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Report to the Commissioner of Soil and Land Conservation on the trend of the Western Australian pastoral resource base 2014

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Summary

This report provides a regional overview of the trend in the pastoral rangelands of Western Australia, based on data from the Bureau of Meteorology, the *Annual return of livestock and improvements* (submitted annually by pastoral lessees) and the Western Australian Rangeland Monitoring System (WARMS), for which data are available for over 20 years The report provides a context for assessment of the range condition and trend of individual pastoral leases within the various regions of the state, as well as providing a current assessment of the status of each of the regions' rangelands, and the drivers (both seasonal and managerial) affecting this status and its trend Such information allows assessment of the environmental status within the pastoral rangelands, and identifies differences among regions in that status

The 2014 report updates changes in the Western Australian pastoral rangelands at the Land Conservation District (LCD) scale, providing information on seasonal quality, stock numbers and changes in the density/frequency of perennial shrubs and grasses This report includes the most recently collected data where sufficient sites in an LCD have been reassessed

Key Points

- Seasonal conditions were generally favourable in the Kimberley and for grassland sites south of Kimberley during 2013 (although there were some regional differences) However, 36% of WARMS sites in the Southern Rangelands (in contrast to 77% in 2012) were assessed as receiving below average seasonal conditions Recent years have illustrated the extreme climate variability of the Southern Rangelands Such inter-annual variability places restrictions on management to avoid overgrazing

- Stock densities remain high in Kimberley rangelands While the run of favourable seasons supports this, the risk of overgrazing is high, if seasons deteriorate

- The frequency of perennial grasses (both desirable and undesirable grasses combined) remains high in all Kimberley LCDs, although the increase was more variable in both the Broome and the North Kimberley LCDs

- A high proportion of reported cattle numbers from leases with grassland sites south of the Kimberley remain above Present Carrying Capacity (Present CC) Desirable grass frequency has generally declined in recent samplings, and recent data for Ashburton and De Grey LCD confirm this trend, although the reverse was recorded for Roebourne LCD Substantial changes in the composition and productivity of vegetation are developing on some leases

- Stock numbers have varied across the shrublands over the past 10 years Reported stock numbers are generally close to or below the Present CC in all LCDs, except for Wiluna and Upper Gascoyne LCDs However, there was considerable variation at the individual lease level, with declines and increases recorded in all LCDs

- Shrub numbers have declined at a high proportion of WARMS sites in the Southern Rangelands between Epoch 3 (2005–10) and Epoch 4 (2010–14), with declines even at sites with above average seasonal conditions This suggests the decline is not caused by season alone, but that excessive grazing pressure may also have contributed

1 Introduction

1.1 Objectives of the information provided

Vegetation everywhere changes in response to many factors Using a variety of information sources (objective information from rangeland monitoring, information provided by pastoral lessees as to stock numbers, seasonal assessments etc) this report provides a regional overview of the trend (the direction of change in range condition) in the pastoral rangelands of Western Australia and information on those processes driving this trend It provides data and assessments at the Land Conservation District (LCD) level, aggregated into three regions (the Kimberley, grasslands south of the Kimberley (essentially most of the Pilbara) and the Southern Rangelands (or shrublands))

While not providing information at the individual pastoral lease level, this report

- Provides information on the status and trend of various regions of Western Australia for sustainable pastoralism and the data used to develop assessment of trend,
- Assists in understanding the changes occurring, provides information on their scale, and attempts to separate the effects of management from changes that cannot be controlled
- Provides the framework and context within which to register and assess information obtained by range inventories on the basic status of existing vegetation of individual pastoral leases, and to gauge the impact of changes or range trend on the carrying capacity identified either through monitoring or rangeland condition survey
- Assists in identifying drivers of change in range land condition and hence potential land management or policy responses to ensure sustainable land use

1.2 The Western Australian pastoral rangelands

Western Australia's rangelands cover 87% of the state (all but the south-west) Pastoral leases, used for grazing livestock on native vegetation, cover 35% (874 000 km^2) of the rangelands, the balance consists of Unallocated Crown Land (UCL) and land vested for conservation and indigenous purposes There are currently 453 registered pastoral stations (comprised of 508 pastoral leases), 152 stations in the Northern Region (Kimberley and Pilbara – 93 in the Kimberley and the remainder in the Pilbara), 292 stations in the Southern Region, and nine stations in the South West Land Division, which are usually grouped with the Southern Region Ownership is variable, ranging from large corporate conglomerates, private companies, family operations, and indigenous organisations and, particularly in the Pilbara and Goldfields, mining companies

In the Pilbara, vegetation gradually changes from grasslands common to the Kimberley (hummock, mainly spinifex, or tussock grasses) to a shrub-dominated understorey (a mix of semi-arid mulga, spinifex and saltbush/bluebush vegetation communities) common in the south Consequently, range condition assessment in the Kimberley and much of the Pilbara is based on the frequency of perennial grasses, and in the Southern Region (also referred to as shrublands) it is determined by the density of perennial shrub species

1.3 Data sources and information provided

This report provides information on seasonal conditions, and information provided by the Western Australian Rangeland Monitoring System (WARMS), the PLB's *Annual Returns* database and the Bureau of Meteorology (BoM)

Data are provided at the LCD scale Pastoral (Rangelands) LCDs, as with all LCDs, are constituted under section 22(1) of the *Soil and Land Conservation Act,* and are composed of

pastoral leasehold land, defined conservation areas (which may have formed part of the pastoral estate prior to declaration as conservation areas) and UCL There are 27 LCDs in the WA rangelands (Figure 1 and Table 1) This report deals only with that proportion of each LCD that is or was pastoral land, and does not relate to UCL

The Northern Rangelands (Kimberley and Pilbara) encompasses the Broome, Derby-West Kimberley, Halls Creek-East Kimberley and North Kimberley LCDs in Kimberley and Ashburton, De Grey, East Pilbara and Roebourne in the Pilbara (Figure 1) Pilbara LCDs generally have a reasonably uniform number of leases in each LCD, but, in the Kimberley, the two major catchments of the Ord and the Fitzroy Rivers contain the majority of pastoral leases

This report considers the Southern Rangelands to be the southern pastoral zone (south of the Pilbara) between the South-West Agricultural Area and the arid interior, with a boundary delineated by LCD It includes the Gascoyne, Murchison, Goldfields and Nullarbor Regions There are 19 LCDs in the Southern Rangelands (Figure 1)

Plant Population Data

The *Western Australian Rangeland Monitoring System* (WARMS) was established in its current form in the early 1990s WARMS provides objective (numerical) data on change in the numbers of plants at sites throughout the pastoral rangelands WARMS reports at the vegetation type or regional scale, not the individual station scale WARMS consists of a set of fixed, ground-based sites, located on representative areas of pastoral land, and most stations have at least one WARMS site On average there are about three WARMS sites per station

WARMS site installation began in 1994, with final sites installed in 1999 There are currently 1622 WARMS sites, 633 grassland sites throughout the Kimberley, Pilbara and some areas south of the Pilbara, and 989 shrubland sites mostly south of the Pilbara Grassland sites are reassessed every 3 years and shrubland sites every 5 years Each re-sampling is referred to as an *Assessment,* and all sites are assessed during an *Epoch.* Comparison between assessments is defined as a *Cycle.*

The sixth sampling (Assessment 6) of the grassland sites was completed in 2011

The most recent sampling of shrubland sites (Assessment 3) was completed in 2010 (Table 2 a and b)

Livestock Numbers

All pastoral lessees in WA submit an *Annual return of livestock and improvements* to the PLB, providing, among other information, an estimate of the number of stock held on the lease, defined by specific categories This information is made available to the Department of Agriculture and Food Western Australia (DAFWA) for analysis and interpretation

Table 1 Western Australian pastoral Land Conservation Districts (LCDs)

LCD NUMBER	LCD	LCD CODE	LCD area (ha)	Pastoral stations	% of LCD as pastoral lease
1	North Kimberley	NTK	11 276 364	14	33
2	Halls Creek East Kimberley	HAL	8 753 170	36	95
3	Derby West Kimberley	DWK	7 518 115	32	98
4	Broome	BRM	2 582 365	9	63
5	De Grey	DEG	5 082 429	15	76
6	Roebourne	ROE	5 177 240	18	59
7	East Pilbara	EAP	4 831 201	13	69
8	Ashburton	ASH	6 152 959	16	62
9	Gascoyne Ashburton Headwaters	GAH	6 906 425	16	72
10	Upper Gascoyne	UPG	4 181 585	18	78
11	Wiluna	WIL	33 705 599	18	13
12	Lyndon	LYN	3 715 081	21	90
13	Gascoyne Wooramel	GAW	1 653 843	16	117 *
14	Shark Bay	SBY	2 667 947	13	56
15	Murchison	MUR	4 475 451	26	93
16	Meekatharra	MEK	3 211 619	20	112
17	Cue	CUE	1 257 263	8	71
18	Mount Magnet	MTM	1 223 568	17	135 *
19	Sandstone	SAN	3 330 243	12	72
20	Yalgoo	YAL	3 020 649	19	81
21	Mount Marshall	MML	1 017 906	2	28
22	Binnu	BIN	1 216 520	5	17
23	Perenjori	PER	782 248	3	24
24	North-eastern Goldfields	NEG	3 936 601	29	161 *
25	Kalgoorlie	KAL	6 092 703	22	73
26	Yilgarn	YLG	3 057 623	6	10
27	Nullarbor Eyre Highway	NUE	6 247 761	20	97

* Some parts or all of several stations are not aligned (or incorporated) with a particular LCD However, for this report, they have been associated with the most relevant LCD Therefore, for some LCDs the station area can exceed the registered LCD area

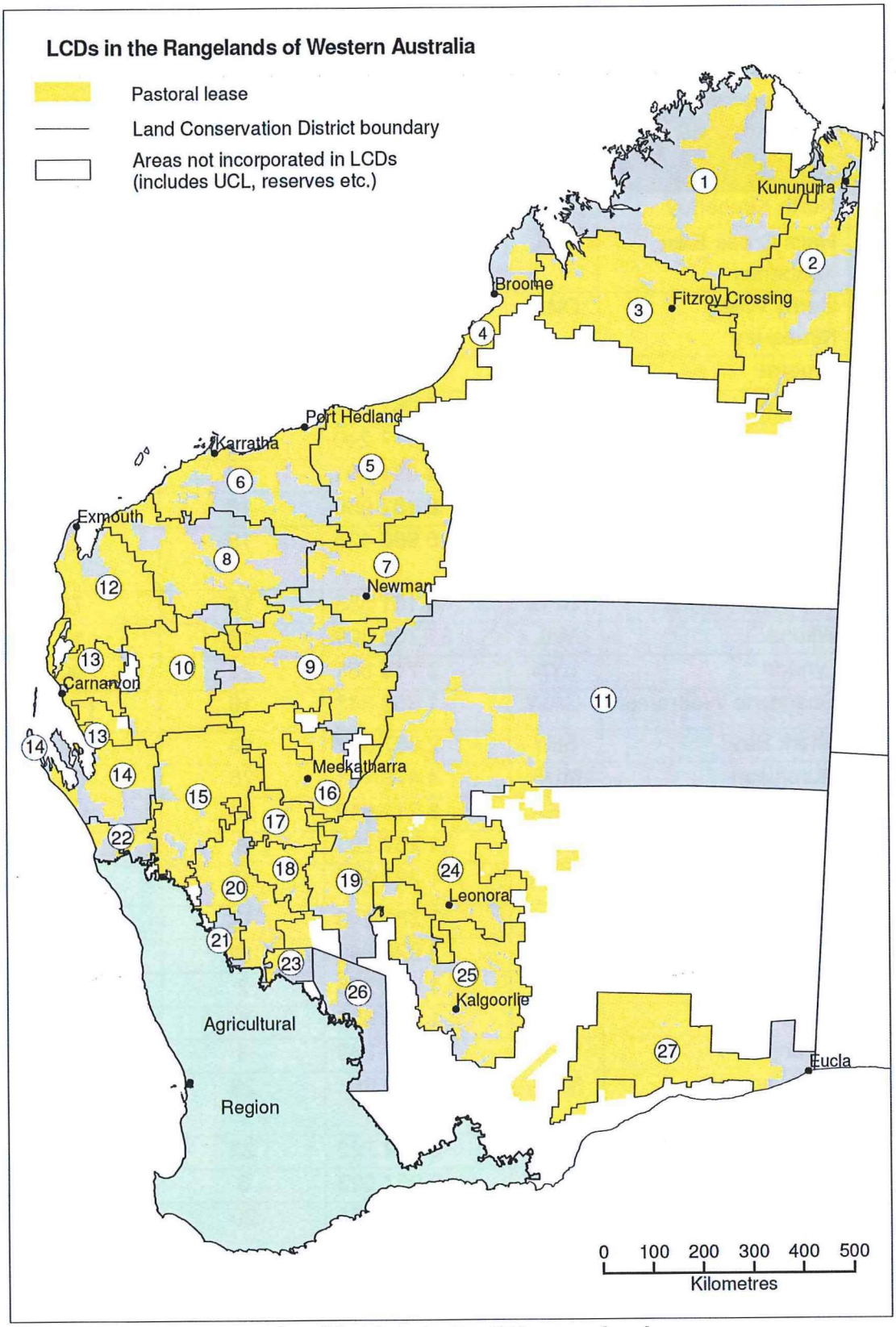


Figure 1 **Land Conservation Districts in the WA rangelands**

Table 2 (a). Sampling periods, Epochs and Cycles, WARMS grassland sites.

