup transects (Sustainable management)

The majority of these sites were monitored in the early part of the ACRIS monitoring period between 1989 and 1994 (See Table 33 below). The average interval between time 1 and time 2 was 5 years.

Table 33. Northern Flinders sub-region sites with Jessup visited by year.

	Year																
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Visit 1	49	5				1					1						
Visit 2						53					1			1	1		

Figure 38 shows that plant density increased at 63% of the sites and decreased at 19%.

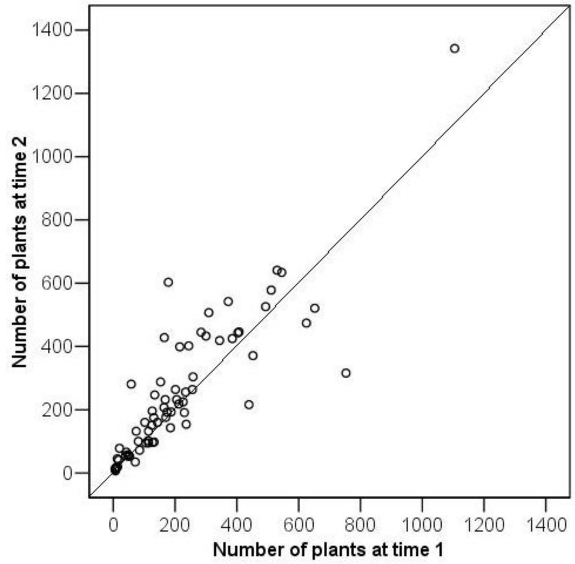


Figure 38. Change in perennial plant density for the Northern Flinders sub-region.

Change matrix.

- 88% of the sites were monitored during above average seasonal conditions.
- 12% of the sites were monitored during average seasonal conditions.
- None of the sites were monitored during below average seasonal conditions.
- 8% of the sites monitored during above average seasonal conditions showed a decline in plant density indicating management (grazing) as a causal factor.
- 86% of sites monitored during average seasonal conditions had an increase in plant density recorded. The other 14% of sites showed a reduction.

Table 34. Change matrix for the Northern Flinders sub-region.

Seasonal Quality	No sites	Percent of monitoring sites		
		Decline	No change[1]	Increase
Above average	49	8%	27%	65%
Average	7	14%	0%	86%
Below average	0	0%	0%	100%

A long history of grazing has left its mark on the Flinders Ranges landscape. The changes resulting from grazing vary between landforms. Figure 39 shows an increase grass cover and woody shrubs.

Figure 39. Left photo taken in 1966, right in 1999. Sequence shows the colonisation of a heavily grazed stony rise by perennial grasses in the foreground and an increase in the density of woody shrubs on the hillside in the background. The growth of this persistent vegetative cover has enhanced the ability of this landscape to retain soil, rainwater and nutrients. Landscape function has moved from a dysfunctional state towards a fully functional state.

Summary

The decline in plant density shown by 8% of the samples acquired during above average seasonal conditions of the sites is cause for concern. This figure has credibility, as there are a reasonable number of sites included. A decline in perennial plant density has implications for landscape function in reducing the ability of the land to trap and store rainwater and nutrients.

3.1.11 GAWLER BIOREGION

This entire bioregion lies in South Australia. It includes the Gawler Ranges as well as salt lakes, sandy or calcareous plains, and woodlands of western myall, mulga or blackoak, homogenous chenopod open plains of pearl bluebush, bladder saltbush or black bush. Western myall or mulga woodlands comprise about one-third of the sites with the remainder located on the open bluebush or saltbush plains.

Figure 40. Location of the Gawler Bioregion in SA.

Table 35 shows there are data from 211 sites to inform reporting on 118,361 km^2. The ratio of sites to square kilometres for the Landscape Function theme is thus around 1:600. There are data from 165 sites relevant to the Sustainable Management theme, giving a ratio of 1:700.

Table 35. Gawler Bioregion

Attribute	Description
Name	Gawler (GAW)
Area km^2	118,361
Reporting unit	Bioregion
Data used to report	Landscape function: Perennial plant density from 211 Jessup transects
	Sustainable management: Palatable perennial plant density from 165 Jessup transects

The Gawler Bioregion had a consistent monitoring regime with most sites monitored in the early 1990s and again in the early 2000s. Table 36 shows visits for the 211 sites used in the Landscape Function Theme. The average interval between time 1 and time 2 was 9 years.

Table 36. Gawler Bioregion sites with Jessup visited by year

	Year																
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Visit 1		23	50	90	8	1	1		21		7		5	5			
Visit 2						5	3	2		2	3	2	81	77	7	29	

Figure 41 shows the distribution of monitoring sites over the Gawler Bioregion. The availability of this quantity of monitoring information from suitably dispersed sites is due to this bioregion being chosen as South Australia's region for the ACRIS pilot reporting project. The collection of these field data in the early 2000's was specifically funded for this purpose.

Figure 41. Distribution of monitoring sites within the Gawler Bioregion.

Figure 42 below shows around 60% of sites showed an increase in plant density. More than half of these sites were monitored during above average seasonal conditions.

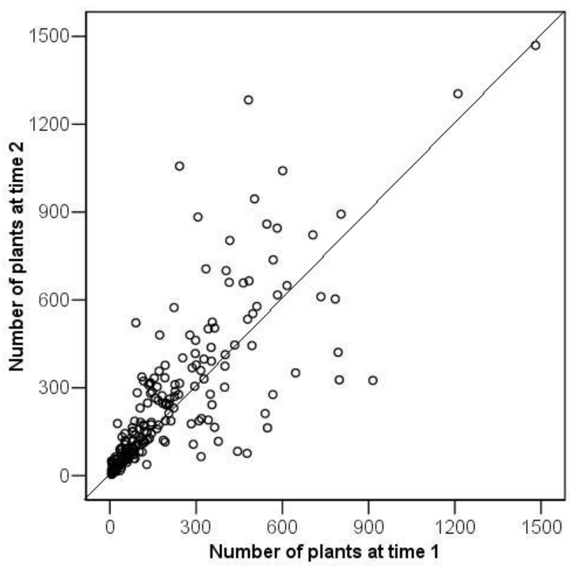


Figure 42. Change in perennial plant density for the Gawler Bioregion

Change matrix

- 65% of the sites were monitored during above average seasonal conditions.
- 34% of the sites were monitored during average seasonal conditions.

- 1% of the sites were monitored during below average seasonal conditions.
- 16% of the sites monitored during above average seasonal conditions showed a decline in plant density. These sites represent landscapes that are becoming dysfunctional through a reduced ability to trap and store water and nutrients.
- 59% of sites monitored during above average seasonal conditions had an increase in plant density.

Table 37. Change matrix for the Gawler Bioregion

Seasonal Quality	No sites	Percent of monitoring sites		
		Decline	No change[1]	Increase
Above average	107	16%	25%	59%
Average	56	21%	25%	54%
Below average	2	50%	0%	50%

Most of the land tenure in the Gawler Bioregion is Pastoral Lease. The distribution pattern of stock watering points can be seen in Figure 43 below. Water points are more dispersed in the lower rainfall areas of the northern parts of the bioregion where the paddocks are larger.

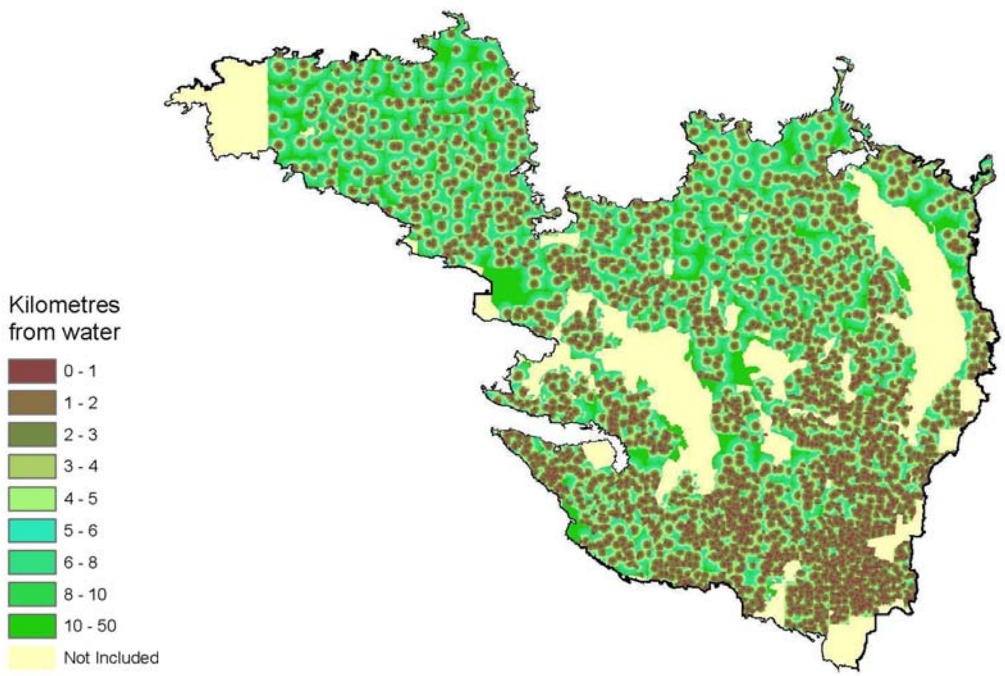


Figure 43. Distribution of stock watering points in the Gawler Bioregion

Table 38 below shows the area and proportion of land for distance from water in 1 km increments. The predominant domestic grazing species in this bioregion is sheep. Assuming

5 km as the maximum distance that sheep range out from water, Table 38 shows 70% of the land area analysed as being within the usual grazing range of sheep.