Grasslands

Assessment	Epoch	Years	Cycle	
First	1	1994 - 1996		
Second	2	1997 - 1999	1	Epoch 1 to Epoch 2
Third	3	2000 – 2002	2	Epoch 2 to Epoch 3
Fourth	4	2003 - 2005	3	Epoch 3 to Epoch 4
Fifth	5	2006 - 2008	4	Epoch 4 to Epoch 5
Sixth	6	2009 - 2011	5	Epoch 5 to Epoch 6
Seventh	7	2012 - 2014	6	Epoch 6 to Epoch 7

Table 2 (b). Sampling periods, Epochs and Cycles, WARMS shrubland sites.

Shrublands

Assessment	Epoch	Years	Cycle	
First	1	1994 - 1999		
Second	2	1999 – 2006*	1	Epoch 1 to Epoch 2
Third	3	2005 – 2011*	2	Epoch 2 to Epoch 3
Fourth	4	2010 - 2015*	3	Epoch 3 to Epoch 4

* **Not** all Shrubland sites were installed prior to the end of Epoch 1 Therefore, sites installed in 1994 were re-assessed (the second assessment) prior to the first assessment of other Shrubland sites

2 Seasonal conditions

2.1 Annual rainfall

Rainfall during 2013, particularly across large parts of northern WA, was above average (Figures 2 and 3) Record rainfall was reported at sites in the Kimberley and Pilbara

Average to much above average rainfalls were reported in the West Kimberley, East Pilbara, and the Northern Interior, largely as a result of cyclone *Rusty* in late February, along with significant unseasonal heavy rainfall in May and June Pardoo Station in the Pilbara recorded its highest annual rainfall in a 98 year recording history Port Hedland airport and Cape Leveque in the Kimberley also reported their wettest year on record In contrast, the West Gascoyne recorded below to very much below average rainfall, mainly as a result of a lack of winter rainfall

2.2 Autumn/spring 2013

Autumn/spring rainfall was generally average to above average across WA, except for areas on the central west coast and associated hinterland (Figure 4)

Autumn rainfall was above average across much of the east and south A particulary wet season was observed in the southern Goldfields and western Eucla, some sites recording the wettest autumn on record The remainder of WA was generally near average, apart from

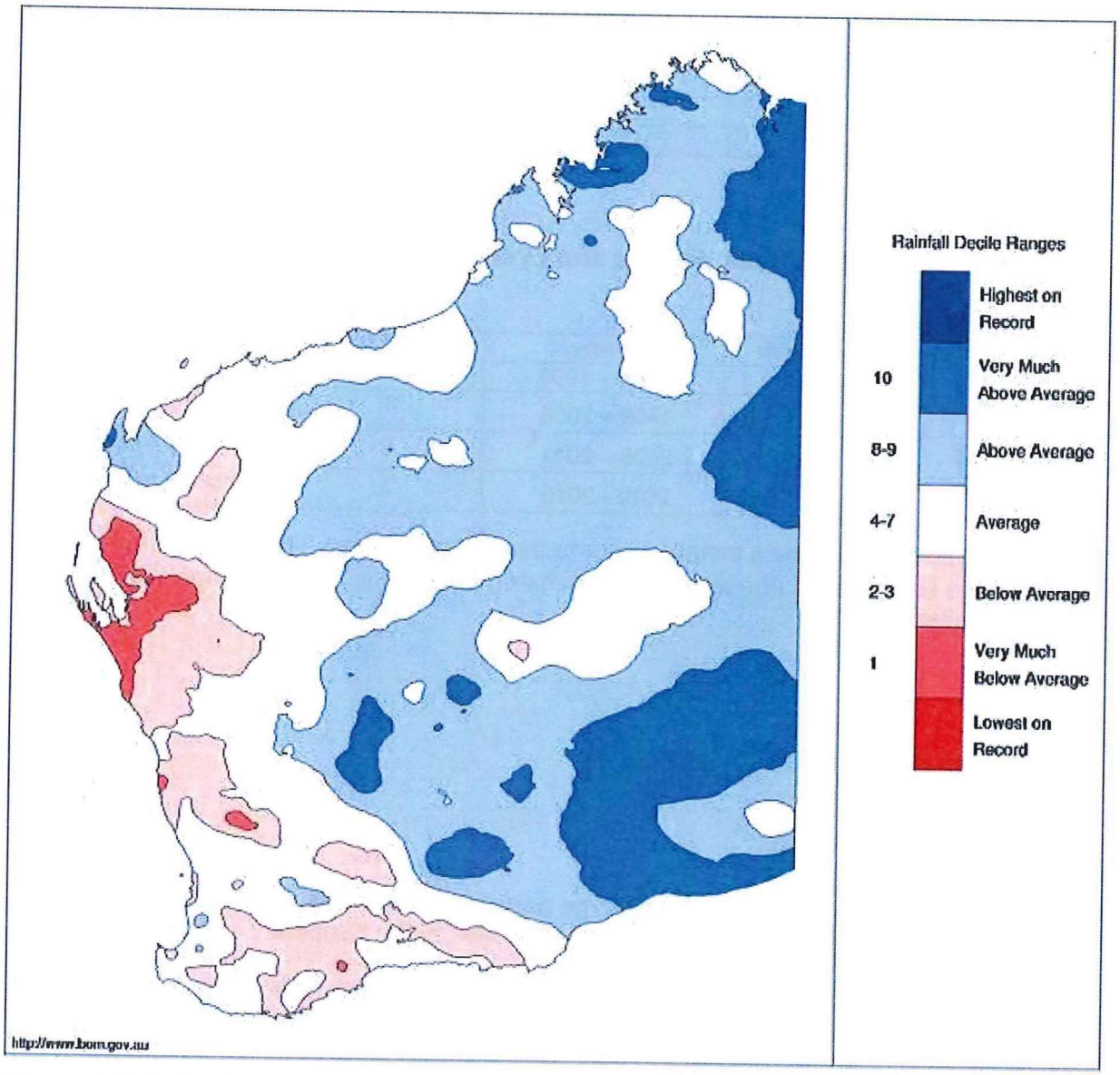


Figure 2 Rainfall deciles for July 2013 to June 2014. Source: BoM.

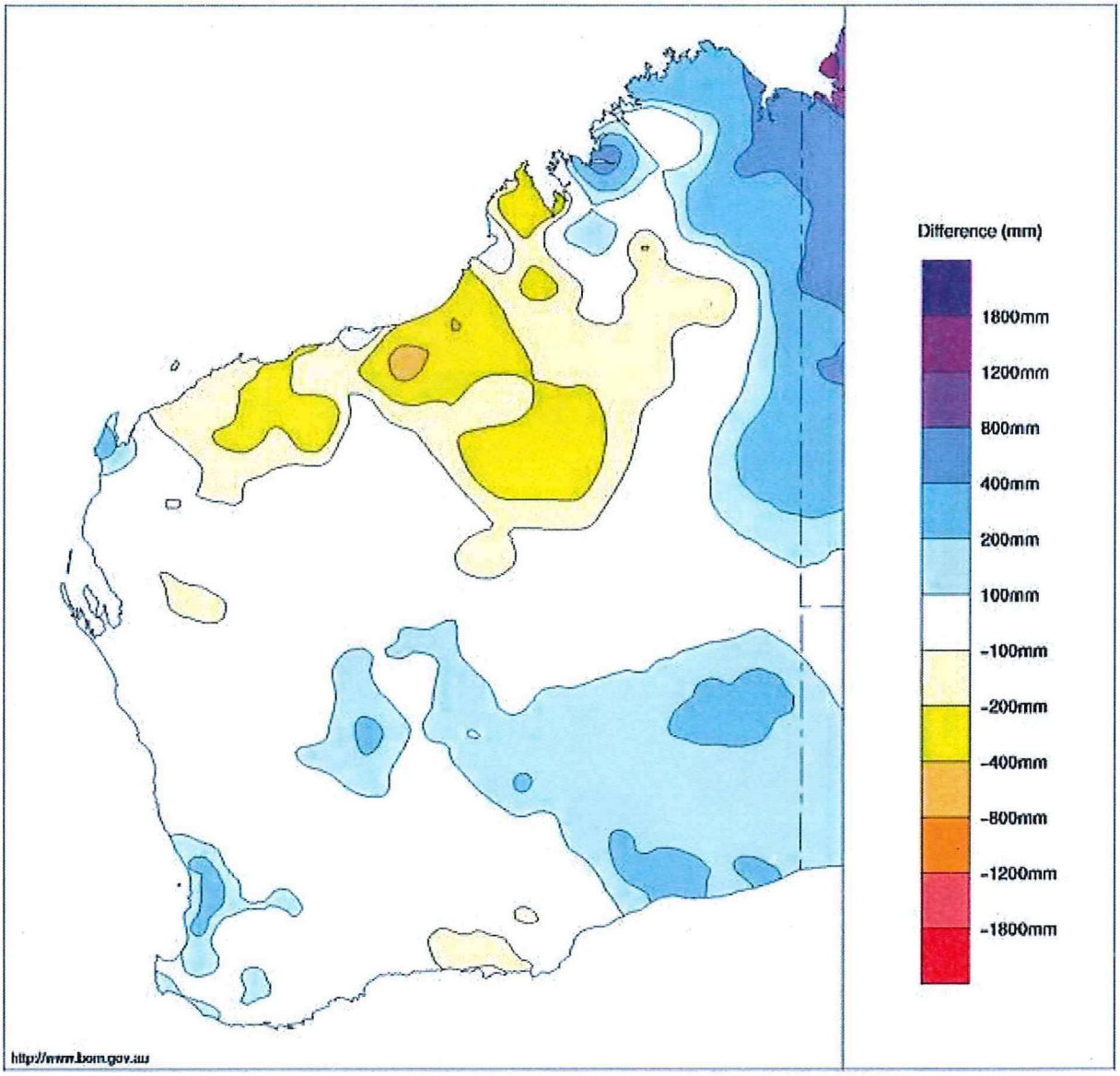


Figure 3 Inter-annual rainfall variations, 2013/14 versus 2012/13. Source: BoM.

Blue and purple shades indicate areas which have been wetter this year. Yellow and red shades indicate areas which have been drier this year.

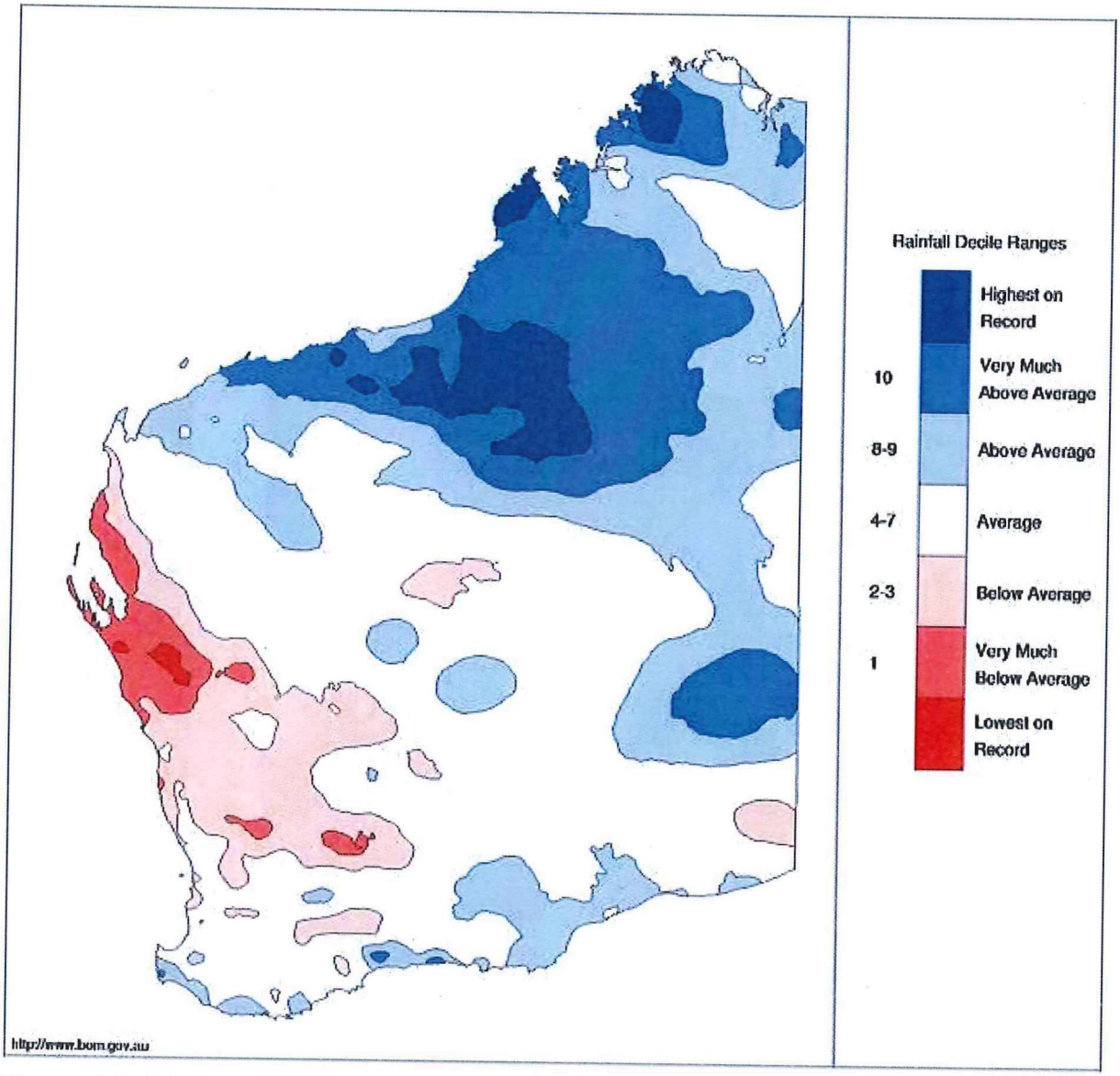


Figure 4 Rainfall deciles for April to September 2013 (winter rain). Source: BoM.

patches of below average rainfall in the Pilbara and Gascoyne Numerous unseasonal rainfall events occurred across northern WA in May

Winter rainfall was below to very much below average across the western and southern Gascoyne, the southern Goldfields, and parts of the Eucla Above to very much above average winter rainfall was reported in much of the Pilbara, northeast Gascoyne, large parts of the Kimberley, and most of the Northern and Southern Interior, with Port Hedland and Karratha both recording their wettest winter on record

Spring rainfall was above to very much above average in much of the Goldfields, Pilbara, Kimberley and adjacent Northern Interior Cygnet Bay in the Kimberley recorded its wettest spring, mainly due to tropical cyclone *Alessia* in late November Parts of the far east inland Pilbara, western Northern and Southern Interior, and north Gascoyne coast saw below to very much below average spring rainfall

2.3 Summer/autumn 2013 - 2014

Rainfall during summer 2013-14 was above to very much above average in much of northern and central WA, with areas of highest on record in the East Kimberley and Eucla (Figure 5) In contrast, the southwest saw below to very much below average summer rainfall, with some sites reporting no rainfall during the season, and ranking as one of the driest summers on record for some locations near the west coast

Rainfall for WA as a whole was near average in autumn 2014 due to a dry March and a wet April and May A mid-level trough combined with ex-tropical cyclone *Jack* in late April to produce widespread moderate to heavy rainfall in the west Pilbara, Gascoyne, Central West Flash flooding was reported on the North West Cape as Exmouth recorded 206 mm on the 27th, and partly as a result of this event and a second heavy rainfall event in the first half of May, Learmonth recorded its wettest autumn on record

2.4 General comments on recent and longer-term rainfall

In general terms, the calculated seasonal greenness response (based on MODIS NDVI) for the last decade (2005 to July 2014 - Appendix 1) shows the Kimberley has had an average or above average response for each year, with the Pilbara more variable, with a noticeably poor response in 2005 and 2010 The Pilbara also shows a variation between east and west in some years The Southern Rangelands have been variable In 2006 and 2011 response was generally average or above average across the region However, for much of the region there have rarely been consecutive years of average or above average response

While rainfall deciles indicate an average to above average annual rainfall throughout the rangelands (except in the coastal zone south of Carnarvon – Figure 2), Figures 4 and 5 (seasonal rather than annual conditions) paint a bleaker picture for parts of the state, and illustrate the potential misinterpretations associated with annual rainfall data Winter (April to September) rainfall is vital for the germination, establishment and growth of shrub species in the Southern Rangelands The winter rainfall in 2013 was average to below average throughout this Southern Rangelands, with some areas very much below average This would have increased stress and fragility to grazing for existing plants, and potentially severely restricted growth and development of juvenile shrubs Conversely, the summer was generally average to above average, except for isolated areas in the west This variation highlights the importance of seasonality of rainfall and the basis for the seasonal quality assessments discussed in sections 3 1 1, 3 2 1 and 3 3 1

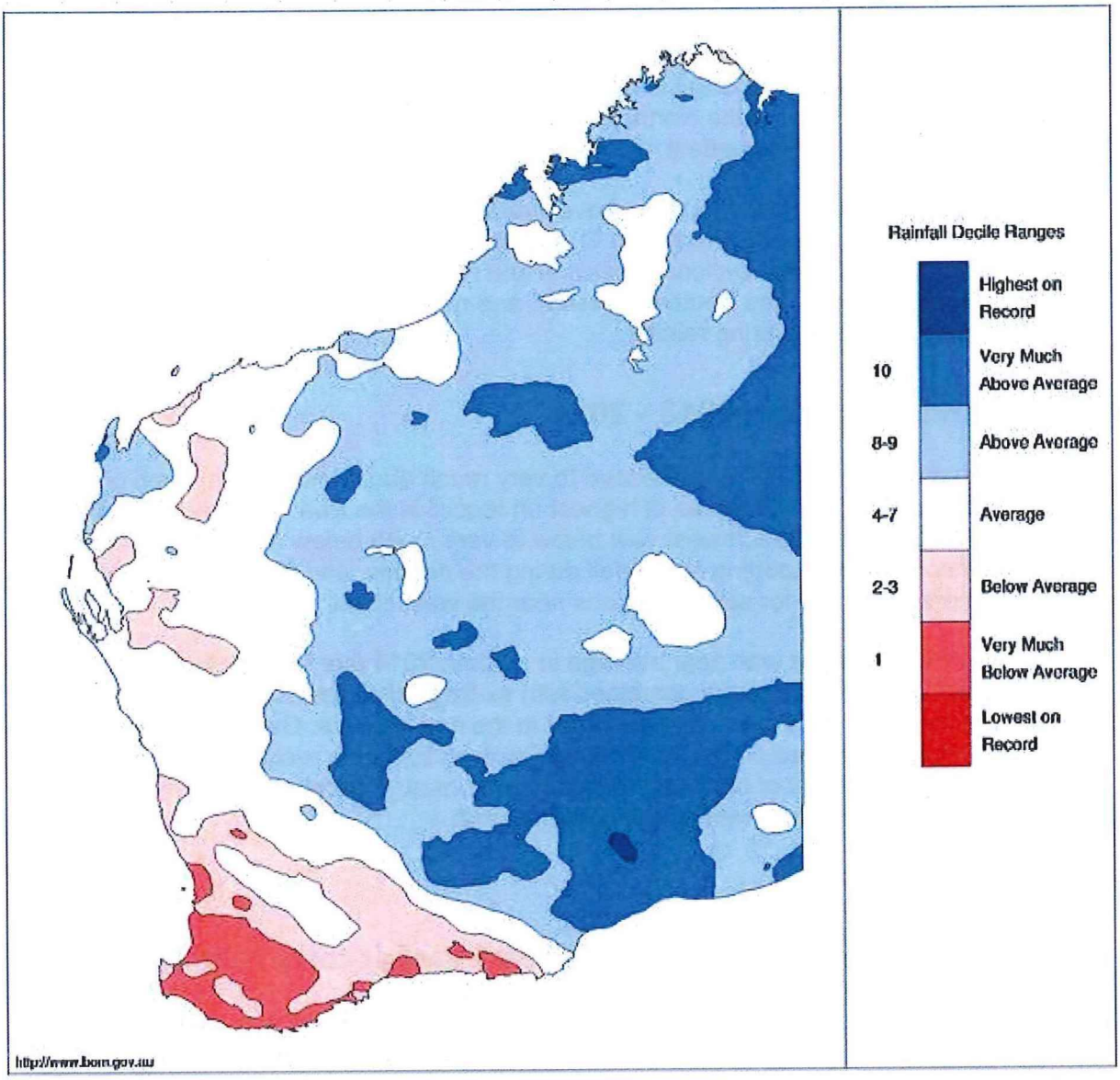


Figure 5 Rainfall deciles for November 2013 to April 2014 (summer rain). Source: BoM.

3 Regional rangeland assessments

3.1 Grasslands in the Kimberley LCDs

3.1.1 Seasonal quality

At each WARMS site, seasonal quality was estimated for each reassessment period (Epoch) or each year. Seasonal quality describes the relative value of recent climate (principally interpolated rainfall from the patch point dataset) with respect to biological functioning. Biological functioning broadly means vegetation growth as a basic resource for both livestock (forage) and fauna (food and shelter), and for soil protection.

Seasonal quality is calculated from interpolated long term rainfall data at the specific WARMS site location. In the Northern Rangelands summer rainfall is considered more effective for vegetation growth and is the primary seasonal driver. In contrast, winter rainfall is considered more effective for vegetation growth in the Southern Rangelands.

Assessed seasonal quality was generally above average at WARMS sites in Kimberley LCDs over the past 20 years, with the majority of WARMS sites classified as above average or average. As expected from Section 2 data, and based on interpolated rainfall data of WARMS sites, all Kimberley LCDs received above, or close to, the average of their long-term summer rainfall for 2013/14 (Table 3, Figures 5 and 6).