This leaves 30% beyond the usual grazing range of sheep.

Table 38 Distance from water zones by area and proportion

Distance km	km^2	% Area	Cumulative %
0-1	7865	8	8
1-2	15439	16	25
2-3	16654	18	42
3-4	14531	15	58
4-5	11264	12	70
5-6	8420	9	78
6-7	6136	6	85
7-8	4338	5	90
8-9	3016	3	93
9-10	2091	2	95
10 +	4795	5	100

Figure 44. Left photo taken in 1990, right in 2003. Sequence shows an increase in woody vegetation cover on a sandplain.

Figure 45. Left photo taken in 1952, right in 1992. There is no bladder saltbush visible in the foreground of the earlier photo. The later photo shows a remarkable increase in the density of bladder saltbush, now contributing a level of crown cover similar to that of the bluebush.

Summary

The Gawler Bioregion has had the most comprehensive and consistent site monitoring program of any of the South Australian bioregions. A total of 211 sites were visited twice within the ACRIS monitoring period. This number of sites gives some degree of confidence in the results of any analysis. However, the Gawler Bioregion covers a very big area. Even with 211 sites, this still results in a ratio of 1 site to every 561 square kilometres.

The change matrix shows that of 123 sites monitored during above average seasonal conditions, 18% demonstrated a decline in plant density. This decline during seasons where plant density should be increasing suggests unsustainable management practises and warrants further investigation. Loss of perennial vegetative cover infers a negative impact on landscape function. Affected landscapes move towards a dysfunctional state, losing some ability to respond to rainfall.

3.1.12 STONY PLAINS

Most of this bioregion (99%) lies within South Australia. It is comprised of gently undulating, treeless gibber plains with gilgais, low rocky hills and mesas. Trees are generally confined to creek lines with mulga or gidgee in the upper reaches. Coolibah and river redgum occur in the larger creeks. Plains with Oodnadatta saltbush, bladder saltbush and Mitchell grass.

Figure 46. Location of the Stony Plains Bioregion in SA.

Table 39. Stony Plains

Attribute	Description
Name	Stony Plains (STP)
Area km^2	129,619
Reporting units	4 Land Types
Data used to report	Grazing gradient over four Land Types; STP1 Coongra STP1 Mount Willoughby STP6 Coongra STP6 Crispe

Figure 47 shows the distribution of stock watering points and the distance from water across the Stony Plains Bioregion. Cattle exclusively graze the northern part while sheep are the most common domestic grazing animal south of the dog fence.

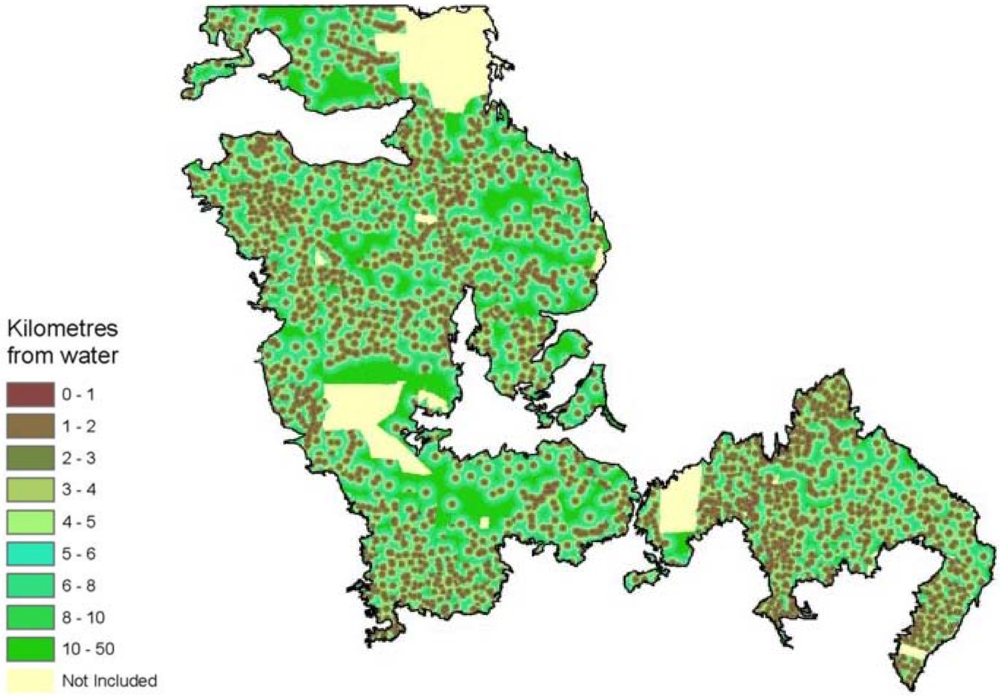


Figure 47. Distribution of stock watering points and distance from water for the Stony Plains Bioregion

As sheep and cattle vary in the distance that they will range out from water and this bioregion is grazed by both species, the figures in Table 40 do not reflect grazing by a specific animal. However, it does show that 50% of the analysed area is within 4 km of water therefore is potentially grazed by domestic stock.

Table 40. Distance from water zones by area and proportion

Distance km	km^2	% Area	Cumulative %
0-1	6392	5	5
1-2	14874	13	18
2-3	18879	16	34
3-4	18567	16	50
4-5	15454	13	63
5-6	11882	10	73
6-7	8491	7	81
7-8	5927	5	86
8-9	4184	4	89
9-10	2982	3	92
10 +	9476	8	100

Figure 48. Left photo taken in 1950, right in 1999. Sequence shows the growth of vegetation at a mound spring after excluding stock.

Reporting for the Stony Plains Bioregion utilises South Australia's revised IBRA sub-region boundaries and land types. All reporting for this bioregion has been at the individual land type level. These are STP 1 Coongra, STP 1 Mount Willoughby, STP 6 Coongra and STP 6 Crispe. The relationship between these four land types, the sub-regions and the Stony Plains Bioregion is shown in Figure 10. Descriptions and grazing gradient results for the four land types follow.

3.1.13 STP1 COONGRA

Figure 49 shows the location of the STP1 Coongra land type within the Stony Plains Bioregion. STP1 Coongra consists primarily of undulating gibber plain with numerous shallow gilgais. A dense gibber mantle covers soil. These stones are a pale colour in comparison to other gibber land types in the bioregion. Mesas and watercourses support mulga. The gibber plains are dominated by bladder saltbush. Common grasses include barley Mitchell grass, feathertop wiregrass and oatgrass. This is a very productive land type - heavily utilised and impacted in the past. Mitchell grass and long-spined poverty bush tend to increase as bladder saltbush decreases with increased grazing impact.

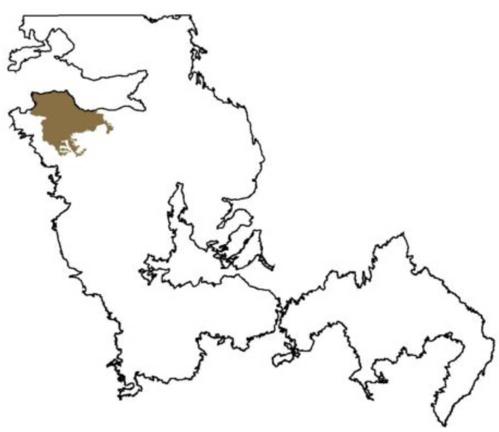


Figure 49. Location of STP1 Coongra land type within the Stony Plains Bioregion.

Table 41 provides some seasonal information relating to the image dates used in the grazing gradient analysis for the STP1 Coongra land type.

Table 41. STP1 Coongra land type

Attribute	Description
Reporting unit	Land type
Name	STP1-Coongra
Area km^2	4688
Image dates	1988 dry (October 1988)
	1989 wet (July 1989)
	1997 wet (April 1997)
	2000 dry (16/09/99, 31/01/00)
	2002 wet (9/03/02)
Seasonal context	1988 dry image acquired during dry conditions following period of low and nil monthly rainfall. Very dry conditions
	1989 wet image acquired July 1989 following high rainfall in March 1989. Minor rainfall recorded in all months between March rain and July acquisition. Total cover would have included a high proportion of winter herbage.
	1997 wet image acquired mid-April 1997, two months after high rainfall in February 1997. No rain in March or April.
	2000 dry images (2) are separated by significant rainfall in October and December 99. Very low and nil monthly rainfall in six months prior to first image, acquired in mid-September 99. Second image acquired late January 2000.
	2002 wet image acquired in mid-March 2002 following high rainfall in February 2002 and December 01. Good conditions prevailing through most of 01.
99-02 Rainfall Station	Todmorden

Comments

- The grazing gradient analysis for dates the 1988 dry and the 1989 wet were conducted over a slightly smaller region (94.5% of STP1 Coongra) than the later dates.
- Grazed areas extend out to 9 km from water with most within 6 km of water
- Highest cover in summer 2002 but only marginally above the 1989 wet. Both of these have much flatter gradients relative to the other dates but still show a persistent gradient out to 3 km.
- Lowest cover in the 1988 dry.
- Consistent gradients from 0.5 to 9 km for the 1988 dry, 1997 wet & 2000 dry.
- Cover levels for 1997 wet and 2000 dry are congruent.
- All dates show a persistent inverse gradient 0 to 500m from water.