Table 3 **Seasonal quality 2013/14 at WARMS sites in Kimberley LCDs.**

	Seasonal quality				
LCD	Above average %	Average %	Below average %	Proportion of long-term summer rainfall %	Average long-term (114 years) summer rainfall mm
Broome	100	0	0	137	463
Derby West Kimberley	48	52	0	131	507
Halls Creek East Kimberley	79	21	0	136	536
North Kimberley	85	15	0	124	787
Kimberley LCDs overall	**67**	**33**	**0**		

3.1.2 Perennial grass frequency

In grasslands, DAFWA assesses trend using the frequency (presence or absence) of perennial grasses. As perennial grass frequency declines (replaced by either annual species or bare ground), rangeland stability and resilience declines. A subset of perennial grasses are those species (productive and palatable) considered desirable for animal production. As the frequency of desirable perennial grasses declines, livestock carrying capacities and animal production also decline.

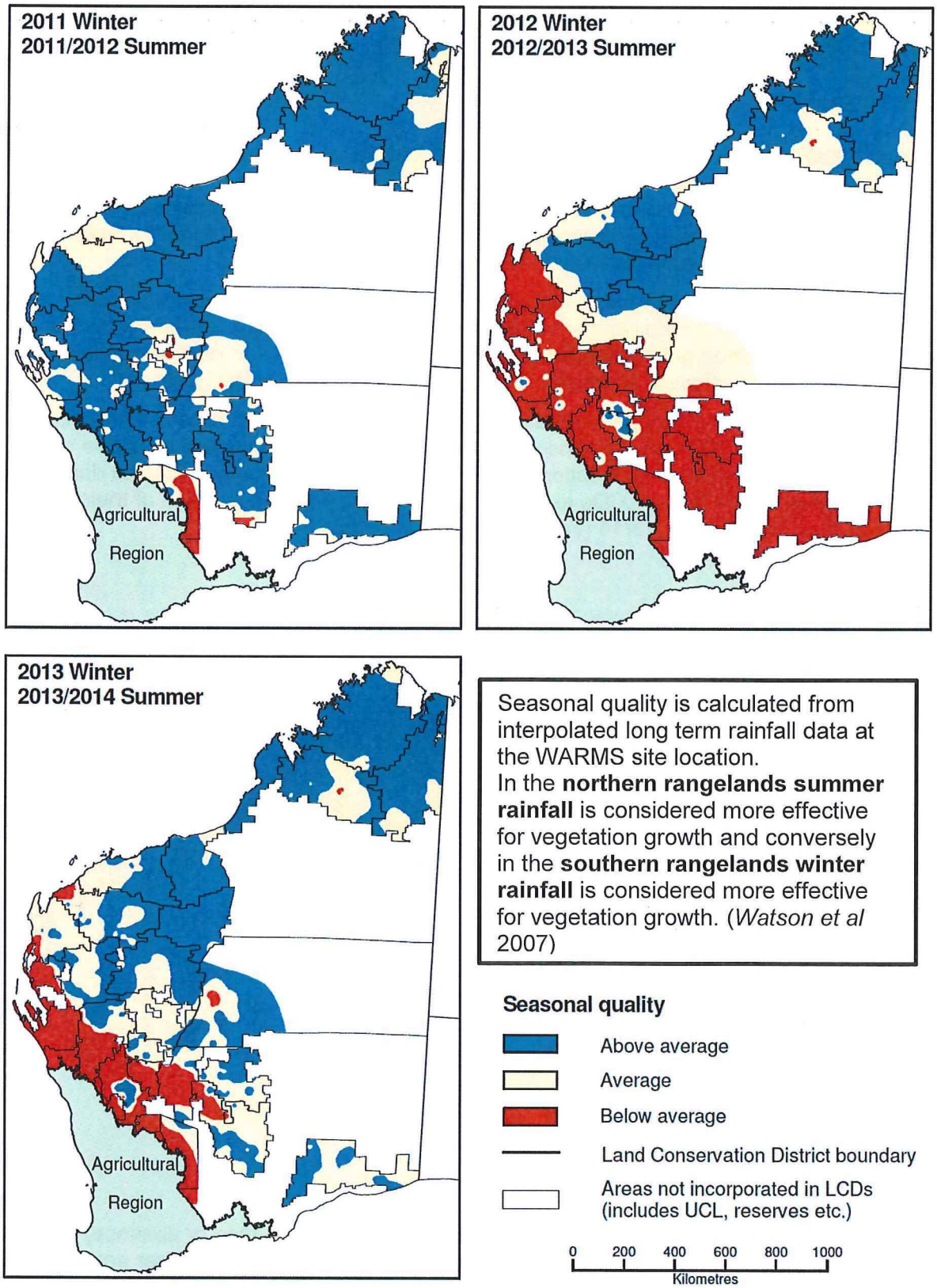


Figure 6. Seasonal quality assessed for rangeland LCDs.

Perennial grass frequency (of both all perennial grasses and desirable grasses alone) recorded at WARMS sites was generally stable or increased in all Kimberley LCDs from Epochs 1 to 5 and into Epoch 6, although change was more variable in Broome and North Kimberley LCDs (Figure 7 (all perennial grass frequency) and Table 4 (changes in desirable grass frequency)). Frequency of all perennial grasses is above that recorded in the initial sampling in Epoch 1, except for the Broome LCD, where frequencies recorded during initial sampling (1994 to 1996) were particularly high (Figure 7). This suggests a steady increase in rangeland stability over time.

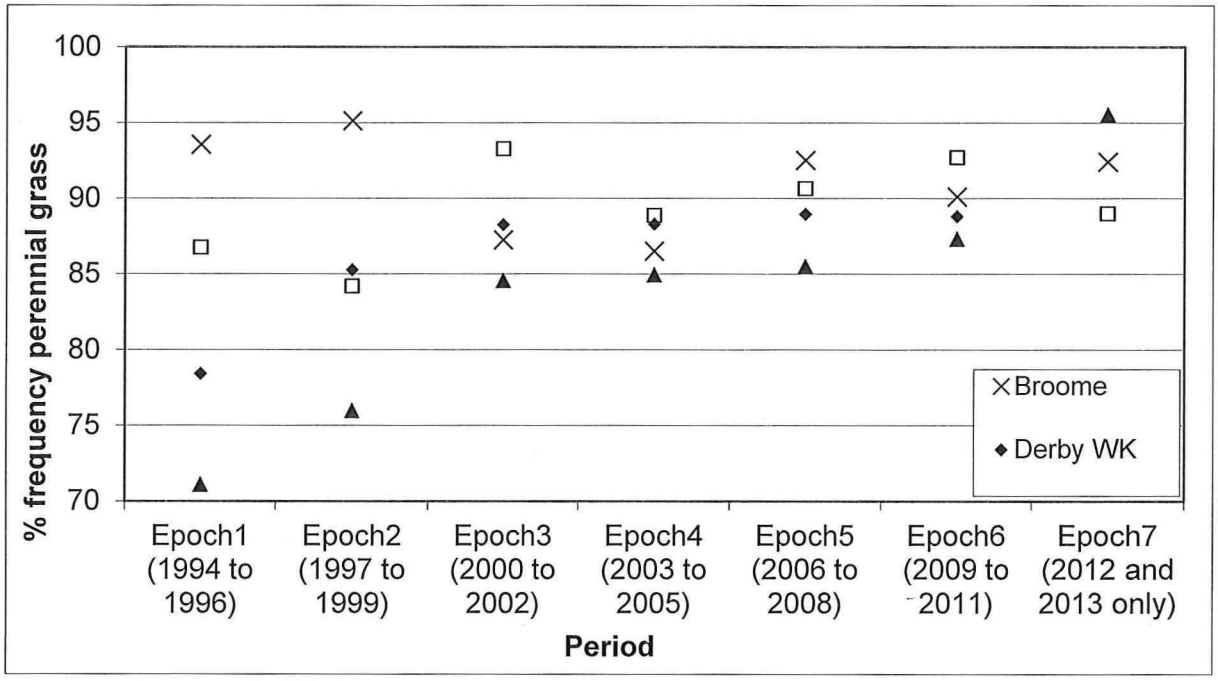


Figure 7 Mean perennial grass frequencies (all grasses) in the current cycle, Kimberley LCDs, Epoch 1 to Epoch 7. (Note: Halls Creek LCD has only 75% of sites assessed).

Table 4 **Change in frequency of desirable perennial grasses, Kimberley LCDs.**

LCD	Cycle 1 E1 to E2 1994-99	Cycle 2 E2 to E3 1997-2002	Cycle 3 E3 to E4 2000-05	Cycle 4 E4 to E5 2003-08	Cycle 5 E5 to E6 2006-11	Cycle 6 E6 to E7 2012-14
Broome	-6.0%	-0.7%	-1.7%	2.7%	-2.9%	1.9%
Derby West Kimberley	7.1%	6.9%	-2.3%	-1.1%	0.0%	– *
Halls Creek East Kimberley	0.2%	12.7%	-2.5%	4.5%	1.3%	6.2%**
North Kimberley	-2.9%	12.4%	-6.5%	1.7%	3.5%	-1.5%

* insufficient WARMS sites assessed to December 2013

** based on 75% of WARMS sites assessed

3.1.3 Stock densities

Relative stock densities between LCDs reflect both the different carrying capacities of LCDs and the degree of individual lease development Grazing capacity is defined by DAFWA as a Present Carrying Capacity (Present CC) The Present CC is the Potential Carrying Capacity (Potential CC - the inherent capacity of the rangeland to run stock when the rangeland is in good condition, all areas of the lease are accessible to domestic stock and seasonal conditions are average), discounted (if appropriate) for the current range condition of the lease in question Neither the Potential nor Present CC values are defined maximum stock numbers, lessees can carry stock numbers in excess of these figures, and would be expected to do so during favourable seasons Conversely, during unfavourable seasons stock numbers would be expected to be substantially below these values

Reported stock numbers (from the *Annual return of livestock and improvements* provided by each pastoral lease) show that, although variable, stock densities (cattle units per square kilometre - cu/km^2) generally rose in Kimberley since WARMS sampling began, except for Halls Creek East Kimberley LCD (Figure 8) Reported 2013 figures indicate stable stock numbers except Derby West Kimberley, where there was a rise As a point of contrast to current stocking levels, estimated Present CC for the Kimberley are 4 1 cu/km^2 in Broome LCD, 3 1 cu/km^2 in Derby West Kimberley LCD, 2 5 cu/km^2 in Halls Creek East Kimberley LCD and 2 2 cu/km^2 in North Kimberley LCD These reported figures indicate that Derby West Kimberley LCD is running stock numbers in excess of the Present CC, and that this is being sustained by the long run of favourable seasons

LCD values are an average, and stock densities vary significantly between leases with the one LCD Some Kimberley leases are virtually destocked Lease carrying capacities per unit area also vary widely Of the leases reporting stock numbers in 2013, numbers were above the Present CC in 33% of Broome LCD leases, 87% of Derby West Kimberley LCD leases (including one lease stocked to over 510% of the Present CC), 53% of Halls Creek East Kimberley LCD leases and 42% of North Kimberley LCD leases Finally, with the cessation of rangeland traversing by DAFWA, data on current range condition are no more recent than 2008 at best Therefore, comparisons between an estimated Present CC and reported stock numbers should be treated with caution

3.1.4 Interaction of stock numbers and desirable plant counts

The relationship between reported stock numbers and changes in recorded frequencies of desirable grasses are presented in Figure 9 Desirable grass frequency is represented horizontally, either increasing (to the right) or decreasing (to the left) compared with the previous WARMS sampling (Epoch 5 versus Epoch 6, or Epoch 6 versus Epoch 7 for those LCDs where a complete set of data for the most recent assessment are available)

Reported stock numbers relative to the Present CC of leases within each LCD are represented vertically on a relative scale, with reported stock numbers above the Present CC above the horizontal axis, and less than the Present CC below the horizontal axis Present CC has been averaged for stations within each LCD Note that not all stations have a calculated Present CC LCDs with average reported stock numbers above the average Present CC are in the upper half of the figure, and those with average stock numbers below the average Present CC are in the lower half of the figure

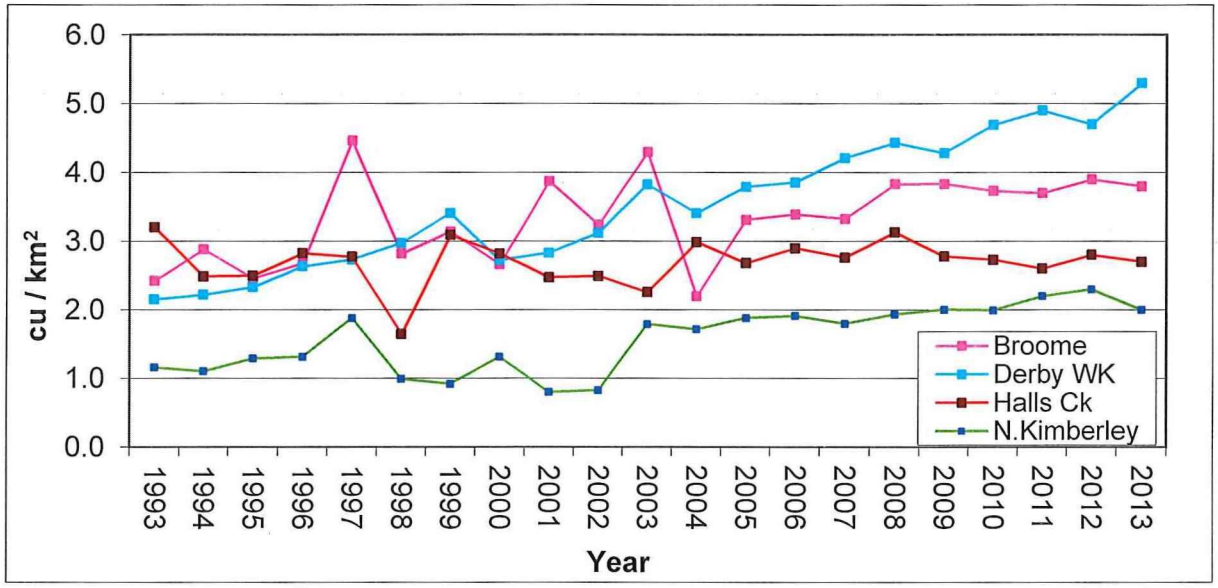


Figure 8 Mean reported stock densities (cu/km^2) in Kimberley LCDs, 1993–2013.

Change data for the most recent sampling cycle (Epoch 6 (2009 to 2011) to Epoch 7 (2012 and 2013)) indicate an increase in desirable grass frequency in the Broome and Halls Creek LCDs, and a minor decline in the North Kimberley LCD (Figure 9 and Table 4).

Stocking levels in the Kimberley remain high, with Derby West Kimberley at 170% of Present Carrying Capacity, Halls Creek 108%, Broome 93% and North Kimberley 91% in 2013.Derby West Kimberley LCD is scheduled for WARMS reassessment in 2014.

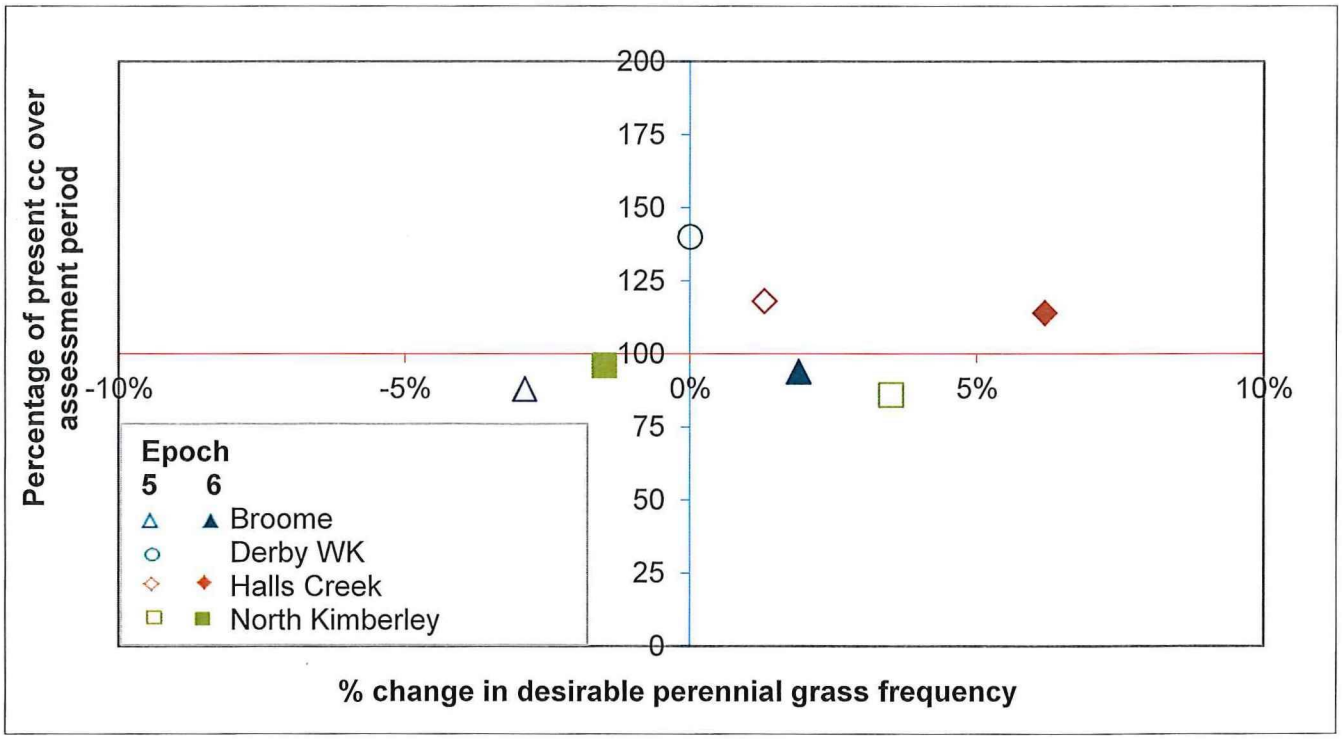


Figure 9 Changes in recorded frequency of desirable perennial grasses (Cycles 5 or 6) in relation to grazing pressure, Kimberley LCDs. (refer to data in Table 4)

3.2 Grasslands south of Kimberley

3.2.1 Seasonal quality

Seasonal quality is described in Section 3.1.1.

Seasonal conditions in grasslands south of Kimberley have been variable. Favourable conditions were recorded in the 1990s, with prevalence of average or below average years since 2000. Although the 2013/2014 wet season was drier than the previous year (Figure 3), in 2013 seasonal quality was assessed as above average or average in most of the grasslands south of the Kimberley, the exception being a portion of Ashburton LCD (Table 5; Figures 5 and 6).

Table 5 **Seasonal quality at WARMS sites south of Kimberley grassland LCDs, 2013.**

	Seasonal quality			Proportion of long-term summer rainfall	Average long-term summer rainfall (114 years)
LCD	Above average %	Average %	Below average %	%	mm
Ashburton	6	78	16	81	177
De Grey	89	11	0	150	250
East Pilbara	100	0	0	166	194
Lyndon	2	98	0	88	125
Roebourne	63	37	0	126	221
South of Kimberley grasslands overall	**52**	**45**	**3**		

3.2.2 Perennial grass frequencies

Lyndon LCD is the changeover LCD between grasslands and shrublands in pastoral WA. Three stations (Maroonah, Wandagee and Williambury) have no WARMS grassland sites and five stations (Koordarrie, Ningaloo, Yanrey, Exmouth Gulf and Emu Creek) have grassland sites only. Other Lyndon LCD stations have both grassland and shrubland sites.

Recorded frequency of all perennial grasses and of desirable perennial grasses in south of Kimberley grasslands has been variable (Table 6 and Figure 10). Desirable grass frequencies declined in consecutive periods (cycle 5 and cycle 6) in Ashburton and De Grey LCDs. Desirable grass frequencies in East Pilbara LCD (scheduled for reassessment in 2014) have declined since site installation (Table 6). Likewise De Grey LCD has consecutive declines in desirable grass frequency for the last 4 assessments, although this decline is being replaced to some extent by other, non-pastorally desirable perennial grasses. Changes in frequency of desirable perennial grasses (Table 6) and all perennial grasses (Figure 10) in Roebourne LCD have been variable.

Table 6 **Change in desirable grass frequency, south of Kimberley LCDs.**

LCD	Cycle 1 (E1 to E2) 1994-99	Cycle 2 (E2 to E3) 1997-2002	Cycle 3 (E3 to E4) 2000-05	Cycle 4 (E4 to E5) 2003-08	Cycle 5 (E5 to E6) 2006-11	Cycle 6 (E6 to E7) 2012-14
Ashburton	8 6%	-9 1%	-	-	-12 0%	-8 6%
De Grey		6 5%	-1 1%	-2 5%	-9 2%	-6 5%
East Pilbara			-3 2%	-2 7%	-5 9%	-
Lyndon		1 5%	-19 3%	1 0%	5 6%	-
Roebourne		6 8%	-13 6%	8 7%	-4 1%	6 1%

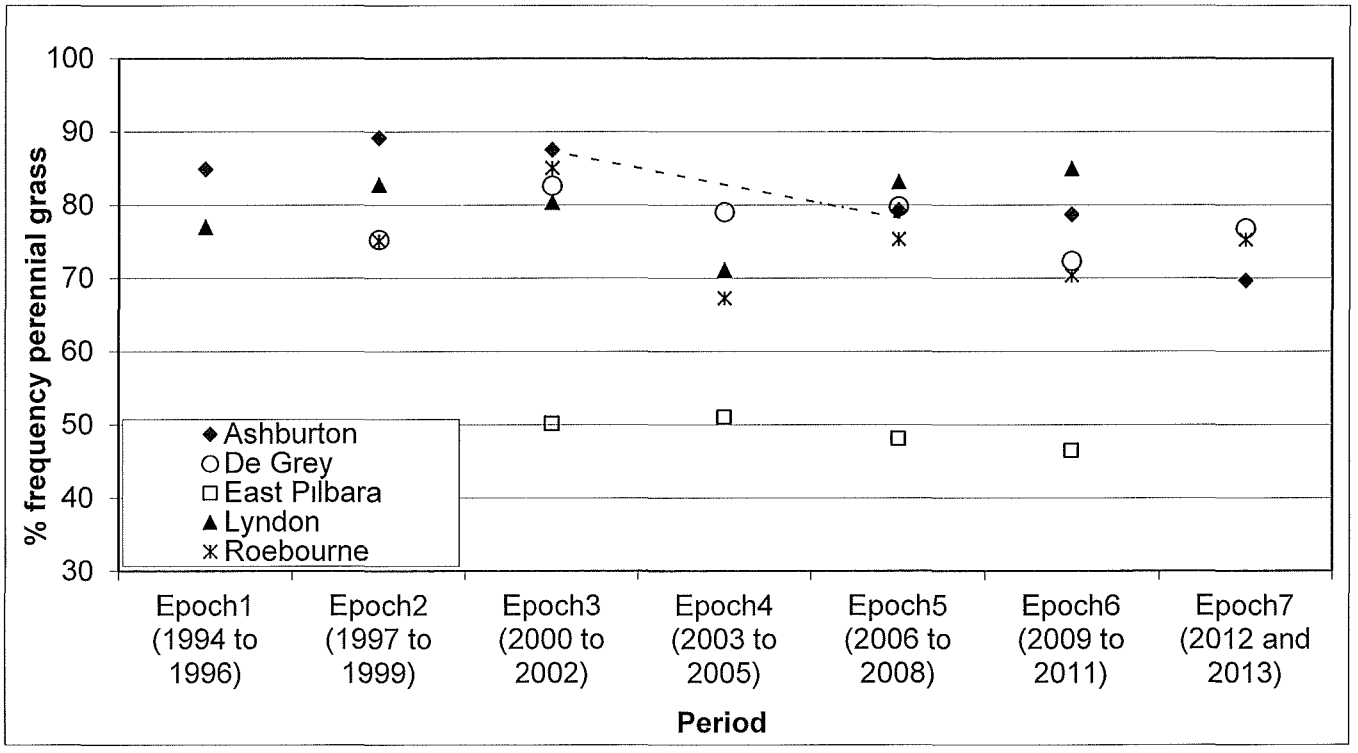


Figure 10 Mean perennial grass frequencies (all grasses) south of Kimberley LCDs. Note that data for 2014 are not yet available for Epoch 7.