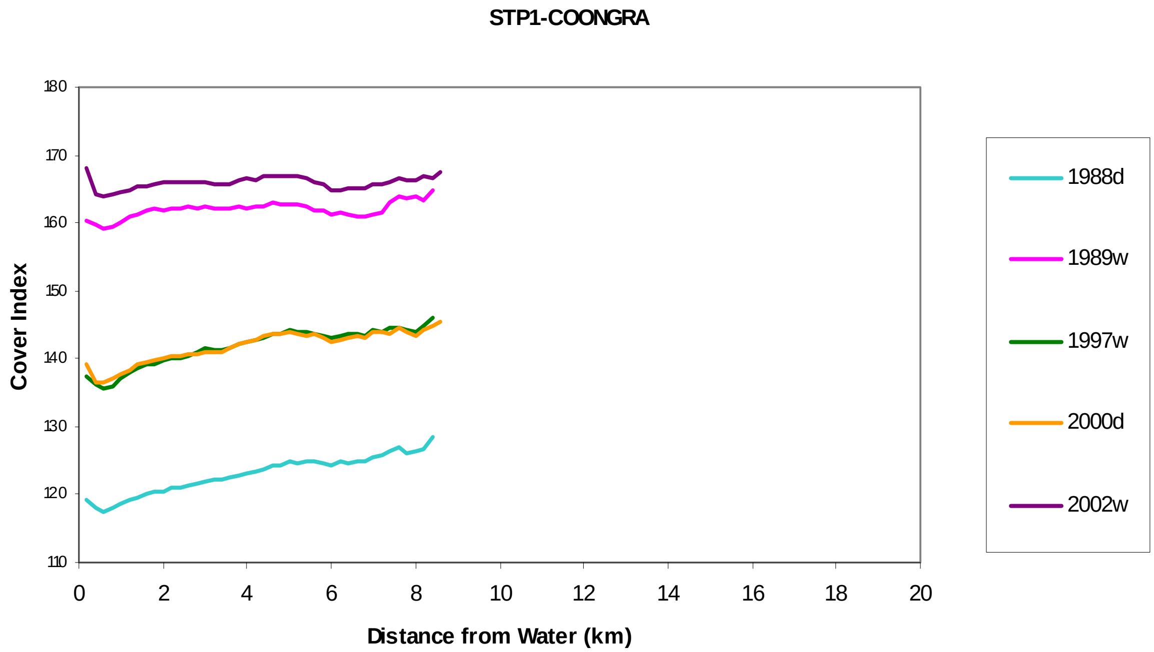


Figure 50. Grazing gradient for STP1 Coongra land type

There were a few minor rainfall events prior to the acquisition of the 2000 dry image. This may account for the higher cover levels relative to the 1988 dry.

The inverse gradient near to water is a common feature of land types with trees generally restricted to the drainage lines. As a high proportion of the water points are located along drainage lines, vegetation cover measurements immediately surrounding the water points are often heavily influenced by tree foliage.

The clay soils and the drainage patterns of the Coongra land system allow for a relatively high level of moisture retention when compared to sandier types. These attributes combined with the particular rainfall sequence of 1989 and the winter image acquisition mean that there would have been a high proportion of short-lived winter herbage contributing to the overall cover level for that date. The March acquisition of the 2002 wet image may thus be a better measure of perennial vegetation cover and the ability of the land to respond to rainfall.

Percentage Cover Production Loss

The respective areas used for the sequence of analyses are very similar with the 1988 dry and the 1989 wet area comprising 94.5% of the area covered by the later dates.

An increase in %CPL over time is indicated by the 1989 wet and 2002 wet figures in Table 42 below. The area is also larger in 2002, out to 4.6 km from 1.8 km in 1989. This again may be due to the particular land type, the differing rainfall pattern and the timing of the wet scene image acquisition.

Table 42. %CPL for the STP1 Coongra land type

Year	Distance in km.	% CPL	Km2
1989	1.8	0.6	755
2002	4.6	3.6	3,469

Summary

Some parts of the STP1 Coongra land type within grazing range of water have become leaky, losing water and nutrients to a greater degree than areas beyond grazing range. This change can be seen in the persistent gradient evident in both the 1989 wet and 2002 wet. Despite receiving rainfall adequate to stimulate plant growth, these regions within 3 km of water have failed to respond to the same degree as those further from water. This loss in production is quantified by the %CPL as being in the order of 3.6% for the regions inside of 4.6 km from water (3,469 km^2) for the 2002 event.

3.1.14 STP1 MOUNT WILLOUGHBY

STP1 Mount Willoughby consists of red pebbly clay plains with sparse shallow sand drifts and occasional low irregular sand dunes. This land type is located on the western edge of the Stony Plains Bioregion bordering the sandy expanses of the Great Victoria Desert (See Figure 51 below). The hard red flats support sparse to open mulga with rock emubush also common. Numerous small swamps or depressions support denser mulga woodland with emubushes, sennas and chenopod shrubs. Perennial grasses include needle-leaved three-awn, cotton grass and neverfail. Annual grasses such as mulga grass and spear grass are common.

Figure 51. Location of the STP1 Mount Willoughby land type within the Stony Plains Bioregion.

Table 43 provides seasonal information relating to the image dates used in the grazing gradient analysis for the STP1 Mount Willoughby land type.

Table 43. STP1 Mount Willoughby land type

Attribute	Description
Reporting unit	Land type
Name	STP1-Mt Willoughby
Area km^2	1489
Image dates	1988 dry (October 1988)
	1989 wet (July 1989)
	1997 wet (April 1997)
	2000 dry (16/09/99)
	2002 wet (9/03/02, 16/03/02)
Seasonal context	1988 dry image acquired during dry conditions following period of low and nil monthly rainfall. Very dry conditions
	1989 wet image acquired July 1989 following high rainfall in March 1989. Minor rainfall recorded in all months between March rain and July acquisition. Total cover would have included a high proportion of winter herbage.
	1997 wet image acquired mid-April 1997, two months after high rainfall in February 1997. No rain in March or April.
	2000 dry. Very low and nil monthly rainfall in six months prior to image acquisition in mid-September 99.
	2002 wet images acquired one week apart, in mid-March 2002, following high rainfall in February 2002 and December 2001. Good conditions prevailing through most of 2001
99-02 Rainfall Station	Todmorden

Comments

- The grazing gradient analysis for the 1988 dry and the 1989 wet were conducted over a much smaller region (43% of STP1 Mount Willoughby) than the later dates. The 1997 wet, 2000 dry and 2002 wet images cover 100% of STP1 Mount Willoughby.
- Grazed areas out to 7 km from water with most within 6 km of water
- Highest cover in the 1989 wet and 2002 wet with cover levels very similar.
- Lowest cover in the 1988 dry with a trend of increasing cover with distance out to 6 km.
- All dates show a persistent inverse gradient 0 to 500m from water.
- Very obvious persistent gradient evident from 500m to 3 km for all image dates except the 2000 dry which has a much flatter gradient.

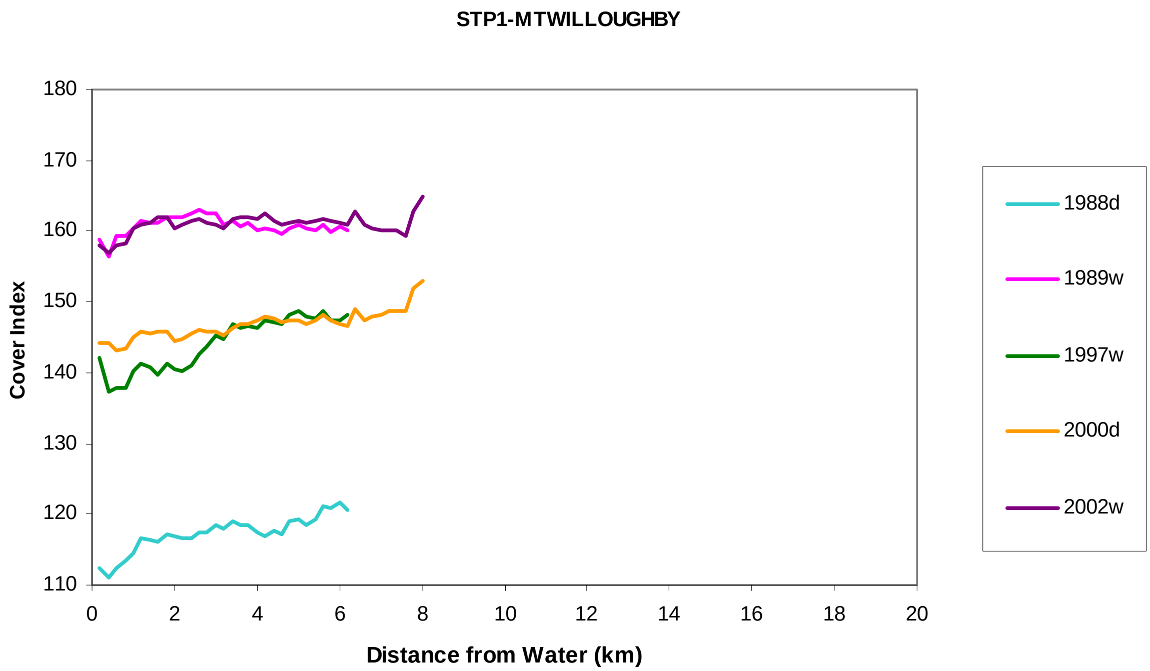


Figure 52. Grazing gradient for the STP1 Mount Willoughby land type

Percentage Cover Production Loss

Minor negative change in landscape function indicated by the %CPL measure for both dates in Table 44.