3.2.3 Stock numbers

Reported stock numbers in south of Kimberley grasslands have increased since 1993, more than doubling in East Pilbara and De Grey LCDs (Figure 11) and are generally above estimated Present CC

Estimated Present CC is 1 5 cu/km^2 for Ashburton LCD, 1 6 cu/km^2 for De Grey LCD, 1 0 cu/km^2 for East Pilbara LCD, 1 7 cu/km^2 for Roebourne LCD and 1 5 cu/km^2 for Lyndon LCD For leases reporting in 2013, numbers are above Present CC in 86% of leases (12 of 14 leases) in De Grey LCD, with densities in Ashburton, East Pilbara and Roebourne LCDs also above Present CC at 50% (8 of 16 leases), 64% (7 of 11 leases) and 71% (12 of 17

leases) respectively. Stock numbers in the Lyndon LCDs are above Present CC on 11 of 21 leases (52%). Stock numbers on some of these leases are at levels of twice the estimated Present CC. Again the lack of current range condition data should be noted.

3.2.4 Interaction of stock numbers and desirable plant counts

The declines in the frequency of desirable species recorded in Table 6 occurred during a period of average to above average seasonal quality over the previous few years (Figure 6). This potentially reflects the effect of high grazing pressure, and suggests that the estimation of the resilience of the rangelands and their production of usable forage by lessees (and consequently the stocking rates that can be supported) is, in the main, optimistic and potentially unsustainable. The rise in stock numbers in all LCDs since the mid-1990s has not been buffered by the constant above average seasons as recorded in Kimberley LCDs.

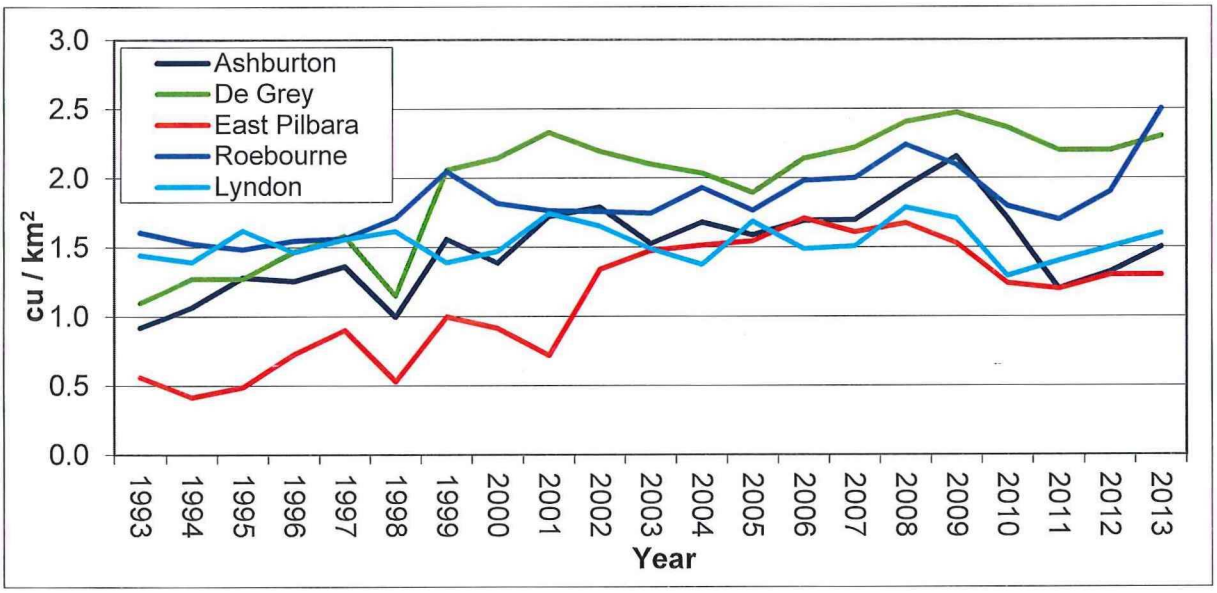


Figure 11 Mean reported stock densities (cu/km^2) in south of Kimberley grassland LCDs, 1993–2013.

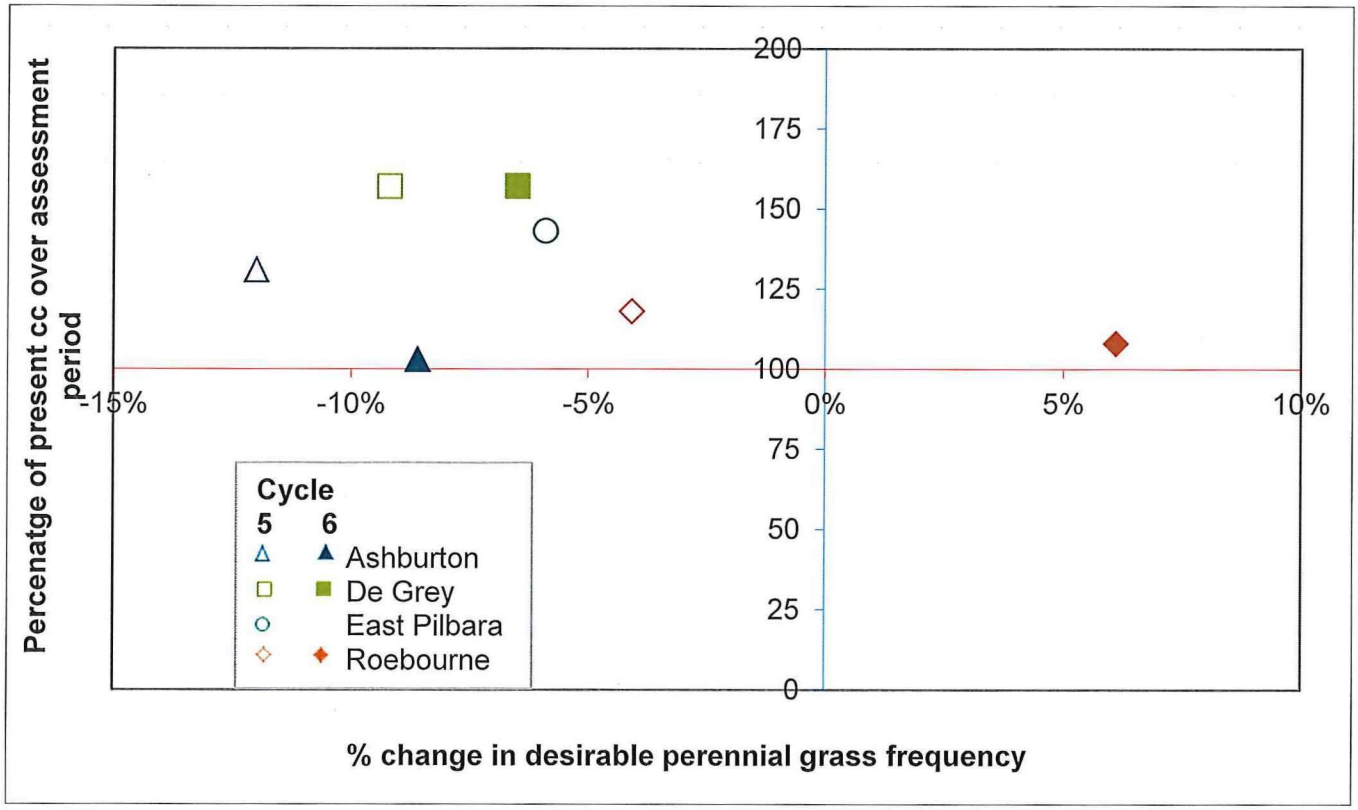


Figure 12 Changes in recorded frequency of desirable perennial grasses (cycles 5 or 6) in relation to grazing pressure, in the grasslands south of the Kimberley LCDs (refer to data in Table 6).

3.3 Shrublands in the Southern Rangelands

3.3.1 Seasonal quality

Seasonal conditions in the Shrublands in 2013 were mixed, with seven LCDs reporting large proportion of WARMS sites with below average season quality, and nine LCDs with average or above average seasonal quality (Table 7, Figures 4 and 6, Appendix 1). Binnu LCD has only two WARMS sites and seasonal condition rating at these sites does not necessarily reflect the entire LCD.

Winter rainfall is important for perennial shrub establishment and survival, and in considering seasonal quality for the most recent year, the phenology of perennial shrubs is also important in a longer time frame (Appendix 1). Many parts of the Southern Rangelands have experienced below average or well below average seasonal conditions (and therefore a greening response), particularly the Gascoyne Ashburton Headwaters, Murchison and Wiluna and Gascoyne Wooramel in recent years.

Table 7 **Seasonal quality in the Southern Rangelands, 2013.**

	Seasonal quality				
LCD	Above average %	Average %	Below average %	Proportion of long-term winter rainfall %	Average long-term winter rainfall (114 years) mm
Binnu	0	0	100	52	257
Cue	25	69	6	84	114
Gascoyne Ashburton Headwaters	71	29	0	92	90
Gascoyne Wooramel	8	2	90	50	139
Kalgoorlie	36	49	15	94	119
Lyndon	30	47	23	77	124
Meekatharra	8	92	0	93	101
Mt Magnet	6	14	80	68	133
Murchison	23	19	58	68	129
North-eastern Goldfields	48	50	2	103	100
Nullarbor Eyre Highway	45	55	0	109	109
Sandstone	16	20	64	74	123
Shark Bay	0	0	100	51	162
Upper Gascoyne	42	58	0	87	110
Wiluna	66	29	5	78	83
Yalgoo	23	2	75	73	158
Yilgarn	0	0	100	69	164
Shrublands overall	**39**	**25**	**36**		

3.3.2 Shrubland sites

Data to May 2014 show declining density of desirable perennial shrubs in the Southern Rangelands (Tables 8 and 9 and Figure 13). In Gascoyne Ashburton Headwaters LCD, about half of all desirable shrubs have disappeared on WARMS sites between Epoch 3 (2005 to 2009) and Epoch 4 (2010 to 2014). Assessments of seasonal quality (see also Figure 6) suggest that, in general terms, seasonal conditions, while variable, have not been extreme, and grazing pressure appears a major driver of declining desirable shrub density.