Table 44. %CPL for the STP1 Mount Willoughby land type

Year	Distance in km.	% CPL	km2
1989	2.6	1.0	429
2002	1.6	1.5	180

Figure 53 shows an increase in the density of mulga and shrubs on a hard red pebble plain.

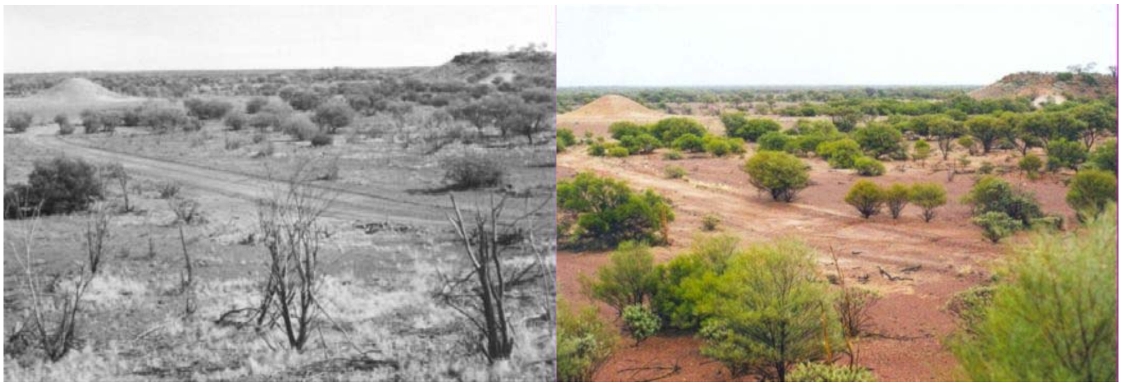


Figure 53. Left photo taken in 1956, right in 1999. Sequence shows an increase in the density of woody shrubs in the foreground.

Summary

A persistent gradient of increasing cover with distance from water is apparent for all three wet dates. This clearly indicates that landscape function has been detrimentally affected by grazing within a radius of 3 kilometres from the water points in this land type. The extent to which production has been affected is indicated by the %CPL, which for 2002 was 1.5%.

3.1.15 STP6 COONGRA

STP6 Coongra lies to the north of the larger STP1 Coongra, separated by the sands of the Pedirka Desert. It varies from STP1 in being generally undulating, the stone having a darker colour and more gidgee in the watercourses. On the gibber plains bladder saltbush grows with feathertop wiregrass, Mitchell grass, native millet, katoora and *Enneapogon* sp. Oodnadatta saltbush is uncommon.

Figure 54. Location of the STP6 Coongra land type within the Stony Plains Bioregion.

Table 45 provides some seasonal information relating to the image dates used in the grazing gradient analysis for the STP6 Coongra land type.

Table 45. STP6 Coongra land type

Attribute	Description
Land type	STP6-Coongra
Area km^2	966
Image dates	1988 dry (October 1988)
	1989 wet (July 1989)
	1997 wet (April 1997)
	2000 dry (14/12/99)
	2002 wet (9/03/02)
Seasonal context	1988 dry image acquired during dry conditions
	1989 wet image acquired July 1989 following high rainfall in March 1989. Minor rainfall recorded in all months between March rain and July acquisition. Total cover would have included a high proportion of winter herbage.
	1997 wet image acquired mid-April 1997, after two months of nil rainfall following a wet summer.
	2000 dry image acquired in mid-December 99 following and during minor rainfall.
	2002 wet image acquired in mid-March 2002 following rainfall in December 01 and February 2002.
99-02 Rainfall Station	Todmorden

Comments

- The image area was consistent for all dates.
- All image dates have a consistent grazing gradient pattern except for the 1989 wet which has a much steeper gradient to 4 km.
- Grazed areas extend to13 km from water.
- An inverse gradient is apparent between 0 and 1 km for all dates except the 1989 wet. This may reflect the location of the water points within the landscape, as many are located in wooded watercourses in otherwise open plains.
- A persistent gradient is apparent between 1-2 and 10 km for all dates with both the 1989 wet and the 2002 wet having a steeper gradient from 1 to 3 km.
- The 2002 has a persistent gradient to 8 km.
- Highest cover shown in 2002 wet and lowest cover in the 1988 dry
- Cover levels for the 1989 wet and 2000 dry very similar

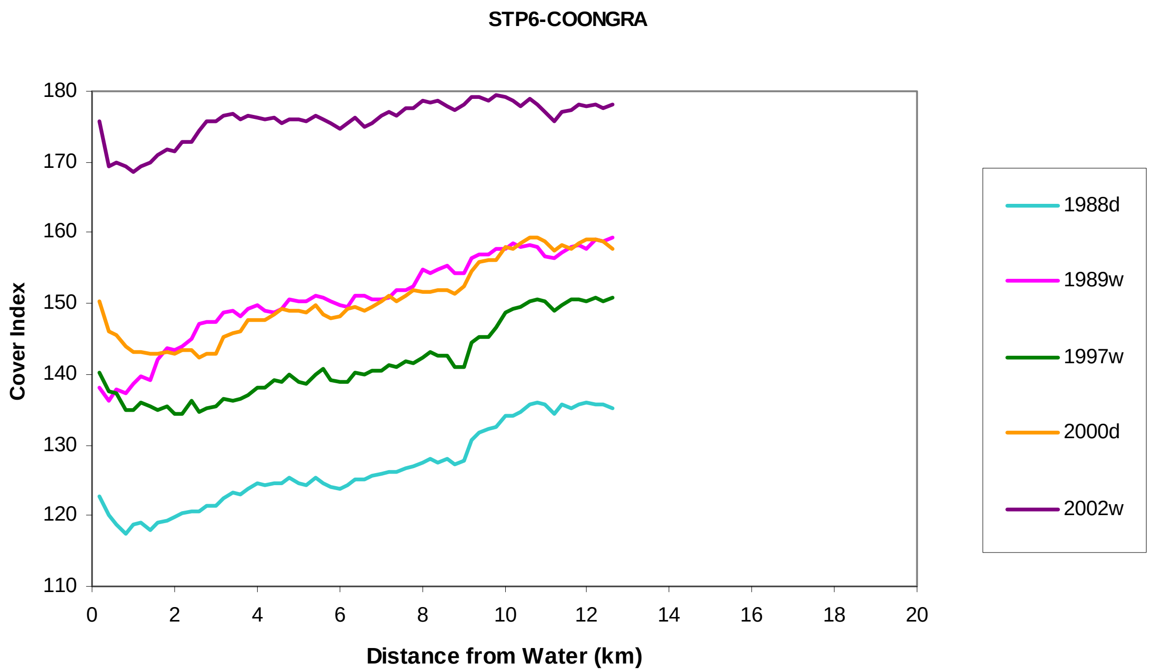


Figure 55. Grazing gradient for the STP6 Coongra land type

Percentage Cover Production Loss

At 15.6% the %CPL for 1989 is very high but consistent across four image dates. The spatial extent of the effect is also at the higher end of the scale. These measures contrast strongly with those of 2002 in Table 46 below.

Table 46. %CPL for the STP6 Coongra land type

Year	Distance in km.	% CPL	km2
1989	10.2	15.6	592
2002	3.4	2.1	129

This apparent improvement in the ability of the land to respond to rainfall may stem from both rainfall and grazing effects in the intervening years. This land type was subject to intense grazing over a long period of time. The land managers consequently chose to de-stock many of the water points in the late 1990s. This change in management also coincided with a sequence of wet years.

Summary

There is evidence in the 2002 %CPL that some loss in productivity persists within 3.4 km of water. Both the 1989 wet and 2002 wet show steep gradients at this distance from water. These results indicate the loss of landscape function as the result of grazing. The effects extend to 13 kilometres from water.

3.1.16 STP6 CRISPE

STP6 Crispe is shown in Figure 56. It is located immediately south of the Northern Territory border. Landforms consist of undulating gibber tableland and plateaus supporting Oodnadatta saltbush, bladder saltbush, emubushes and sennas. Gilgais support Mitchell grass and neverfail. Numerous shallow sand drifts occur in patches over the gibber plains and slopes and support dense stands of knotty-butt neverfail. The drainage lines are dominated by gidgee in the lower reaches, giving way to often dense stands of mineritchie in the upper reaches. Small clumps of mineritchie occur on the edge of the plateaus, at the very top of the watercourses.

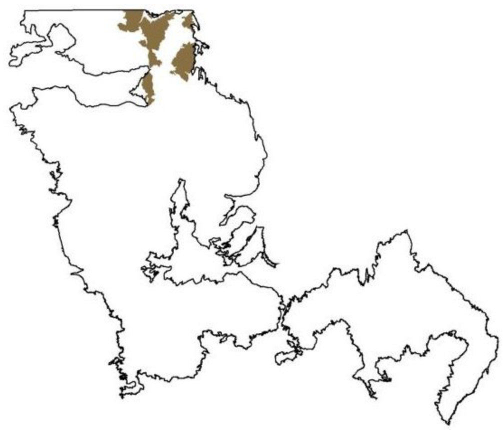


Figure 56. Location of the STP6 Crispe land type within the Stony Plains Bioregion.

Table 47 provides seasonal information relating to the image dates used in the grazing gradient analysis for the STP6 Crispe land type.

Table 47. STP6 Crispe land type

Attribute	Description
Reporting unit	Land type
Name	STP6-Crispe
Area km^2	4001
Image dates	1988 dry (October 1988)
	1989 wet (July 1989)
	1997 wet (April 1997)
	2000 dry (14/12/99, 31/01/00)
	2002 wet (13/01/02, 9/03/02)
Seasonal context	1988 dry image acquired during dry conditions
	1989 wet image acquired July 1989 following very high rainfall in March 1989. Minor rainfall recorded in all months between March rain and July acquisition. Total cover would have included a high proportion of winter herbage.
	1997 wet image was acquired mid-April 1997, preceded by two months of nil rainfall following a wet summer.

Attribute	Description
Seasonal context	2000 dry images (2) acquired in mid-December 99 and late January following and during minor rainfall. Most of STP6 Crispe is covered by the December image. 2002 wet images (2) acquired during rainfall months in mid-January and mid-March 2002, following moderate rainfall in December 01.
99-02 Rainfall Station	Mount Sarah

Comments

- The grazing gradient analysis for the 1988 dry and the 1989 wet were conducted over a slightly smaller region (91.8% of the area of the later dates).
- Grazed areas extend to 8 km from water, most within 6 km.
- Inverse gradient between 0 and 800 metres for all dates.
- Highest cover in 2002 wet with the lowest cover in the 1988 dry.
- 2000 dry and 2002 wet show a gradual gradient from 1 to 8 km from water. The 1988 dry and 1989 wet are similar to those for the 2000 dry and 2002 wet except they show a slight inverse gradient (decrease in cover) from 4 to 8 km from water.
- The 1997 wet has a conspicuous inverse gradient from 3 to 7 km

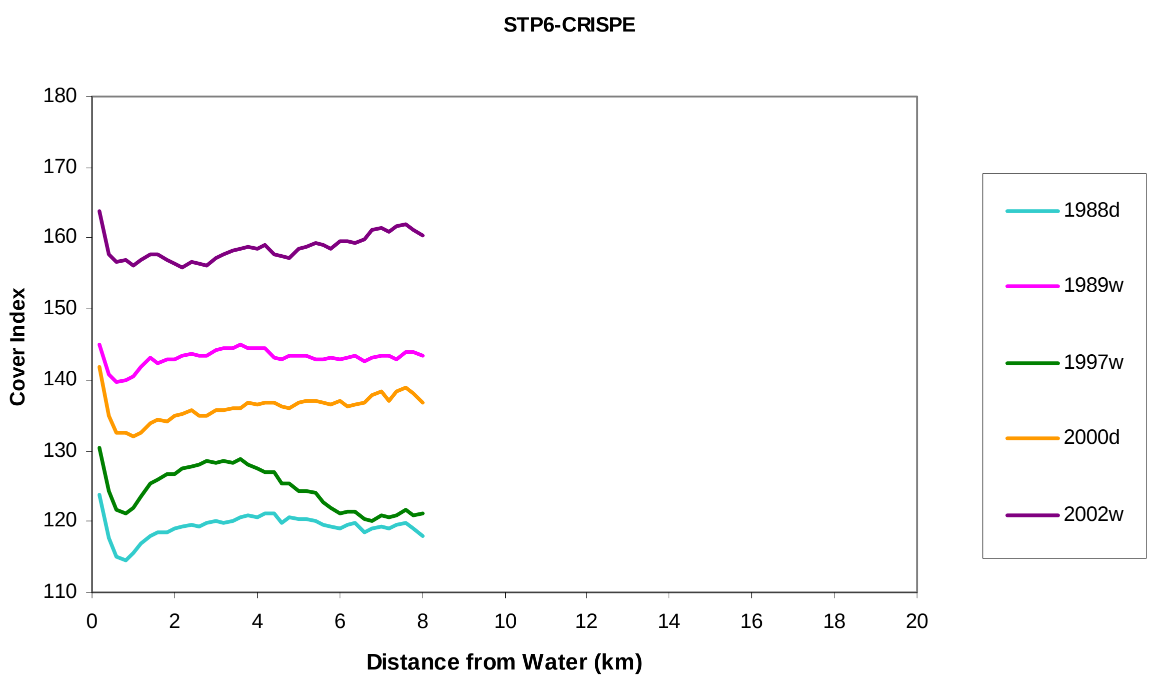


Figure 57. Grazing gradient for the STP6 Crispe land type

Significant %CPL measures for both the 1989 wet and 2002 wet that extend to over 3 km from water. See Table 48 below.

Table 48. %CPL for the STP6 Crispe land type

Year	Distance in km.	% CPL
1989	3.2	2.9
2002	3.8	3.8

The rocky nature of the Crispe land type is shown in Figure 58.

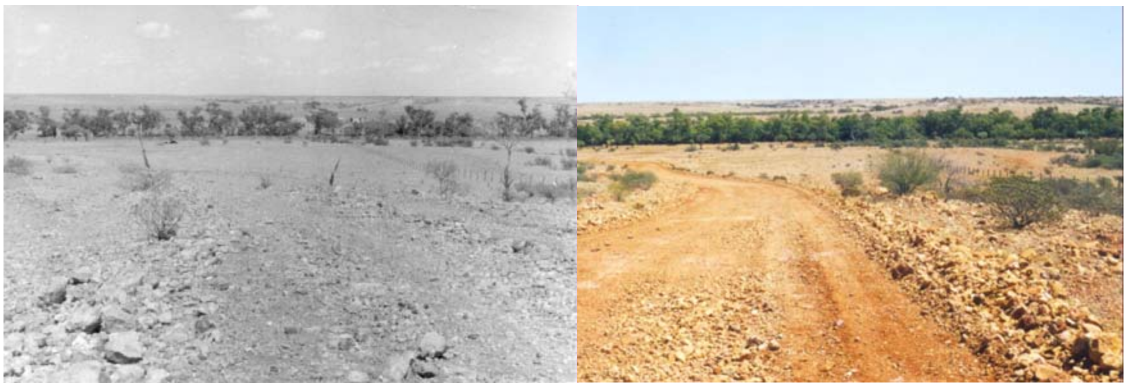


Figure 58 Left photo taken in 1965, right in 1999. Sequence shows an increase in the density of vegetation along the watercourse in the background with little change in the vegetation on the stony tableland.

Summary

The steep inverse gradient less than 1 kilometre is related to the position of the water points within the landscape - most water points are positioned in watercourses that are heavily vegetated. Thus the average cover is much higher close to water.

The short but steep gradient evident between 1 and 2 kilometres for all dates is a result of the dense gibber mantle restricting the grazing range of cattle. Grazing is confined to a smaller range around each water point in this land type compared to most other land types. Subsequently grazing intensity is much more intense, resulting in the steep gradient.

Landscape function has been affected by grazing inside of 4 kilometres from water. This effect has been quantified as a 3.8% Cover Production Loss for 2002.

3.2 SOCIO-ECONOMIC THEME

Table 49 below shows the average unimproved values of pastoral leases within the South Australian rangelands for the years available for this reporting period. Note that not all of the years are consecutive. All of the figures presented here have been CPI-adjusted and are shown as 2005 values in dollars per square kilometre.

Table 49. Unimproved pastoral land values in $ per km^2 by IBRA region for selected years.

IBRA	1998	2001	2002	2003	2004
Broken Hill Complex	126.4	144.3	164.8	177.8	200.9
Channel Country	25.2	30.0	33.9	36.3	41.2
Finke	15.2	21.2	22.8	24.5	27.8
Flinders Lofty Block	115.1	134.4	146.8	159.2	179.6
Gawler	62.6	73.8	83.8	90.6	102.2
Murray Darling Depression	127.4	144.3	163.8	176.3	198.5
Simpson Strzelecki Desert	23.2	27.6	31.5	31.7	35.8
Stony Plains	27.3	33.2	37.9	39.6	44.6

Figure 59 below shows the data presented in Table 49 as a graph. The Broken Hill Complex, the Murray Darling Depression and the Flinders Lofty Block have the highest unimproved values. These values increased by around 56% between 1998 and 2004.