This decline in desirable shrubs is occurring at WARMS sites where seasonal quality has been assessed as above average (Kalgoorlie, Upper Gascoyne, Wiluna and Meekatharra LCDs), again suggesting possibly excessive grazing pressure. Shrub species in this

environment are adapted to variable seasonal conditions and significant variation in rainfall between years, and even consecutive below average seasons are insufficient to cause significant plant mortality The recorded decline therefore suggests that management response to unfavourable seasonal conditions has been insufficient to halt this trend

Table 8 **Change in desirable shrub numbers between Epoch 3 (2005 to 2009) and Epoch 4 (2010 to May 2014), Southern Rangelands.** (LCDs reassessed to May 2014)

	Seasonal quality		
	Above average	Average	Below average
LCD	%	%	%
Cue	5 3	2 1	n a
Gascoyne Ashburton Headwaters	-28 0	-24 4	-66 7
Kalgoorlie	-12 4	-9 8	-22 5
Lyndon	n a	-19 9	-28 8
Mount Magnet	23 3	31 5	n a
Murchison	-12 1	-14 6	-17 0
North-eastern Goldfields	n a	-7 3	-22 1
Shark Bay	n a	-17 4	-7 5
Upper Gascoyne	-20 3	-11 2	-41 5
Wiluna	-19 1	-36 2	-41 8
Gascoyne Wooramel (53% assessed)	n a	-26 8	-6 8
Meekatharra (58% assessed)	-19 4	-28 1	-81 0
Nullarbor Eyre Highway (64% assd)	-27 1*	-6 8	0 8
Shrublands	**-11.4**	**-14.2**	**-24.9**

The large decline in desirable shrubs in above average seasons in Nullarbor LCD is in part due to wildfires on Gunnadorah station Excluding burnt sites on Gunnadorah, desirable shrub density in the Nullarbor Eyre Highway LCD declined -7 5% The impact of wildfires on some sites in the Gascoyne Wooramel LCD - (8 of 26 sites on Boolathana, Cooralya, Hill Springs and Mooka stations) was less pronounced, with shrub densities declining 27 7% on sites in average season and -1 3% on sites in below average season

Figure 13 is based on sites reassessed to May 2014, with Epoch 3 (2005 to 2009) compared with corresponding sites assessed to May 2014 in Epoch 4 (2010 to May 2014) The majority of WARMS sites fall below the diagonal line (along which a site would be considered stable, i e numbers in Epoch 4 equal to numbers in Epoch 3) Whilst seasonal conditions can be expected to be a principle driver, large declines in desirable shrubs are being recorded on sites that have experienced average or above average seasonal conditions (Gascoyne Ashburton Headwaters, Upper Gascoyne and Wiluna LCDs)

Overall, there has been a 17% decline in desirable shrubs on sites assessed between Epoch 3 and Epoch 4 in the Southern Rangelands, with over a 25% decline in sites listed as having below average seasonal quality (Table 8), compared with an 11% decline in above average season and 14% decline in average season This negative trend indicates a steady decline in rangeland carrying capacity, with potential for significant transition (change) in the plant community Such transitions may not be reversible within a management timeframe,

leading to a permanently reduced capacity to run stock (and hence business financial return), as well as a permanent change in the native vegetation, with associated impacts on biodiversity.

Table 9 **Change in all perennial shrub numbers on WARMS Sites in the Southern Rangelands between 2005-14.**

Seasonal quality	Change	Plant population at Epoch 4
Overall	-10.1%	73 177
Above average	-3.3%	23 634
Average	-9.1%	29 356
Below average	-18.1%	20 187

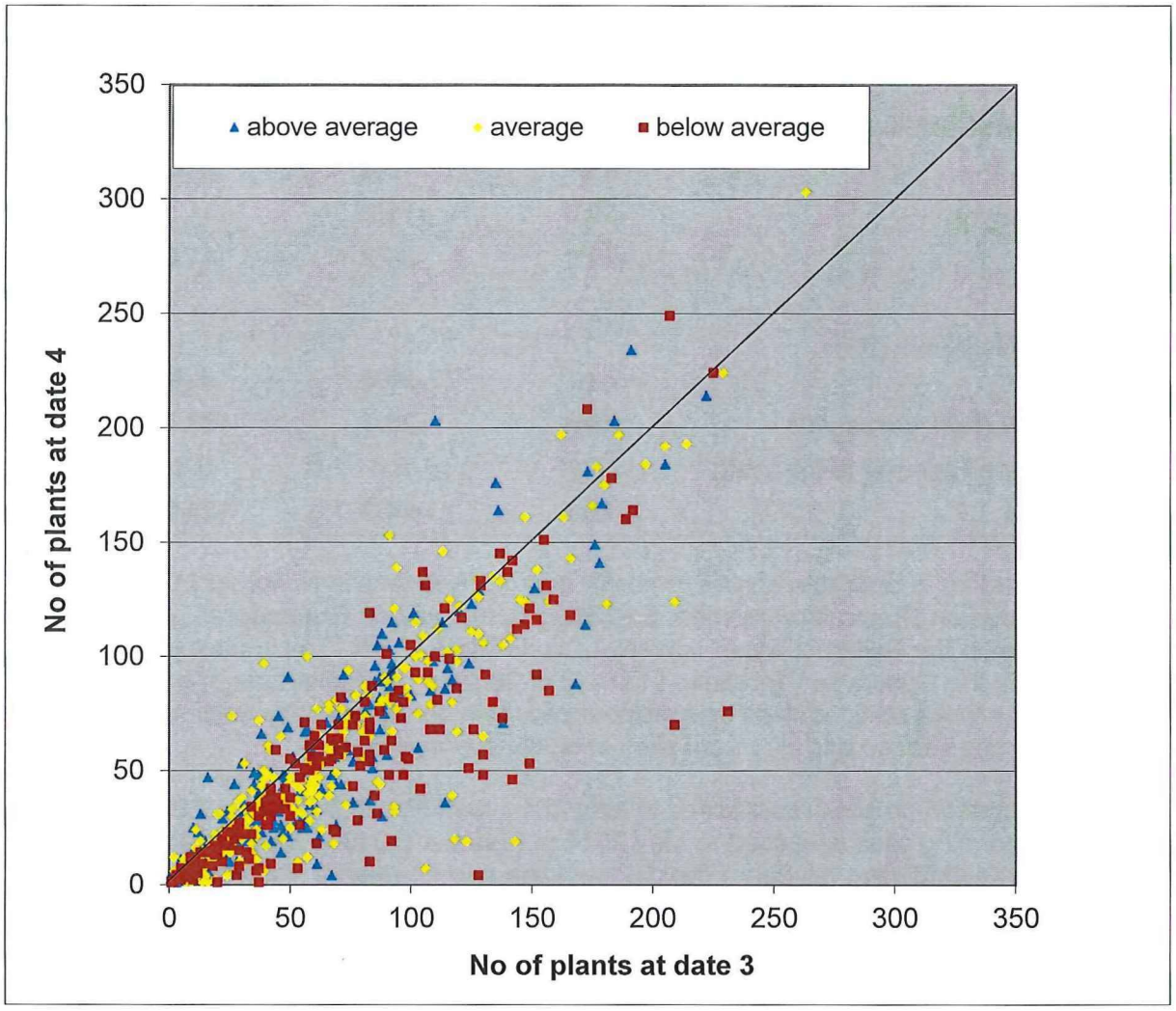


Figure 13 Shrub number on WARMS shrubland sites of varying seasonal quality, as recorded in Epoch 3 (2005 to 2009) and Epoch 4 (2010 to May 2014). Data as at May 2014.

3.3.3 Stock numbers

Only Lyndon, Upper Gascoyne and Wiluna LCDs reported stock numbers in 2013 above the Present CC, highlighting the variability within LCDs and the need for caution when assessing aggregated figures However, when the figures are considered for the region as a whole, of the 241 leases reporting stock numbers in 2013, 80 (33%) reported numbers above the most recently calculated Present CC The percentage was highest in Upper Gascoyne (89%) and Gascoyne Ashburton Headwaters LCDs (62%), and lowest in Sandstone LCD (0%) (Table 10 – note that stock density declines as ha/dse increase)

Table 10 **Reported stock densities in the Southern Rangelands Region, 2003–13.**

		Stock density ha/DSE *										
LCD	Ave. Present CC	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Binnu	25 2	40 6	44 7	54 2	45 1	15 1	60 7	52 7	55 8	51 4	83 8	89 8
Cue	18 7	29 9	46 0	41 6	33 6	26 5	31 9	35 8	67 7	64 9	54 3	62 2
Gascoyne Wooramel	11 4	16 8	14 3	11 6	11 3	11 0	10 1	9 0	11 7	14 6	13 3	13 2
Gascoyne Ashburton Headwaters	20 8**	19 1	20 7	23 9	24 1	19 6	17 9	16 1	27 1	28 9	27 0	25 0
Kalgoorlie	20 3	34 0	37 5	37 2	45 2	53 4	46 5	52 6	61 4	53 1	40 3	37 5
Lyndon	9 5	10 8	10 7	8 7	9 9	9 7	8 1	8 4	11 1	10 4	9 7	9 0
Meekatharra	22 2	30 8	29 1	29 0	26 8	26 8	25 0	24 7	31 8	31 2	29 0	28 6
Mount Magnet	17 1	24 1	25 0	22 1	18 3	22 0	22 9	24 6	29 6	41 8	35 4	44 5
Murchison	18 1	32 2	40 6	33 4	26 4	29 0	22 2	24 7	34 3	37 8	30 9	39 7
North-eastern Goldfields	23 1	46 2	48 6	46 2	55 0	42 2	36 8	44 4	43 8	44 3	34 1	39 2
Nullarbor Eyre Highway	24 2	23 5	22 7	25 0	32 9	27 8	32 0	32 9	33 4	26 1	24 5	24 1
Sandstone	19 2	77 5	64 0	99 2	85 0	74 1	64 2	59 5	64 6	51 3	74 0	136 5
Shark Bay	12 8	18 2	20 2	17 0	18 4	21 7	18 5	16 3	21 7	21 0	23 7	20 1
Upper Gascoyne	19 2	23 0	19 4	16 5	15 3	12 9	12 5	10 9	13 9	15 7	14 8	11 1
Wiluna	23 6*	17 5	19 2	22 4	21 7	20 0	17 5	18 4	21 3	20 6	20 2	20 0
Yalgoo	18 1	33 0	39 1	37 4	30 9	25 6	28 8	28 4	44 9	46 4	40 1	43 7
Yilgarn	16 8	46 9	51 6	111 9	118 7	104 0	52 5	109 7	101 6	54 8	78 8	139 1

* Note the units for this Table (ha/dse - stock density declines as ha/dse increase)

** Not all stations in the LCD have an assessed Present Carrying Capacity.

3.3.4 Interaction of stock numbers and desirable plant counts

Current WARMS sampling in the Southern Rangelands Region is only partially complete in Meekatharra (58%), Nullarbor Eyre Highway (64%) and Gascoyne Wooramel (53%) LCDs, and Yalgoo and Sandstone LCDs have not yet been sampled Consequently, there are only minor changes to those data presented in the 2013 report

The magnitude of change in desirable shrub populations between 2005-2009 and 2010 and May 2014 for those LCDs with available data (Cue, Gascoyne Ashburton Headwaters, Kalgoorlie, Lyndon, Mount Magnet, Murchison, North-eastern Goldfields, Shark Bay, Upper Gascoyne and Wiluna LCDs) is variable (Figures 14 and 15) Of the 13 LCDs assessed in the current round of sampling, the number of desirable shrubs has declined, except in Mount Magnet and Cue LCDs

In Wiluna LCD, reported stock numbers increased steadily over the past decade, in part associated with above average seasonal conditions from 1999 to 2008 All WARMS sites in this LCD were assessed as average seasonal quality in 2012, and only 5% of sites were rated as below average in 2013 (Table 7) In 2011 more than 50% of sites were assessed as below average seasonal quality (see July 2012 report), but stock density actually increased slightly (Table 10) The result is a quite significant decline in perennial shrub densities It is likely that desirable shrub density will continue to decline if stock numbers are not more closely aligned with seasonal conditions

In North-eastern Goldfields LCD, no WARMS site recorded a below average seasonal quality in 2011, all WARMS sites recorded below average seasonal quality in 2012 but only 2% of sites recorded below average seasonal quality in 2013 (Table 7) This inherent inter-year variability (low median rainfall with high inter-annual coefficients of variation) makes management difficult Moreover, of the 30 leases in this LCD, 13 are owned by mining companies (generally running stock numbers well below the Present CC) and two are managed by indigenous communities (again with low stock numbers) This reduces the LCD average stock number Stock numbers are evidently too high on many leases to maintain rangeland condition in the face of unfavourable seasonal conditions, as grazing pressure is not being sufficiently reduced in response