At the other end of the scale, the Finke Bioregion in 1998 was considered to have an unimproved value equivalent to 12% of that of the Broken Hill Complex or the Murray Darling Depression.

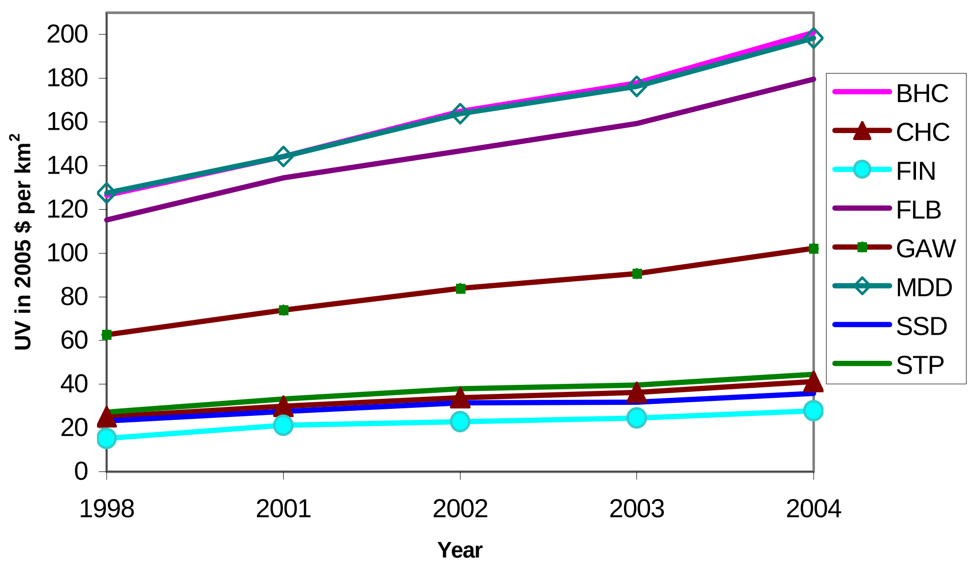


Figure 59. Graph of unimproved pastoral land values by IBRA region for selected years.

As these values are calculated from sales, some turnover is necessary to provide data. Pastoral leases generally do not have a high rate of turnover and so the figures are often calculated from only a few sales. Some of these sales may not be relevant to stations in other pats of the state.

4. DISCUSSION

With a preponderance of data informing this report derived from the administration and monitoring of pastoral activity, some important information gaps are highlighted. These are subject, temporal and spatial gaps.

Subject gaps include an absence of data with which to report upon biodiversity change. Although the bulk of the available data is derived from the monitoring of biophysical processes, these can usually only imply changes in biodiversity. For example, the percentage cover production loss (%CPL) measures can quantify change in the amount of a remotely-sensed vegetative cover index. A persistent 5% reduction in cover production (a biophysical process) over an area of 2,000 km^2 could be assumed to have negative consequences for biodiversity, e.g. the endemic fauna, but cannot be measured directly.

The temporal distribution of both the grazing gradient data and the Jessup belt transect data made reporting of change over the 1992 – 2005 period difficult in some areas. While the image dates used in the grazing gradient analyses were well matched with some significant rainfall events over the northern parts of the Stony Plains Bioregion, the southern regions had much less rainfall in the same periods. This meant that there was less opportunity to calculate %CPL values in the southern region.

Temporal gaps exist within the Jessup transect data for most of the bioregions examined. The average interval between visits for the 397 sites used in this report for the landscape function theme is 7 years. In the short term, this interval length is likely to grow, as there are another 2,200 sites with Jessup transects that have not had a second visit. In 2007, the average age of these sites was 14 years.

Unless there is external funding for field monitoring activities, as was the case with the ACRIS pilot project, the interval length is linked to South Australia's statutory pastoral lease assessment cycle. Monitoring of sites is intended to provide objective data for use in lease assessments. Most of the monitoring sites were established as part of the first iteration of the assessment program. This first round of assessment of pastoral leases was begun in 1989 and completed in December 2000. The second round of assessment is currently underway, but several years from completion. Consequently 65% of all sites have not yet had a second visit. The PLMC Act (1989) stipulates that a pastoral lease must be assessed within 14 years of the last assessment. Thus the usual monitoring of sites is dependent upon the lease assessment cycle, which can be up to 14 years in length.

Also, the existing assessment methodology does not guarantee the ongoing collection of field site data. There is no legislative imperative, nor any other binding requirement to monitor these sites. At present, only select sites are being monitored for the current round of pastoral lease assessments.

Although an extensive area of the South Australian rangelands has been represented in this report, there are substantial regions for which there is no suitable monitoring data available. These spatial gaps reflect the distribution of monitoring sites within the pastoral estate and the extent of other tenures with no data.

Some bioregions with predominantly pastoral land tenure are without sufficient biophysical information for reporting. On the eastern side, the Channel Country Bioregion and the

Simpson Strzelecki Desert Bioregion are poorly represented. Monitoring sites are sparse over extensive areas of pastoral tenure.

There are also regions of non-pastoral tenure with no available data for most themes. In the South Australian rangelands, the most notable is the Alinytjara Wilurara Natural Resource Management (NRM) Region (~280,000 km^2). This area includes the South Australia portions of the Central Ranges Bioregion (28%), the Nullarbor Bioregion (30%) and the Great Victoria Desert Bioregion (48%).

The 2000 and 2002 satellite imagery utilised by the DKCRC project for grazing gradient analysis was limited to image dates available from the Australian Greenhouse Office. This imagery covered an extensive area and was not acquired specifically for performing grazing gradient analysis. Typically, imagery is selected two to four months following significant rainfall. However, to report on grazing impacts for the DKCRC project, the decision was made to use existing imagery. A lack of suitable rainfall events restricted the area where grazing gradient analyses could be used to measure landscape function. Even so, an area of 23,000 km^2 comprising seven sub-regions could still be used in the analyses. This was in an area near the Northern Territory border where rainfall was greater and more general in extent than further south.

The availability of suitable rainfall events is a factor limiting the frequent use of the grazing gradient. However, the many benefits of its use include the potential for retrospective monitoring of any rangeland area through archived satellite images, the identification of grazing as opposed to seasonal change and the ability to quantify change through use of the percentage cover production loss index.

The grazing gradient analysis clearly shows that landscape function has been reduced at distances of up to five km from water in some areas grazed by cattle in the far north of the State. Quantification of the intensity and extent of these impacts through the use of %CPL using the 1989 data highlighted some large areas with lowered production capability. The magnitudes of these production losses were very high for some land types. For example, the %CPL for STP6 Coongra in 1989 was over 15%. Using the more recent data (2002), the degree of change was relatively minor in comparison to 1989 for most land types, although the spatial extents are still considerable. This may indicate some recovery of production capability over time. (also good rainfall over an extended time [2000 & 2001] providing opportunity for increased vegetation growth compared with the one major rainfall event in 1989)

Despite the lack of a direct measure of biodiversity, these grazing-induced changes in biophysical processes can be assumed to be having effects. Research has shown that rangeland biodiversity may be adversely affected in some habitats at any intensity of grazing (Landsberg *et al*, 2002).

For the landscape function theme, perennial plant density measurements at Jessup belt transects were available for 397 (6.87%) of the 5,779 Pastoral Program monitoring sites within the specified monitoring period. For the sustainable management theme, selection for grazed sites reduced this figure to 308 (5.33%). Of these, 211 sites were in the Gawler Bioregion. Some of the remaining bioregions had data from too few sites for reliable analysis.

Field based measurements of perennial vegetation cover alone are of limited value when reporting change. Natural fluctuations in cover levels in response to seasonal conditions occur continuously. Objective discrimination between seasonal influences from grazing is not possible without additional information. The seasonal context data provided by ACRIS allows the separation of these two primary causes of change.

Most monitoring (67% of the sites used in analyses) occurred during above average seasonal conditions. Sites monitored during these conditions are expected to show increases in density of palatable perennial species under sustainable management regimes. That 16% of these sites in the Gawler bioregion showed a reduction in density following above average seasonal quality/conditions suggests less than sustainable management and warrants further investigation. This highlights the importance of taking seasonal conditions into account when interpreting change from field data.

A major issue confronting this and previous reporting activities is the legacy system holding the Pastoral Program monitoring data. White and Gould (2002) described the state of the Pastoral Management Information System (PMIS) database as “A key impediment in undertaking the project”.

The DWLBC Arid Land Information System (ALIS) project is now underway and will replace PMIS in 2008. Information delivery will be through modern web enabled technologies. The new system will provide functionality that enables the capture, consolidation and reporting on South Australian Rangeland assets. ALIS data will include biological, physical, cadastral, tenure, and other related information. It is intended that ALIS will be able to access other government agencies and NGO datasets in real time through web services and database connections. ALIS will make access to field data and reporting of change across the pastoral lease areas of South Australia easier than through the legacy system PMIS. This should greatly improve the ease and efficiency in reporting change in the future.

The development of monitoring and evaluation programs by the two NRM Boards that have responsibility in South Australia’s rangelands may help fill some of these gaps in the future. These are the Alinytjara Wilurara NRM Board and the South Australian Arid Lands NRM Board.

5. CONCLUSIONS AND RECOMMENDATIONS

A reduction in landscape function was detected for all land types where grazing gradient was carried out. The amount of this reduction varied between the different land types in both the %CPL and in the spatial extent of the area affected. The %CPL varied from 1% (1989) and 1.5% (2002) for STP1 Mount Willoughby to 15.6% (1989) and 2.1% (2002) for STP6 Coongra. For most land types where rainfall was sufficient for analysis, the loss in cover production detected was in the order of 1-2%. Nonetheless when the area of this loss is taken into account, a considerable area was affected.

While there was variation between the results from field based monitoring data for the various regions and sub-regions, there were some common features. Most regions showed some level of deterioration in landscape function despite the monitoring occurring during above average seasonal conditions.

The 2000 and 2002 satellite imagery utilised by the DKCRC project for grazing gradient analysis was limited to image dates available from the Australian Greenhouse Office. It was also conducted over an extensive area. A targeted approach to match image dates to localised rainfall over smaller areas is likely to allow more robust analyses of change in landscape function. Reporting for approximately the same period using more appropriate dates of archived satellite imagery is still possible in the future.

The temporal distribution of the Jessup belt transect data is entirely dependent upon when the sites are re-monitored. As re-visits are linked to re-assessment under the statutory 14-year assessment cycle, reporting change for shorter intervals is problematic.

Future ACRIS reporting for South Australia will be dependent upon the availability of suitable data. Monitoring of change in the Alinytjara Wilurara NRM region will likely be from localised reporting of individual projects. It is also unlikely that the density of the site-based monitoring network established through the stations south of the dog fence by the Pastoral Program will be extended into the northern regions of the South Australian Arid Lands NRM.

Both the grazing gradient information and the bulk of the more recent Jessup belt transect data for the Gawler Bioregion are the result of funded projects (i.e. non-core monitoring activity). Thus these are opportune data. The ability of South Australia to report to ACRIS without these data is restricted. NRM regional monitoring may be a future source of data for reporting, but these systems are not yet in place. Unless ACRIS can build linkages with the NRM boards to increase the volume of available monitoring data, future reporting appears to be limited to any Pastoral Program site data generated through the statutory lease assessment process and opportune data through related projects as available.

The new Arid Lands Information System (ALIS) will greatly facilitate the reporting, storage and accessibility of South Australia's rangeland data. ALIS will enhance South Australia's ability to inform future ACRIS reporting.

The seasonal quality matrix as developed by ACRIS is a simple and powerful communication tool. It provides a concise summary of the data analysed. The process adds context about seasonal conditions essential for interpreting change in vegetation data and should be continued in future reporting.

APPENDICES

A. QUANTITATIVE (QS) AND REFERENCE (RS) SITE TYPES USED IN ANALYSES BY IBRA SUB-REGION

IBRA Sub-region	QS	RS	Total
BHC1	22		22
BHC6	5		5
CHC2	2		2
CHC4	2		2
CHC6	4		4
CHC7	2		2
FLB3	21		21
FLB5	69		69
FLB6	4	1	5
GAW1	36	3	39
GAW2	32	3	35
GAW3	17		17
GAW4	22	1	23
GAW5	33	2	35
GAW7	53		53
GAW8	7	2	9
GVD6	2		2
MDD1	3		3
MDD7	13		13
SSD5	5		5
STP1	5	1	6
STP2	5		5
STP3	18		18
STP7	2		2
Total	**384**	**13**	**397**

B. QUANTITATIVE VEGETATION MONITORING METHODS USED AT SITES BY IBRA SUB-REGION.

IBRA Sub-region	Jessup	Step-point	Jessup & Step-point	Step-point only
BHC1	22	12	12	0
BHC5	0	3	0	3
BHC6	5	5	4	1
CHC2	2	0	0	0
CHC4	2	0	0	0
CHC6	4	0	0	0
CHC7	2	0	0	0
FIN3	0	4	0	4
FLB3	21	5	1	4
FLB5	69	19	3	16
FLB6	5	16	0	16
GAW1	39	38	35	3
GAW2	35	43	29	14
GAW3	17	16	15	1
GAW4	23	19	18	1
GAW5	35	33	33	0
GAW7	53	57	47	10
GAW8	9	7	7	0
GVD6	2	2	2	0
MDD1	3	0	0	0
MDD7	13	0	0	0
SSD5	5	0	0	0
STP1	6	5	3	2
STP2	5	4	4	0
STP3	18	8	3	5
STP7	2	2	2	0
Total	**397**	**298**	**218**	**80**

C. DISTRIBUTION OF SITES USED IN ANALYSES WITHIN IBRA REGIONS, SUB-REGION AND LAND TYPE.

IBRA	IBRA code	IBRA sub-region	IBRA sub-region	Land Type	Sites
Broken Hill Complex	BHC	Barrier Range	BHC1	BHC1-Antro	1
				BHC1-Ballara	16
				BHC1-Eringa	3
				BHC1-Wompinie	2
		Telechie	BHC6	BHC6-Sandyoota	3
				BHC6-Wyambana	2
Channel Country	CHC	Sturts Stony Desert	CHC2	CHC2-Koonchera	1
				CHC2-Sturts	1
		Diamantina-Eyre	CHC4	CHC4-Diamantina	1
				CHC4-Ketietoonga	1
		Coongie	CHC6	CHC6-Cooper	4
		Lake Pure	CHC7	CHC7-Marqualpie	2
Flinders Lofty Block	FLB	Olary Spur	FLB3	FLB3-Eringa	16
				FLB3-Olary	5
		Northern Flinders	FLB5	FLB5-Alerumba	5
				FLB5-Anzac	14
				FLB5-Arrowie	4
				FLB5-Burr	3
				FLB5-Hemming	8
				FLB5-Mandarin	1
				FLB5-Morris	10
				FLB5-Paradise	1
				FLB5-Parara	6
				FLB5-Roebuck	1
				FLB5-Saltia	4
				FLB5-Stirrup Iron	4
				FLB5-Umberatana	6
				FLB5-Wertaloona	1
				FLB5-Yankaninna	1
		Wilpena	FLB6	FLB6-Burr	2
				FLB6-Hemming	1
				FLB6-Saltia	1
				FLB6-Upalinna	1

IBRA	IBRA code	IBRA sub-region	IBRA sub-region	Land Type	Sites
Gawler	GAW	Myall Plains	GAW1	GAW1-Bittali	2
				GAW1-Hesso	1
				GAW1-Jungle Dam	1
				GAW1-Pandurra	3
				GAW1-Peter Pan	2
				GAW1-Peterlumbo	3
				GAW1-Roopena	14
				GAW1-Thurlga	1
				GAW1-Yarlerberrie	7
				GAW1-Yudnapinna	5
		Gawler Volcanics	GAW2	GAW2-Ebunbanie	19
				GAW2-Eucarro	8
				GAW2-Kolendo	5
				GAW2-Peterlumbo	1
				GAW2-Yarna	2
		Gawler Lakes	GAW3	GAW3-Beacon	1
				GAW3-Bowen	1
				GAW3-Glendambo	1
				GAW3-Hesso	9
				GAW3-Roxby	2
				GAW3-Vivian	1
				GAW3-Yorkey	2
		Arcoona Plateau	GAW4	GAW4-Arcoona	16
				GAW4-Tent Hill	7
		Kingoonya	GAW5	GAW5-Christie	11
				GAW5-Gina	6
				GAW5-Glendambo	12
				GAW5-Indooroopilly	1
				GAW5-Labyrinth	3
				GAW5-Mailgate	1
				GAW5-Yarna	1
		Roxby	GAW7	GAW7-Glendambo	6
				GAW7-Phillipson	1
				GAW7-Roxby	39
				GAW7-Vivian	7
		Commonwealth	GAW8	GAW8-Christie	1
				GAW8-Commonwealth	5
				GAW8-Gina	3

IBRA	IBRA code	IBRA sub-region	IBRA sub-region	Land Type	Sites
Great Victoria Desert	GVD	Yellabinna	GVD6	GVD6-Narlaby	1
				GVD6-Wynbring	1
Murray Darling Depression	MDD	South Olary Plain	MDD1	MDD1-Bore Hole	1
				MDD1-Jack Halls	1
				MDD1-Nanyah	1
		Braemar	MDD7	MDD7-Braemar	6
				MDD7-Mutooroo	7
Simpson Strzelecki Desert	SSD	Strzelecki Desert	SSD5	SSD5-Tingana	5
Stony Plains	STP	Breakaways	STP1	STP1-Breakaway	1
				STP1-Buckshot	4
				STP1-Mudla	1
		Oodnadatta	STP2	STP2-Oodnadatta	1
				STP2-Paisley	4
		Murnpeowie	STP3	STP3-Mumpie	11
				STP3-Paradise	7
		Baltana	STP7	STP7-Oodnadatta	2

D. PLANT SPECIES REPORTED UPON FOR THE LANDSCAPE FUNCTION THEME BY REGION.

Plant species	Common name	No. of sites where rated as dominant	No. of sites where species present	% of sites where present
Barrier Range IBRA sub-region				
Atriplex vesicaria ssp.	Bladder Saltbush	11	19	39
Maireana appressa	Pale-fruit Bluebush		2	4
Maireana astrotricha	Low Bluebush	5	15	31
Maireana georgei	Satiny Bluebush	1	7	14
Maireana pyramidata	Black Bluebush		3	6
Rhagodia spinescens	Spiny Saltbush		3	6
Channel Country IBRA region				
Atriplex vesicaria ssp.	Bladder saltbush	1	1	8
Chenopodium auricomum	Queensland bluebush		4	30
Corymbia terminalis	Bloodwood	1	1	8
Enchylaena tomentosa var.	Ruby Saltbush		1	8
Eucalyptus coolabah	Coolibah	5	1	8
Maireana aphylla	Cottonbush	2	2	15
Muehlenbeckia florulenta	Lignum		3	23
Olary Spur IBRA sub-region				
Atriplex vesicaria ssp.	Bladder Saltbush	7	9	28
Maireana brevifolia	Short-leaf Bluebush		1	3
Maireana georgei	Satiny Bluebush		4	13
Maireana pyramidata	Black Bluebush	4	9	28
Maireana sedifolia	Bluebush	4	3	9
Nitraria billardierei	Nitre-bush	4	4	13
Rhagodia spinescens	Spiny Saltbush		2	6

Plant species	Common name	No. of sites where rated as dominant	No. of sites where species present	% of sites where present
Northern Flinders IBRA sub-region				
Acacia aneura	Mulga	6	2	1
Acacia rivalis	Silver Wattle	1	2	1
Acacia tetragonophylla	Dead Finish	1	1	1
Acacia victoriae ssp.	Elegant Wattle	13	8	6
Atriplex stipitata	Bitter Saltbush		1	1
Atriplex vesicaria ssp.	Bladder Saltbush	13	31	22
Dodonaea baueri	Crinkled Hop-bush		1	1
Dodonaea lobulata	Lobed-leaf Hop-bush		3	2
Enchylaena tomentosa var.	Ruby Saltbush		2	1
Eremophila freelingii	Rock Emubush		4	3
Frankenia plicata	Sea Heath	1	2	1
Frankenia serpyllifolia	Thyme Sea-heath		1	1
Maireana appressa	Pale-fruit Bluebush		1	1
Maireana astrotricha	Low Bluebush	12	33	23
Maireana georgei	Satiny Bluebush		3	2
Maireana pyramidata	Black Bluebush	2	6	4
Maireana sedifolia	Bluebush	3	5	3
Maireana tomentosa ssp. urceolata	Felty Bluebush		1	1
Maireana turbinata	Top-fruit Bluebush		1	1
Ptilotus obovatus var.	Silver Mulla Mulla		17	12
Rhagodia parabolica	Mealy Saltbush		1	1
Rhagodia spinescens	Spiny Saltbush		5	4
Rhagodia ulicina	Intricate Saltbush		1	1
Sclerostegia sp.	Samphire	1	1	1
Senna artemisioides ssp. artemisioides	Silver Senna		3	2
Senna artemisioides ssp. coriacea	Broad-leaf Desert Senna	1	1	1
Senna artemisioides ssp. filifolia	Fine-leaf Desert Senna		2	1
Westringia rigida	Stiff Westringia		1	1

Plant species	Common name	No. of sites where rated as dominant	No. of sites where species present	% of sites where present
Gawler IBRA region				
Acacia aneura	Mulga	27	3	1
Acacia ligulata	Umbrella Bush	3	2	
Acacia papyrocarpa	Western Myall	47	1	
Atriplex stipitata	Bitter Saltbush	3	12	2
Atriplex vesicaria ssp.	Bladder Saltbush	43	103	21
Casuarina pauper	Black Oak	3	1	
Cratystylis conocephala	Bluebush Daisy		6	1
Dodonaea microzyga	Brilliant Hop-bush		1	
Dodonaea viscosa ssp. angustissima	Narrow-leaf Hop-bush	9	10	2
Enchylaena tomentosa var.	Ruby Saltbush		30	6
Eremophila duttonii	Harlequin Emubush		1	
Eremophila glabra ssp.	Tar Bush		2	
Eremophila latrobei ssp.	Crimson Emubush		2	
Eremophila maculata ssp.	Spotted Emubush		1	
Eremophila rotundifolia	Round-leaf Emubush		1	
Eremophila scoparia	Broom Emubush		2	1
Eucalyptus gracilis	Yorrell	2	2	1
Frankenia serpyllifolia	Thyme Sea-heath		12	3
Gunniopsis quadrifida	Sturt's Pigface	1	1	
Lawrencia squamata	Thorny Lawrencia		2	
Lycium australe	Australian Boxthorn	1	8	2
Maireana appressa	Pale-fruit Bluebush		14	3
Maireana astrotricha	Low Bluebush	9	47	9
Maireana campanulata	Bell-fruit Bluebush		1	
Maireana erioclada	Rosy Bluebush		5	1
Maireana georgei	Satiny Bluebush		29	6
Maireana pentatropis	Erect Mallee Bluebush		5	1
Maireana pyramidata	Black Bluebush	11	28	6
Maireana sedifolia	Bluebush	26	82	16
Maireana trichoptera	Hairy-fruit Bluebush		2	
Maireana triptera	Three-wing Bluebush		7	1
Maireana turbinata	Top-fruit Bluebush		4	1
Melaleuca uncinata	Broombush		1	

Plant species	Common name	No. of sites where rated as dominant	No. of sites where species present	% of sites where present
Olearia calcarea	Crinkle-leaf Daisy-bush		1	
Olearia muelleri	Mueller's Daisy-bush		2	
Ptilotus obovatus var.	Silver Mulla Mulla		31	6
Rhagodia spinescens	Spiny Saltbush		4	1
Rhagodia ulicina	Intricate Saltbush		16	3
Sclerostegia medullosa	Samphire	2	5	1
Sclerostegia sp.	Samphire		1	
Sclerostegia tenuis	Slender Samphire	1	13	3
Senna artemisioides ssp. artemisioides	Silver Senna		1	
Senna artemisioides ssp. coriacea	Broad-leaf Desert Senna		5	1
Senna artemisioides ssp. petiolaris	Punty Bush	2	5	1
Westringia rigida	Stiff Westringia		1	

UNITS OF MEASUREMENT

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
kilometre	km	10^3 m	length
metre	m	base unit	length
minute	min	60 s	time interval
second	s	base unit	time interval
year	y	356 or 366 days	time interval
kilolitre	kL	1 m^3	volume

GLOSSARY

ACRIS. Australian Collaborative Rangeland Information System.

Arid lands. In South Australia arid lands are usually considered to be areas with an average rainfall of less than 250 mm and support pastoral activities instead of broad acre cropping.

Bioregion. Spatial unit within the Interim Biogeographic Regionalisation of Australia (IBRA).

Biological diversity (biodiversity). The variety of life forms: the different life forms including plants, animals and micro-organisms, the genes they contain and the ecosystems they form. It is usually considered at three levels — genetic diversity, species diversity and ecosystem diversity.

CPL. Also %CPL. Percentage Cover Production Loss. Method of quantifying the amount of potential cover production lost through land degradation by grazing.

DKCRC. Desert Knowledge Cooperative Research Centre.

DWLBC. Department of Water, Land and Biodiversity Conservation. Government of South Australia.

Ecology. The study of the relationships between living organisms and their environment.

Ecosystem. Any system in which there is an interdependence upon and interaction between living organisms and their immediate physical, chemical and biological environment.

Forage accessibility. The degree to which edible pasture that can be reached by grazing stock.

Grazing gradient. A remote sensing method that is used to detect patterns of vegetation cover change with increasing distance from watering points.

IBRA. Interim Biogeographic Regionalisation of Australia.

Jessup transect. A standardized belt-transect method for measuring the density of vegetation used by the South Australian Pastoral Program and named for Fred Jessup who developed the initial version.

Land type. Spatial unit within South Australian land system and revised IBRA sub-region mapping.

LFA. Landscape Function Analysis, a land monitoring technique measures the ability of a landscape to trap and store water and nutrients

Natural Resources. Soil; water resources; geological features and landscapes; native vegetation, native animals and other native organisms; ecosystems.

Pasture. Grassland used for the production of grazing animals such as sheep and cattle.

Patchiness. The degree of heterogeneity within a landscape, in particular a reference to the ratio of water and nutrient sinks (patches) to other parts of the landscape.

Percentile. A way of describing sets of data by ranking the data set and establishing the value for each percentage of the total number of data records. The 90th percentile of the distribution is the value such that 90% of the observations fall at or below it.

Plant density. The concentration of plants within an area in relation to its size.

SILO. Meteorological data produced and supplied by the Australian Bureau of Meteorology. Usually delivered by internet.

Sub-region. Spatial unit within the Interim Biogeographic Regionalisation of Australia (IBRA), a subset of a *Bioregion*.

Tercile. A way of describing sets of data by partitioning the data into three groups, each containing one-third of the total number of observations.

PIRSA. (Department of) Primary Industries and Resources South Australia.

Precautionary principle. Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

Woody shrub. A common term for unpalatable shrubs that invade and colonise degraded areas of land.

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