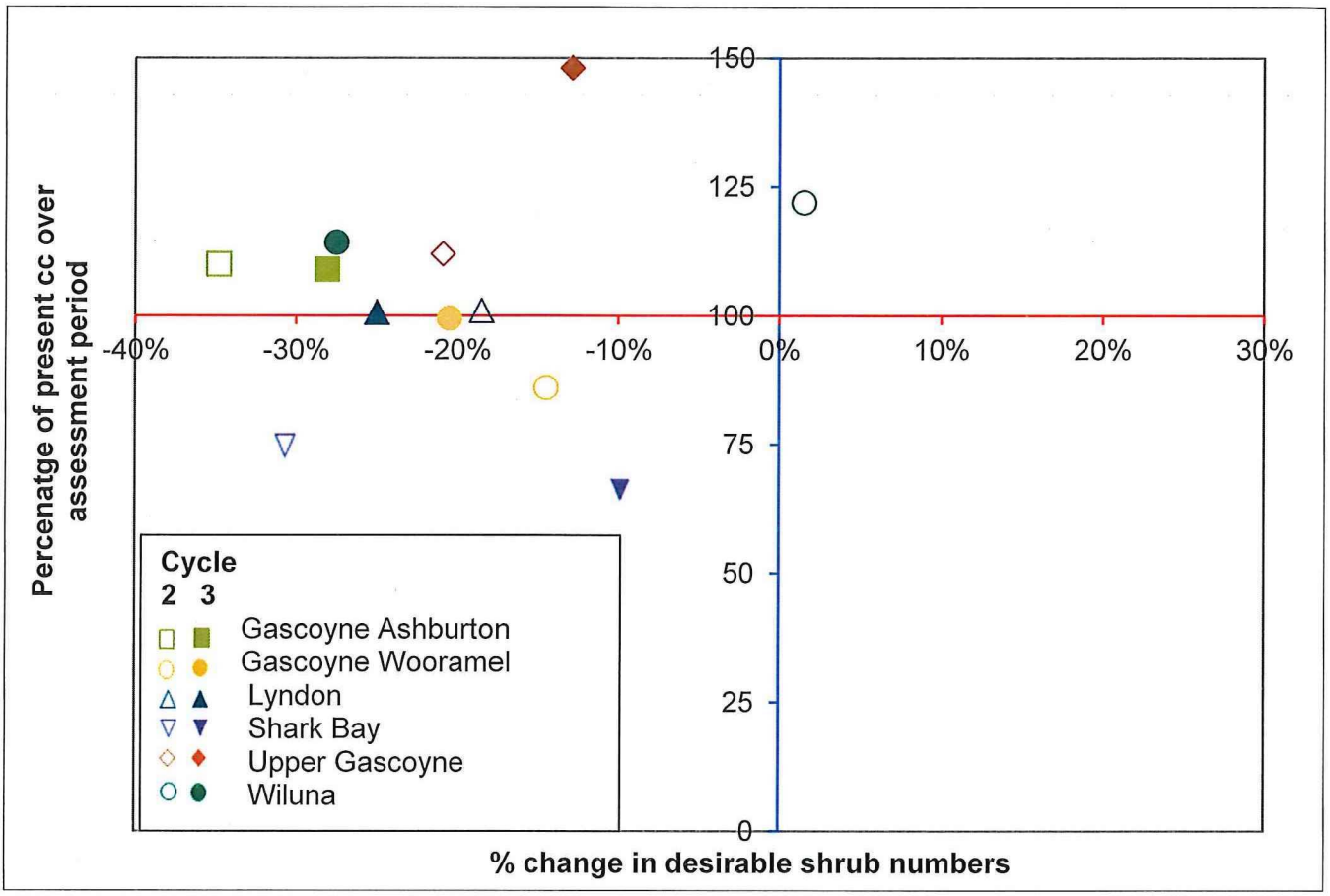
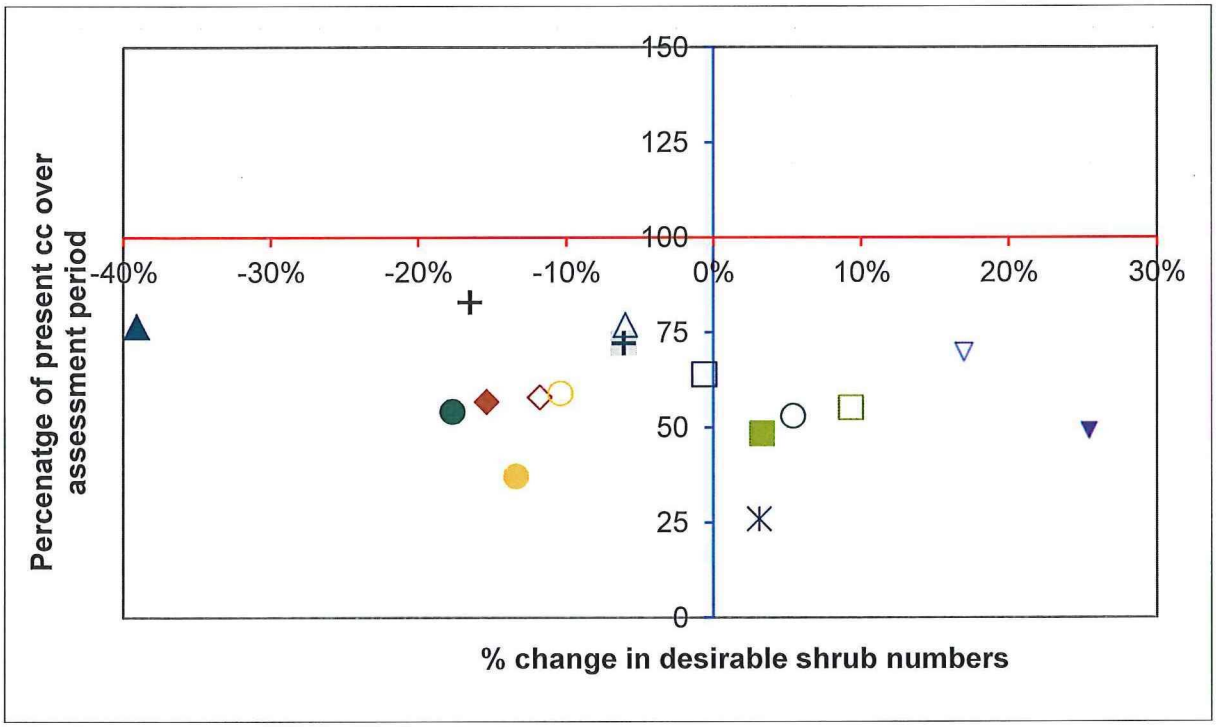


Figure 14 Changes in desirable shrub populations in relation to grazing pressure between Cycle 2 and Cycle 3 (Gascoyne Ashburton Headwaters, Gascoyne Wooramel, Lyndon, Upper Gascoyne and Wiluna LCDs).



Cycle 2	Cycle 3	
□	■	Cue
○	●	Kalgoorlie
△	▲	Meekatharra
▽	▼	Mt Magnet
◇	◆	Murchison
○	●	North - eastern Goldfields
+	+	Nullarbor Eyre Highway
✳		Sandstone
□		Yalgoo

Figure 15 Changes in recorded shrub populations in relation to grazing pressure between 2005-2009 and 2010-May 2014, Cue, Kalgoorlie, Meekatharra, Mount Magnet, Murchison, North-eastern Goldfields and Nullarbor Eyre Highway LCDs.

4 Discussion

4.1 Kimberley LCDs

Seasonal conditions and stock numbers appear relatively balanced in Kimberley, resulting in relatively stable range condition trend However, the decline in desirable perennial grass frequency in Cycle 5 was noteworthy, with a decline in North Kimberley LCD in Cycle 6 Further data collection over the coming 12 months will confirm the situation with the other Kimberley LCDs However, if seasonal conditions were to turn less favourable, current stock numbers would need to be substantially reduced, as the variability in desirable grass frequency indicates a fine margin between sustainable and unsustainable grazing pressure

Data in this report are aggregated at the LCD scale, and numerous Kimberley leases, in particular most of the 30% of leases managed by indigenous communities, are carrying relatively low stock numbers Of the 86 leases that reported stock numbers for 2013, 41 (38%) reported numbers above Present CC The decline in the recorded frequency of desirable perennial grasses over the previous cycle reflects this, with the potential impact of stock numbers mitigated by the remarkable run of favourable conditions since the 1990s

4.2 South of Kimberley grassland LCDs

At WARMS grassland sites south of Kimberley, desirable perennial grass frequency declined in all LCDs except Lyndon LCD during Epoch 6, as well as in Ashburton and De Grey in Cycle 6 (Table 6), despite favourable seasonal conditions, particularly in the latter However, desirable perennial grass frequency did increase in Roebourne LCD, where seasonal quality was average or better at all sites (Tables 5 and 6) Stock densities remain relatively high in all LCDs WARMS and seasonal quality data suggest that excessive grazing pressure may be reducing the capacity of these grasslands to respond to the more favourable seasons of recent years

Both these factors suggest that the current stock numbers in the south of the Kimberley grasslands are unlikely to be sustainable, while in the East Pilbara LCD, a return to average seasons or perhaps below average seasons could cause significant problems if stock numbers are not rapidly reduced Data suggest that many leases analysed in the south of the Kimberley grasslands region as a whole, are stocked above capacity As in the Kimberley LCDs, most areas in the south of the Kimberley grasslands region recorded average or above average rainfall and associated pasture growth for many of the 12 years to 2005 and again in recent years This may have inflated expectations of property carrying capacities Indeed, the current cattle numbers reflect the sharp increase in regional cattle numbers that occurred from 1997 and continued to rise to about 2007 or 2008 (depending on the LCD) The condition of the pastoral resource in south of the Kimberley grasslands region is at considerable risk, and close attention should be paid to this region over the coming 12 months

4.3 Southern Rangeland (shrubland) LCDs

As seasonal conditions declined in the Southern Rangelands, recorded shrub densities declined substantially, suggesting an inadequate response to adverse seasonal conditions More than 50% of sites were recorded as losing desirable plants between Epoch 3 and Epoch 4 (Figure 13) Such changes are leading to long-term, virtually permanent changes (transitions) in the rangeland resource, leading in most instances to reduced carrying capacity, and possibly significant changes to rangeland biodiversity, or both

4.4 General discussion

Range trend states the direction of change in range condition Fewer and fewer desirable forage plants, increasing erosion or bare soil, and other changes characterize downward trend in range condition Much of the poor condition rangeland in WA, particularly in the Southern Rangelands is historical, occurring soon after livestock were introduced, or when drought subsequently interacted with high stock numbers to produce severe degradation episodes However, declines in desirable species are still being recorded throughout the rangelands, with concern that some negative changes represent transitions to less productive rangeland states, and that reversal of these transitions will be neither straightforward nor short term Although contemporary transitions are more common in northern grasslands compared with southern shrublands, perhaps because grassland species are more dynamic than shrubs and species composition is able to change more rapidly, transitions have been recorded throughout the rangelands (Watson and Novelly 2012)

The response to a declining rangeland trend and changes in seasonal conditions must be immediate to prevent a degradation sequence which, once started, is difficult to stop, leads to a transition and often becomes virtually irreversible within a realistic management timeframe That such transitions are currently being recorded is particularly worrying and indicative of totally inappropriate management throughout much of pastoral WA

The consequences of these changes, for both government and pastoral lessees are substantial First, where a persistent change, at least within what could be termed a management timeframe, has occurred in the state of the vegetation, assessment and interpretation of the condition of the rangeland, its production potential and future management scenarios within this new management context must be considered Where change is negative from a pastoral perspective, managers need to accept the new state and its altered productive potential as reality for the foreseeable future, and they will need to adjust their management (and their aspirations for financial return) to reflect the new vegetation community Second, land administrators must accept that the capacity to enact a realistic and feasible management regime that will return the vegetation community to its previous state may not necessarily exist, and that requiring a change in vegetation that is ecologically unlikely under any management regime is pointless

Both condition assessment and prescribed management must be predicated on the fact that, while not a desired outcome, a threshold has been crossed, the ecology of the site has been altered and that reversal of the change may be difficult, independent of the management imposed

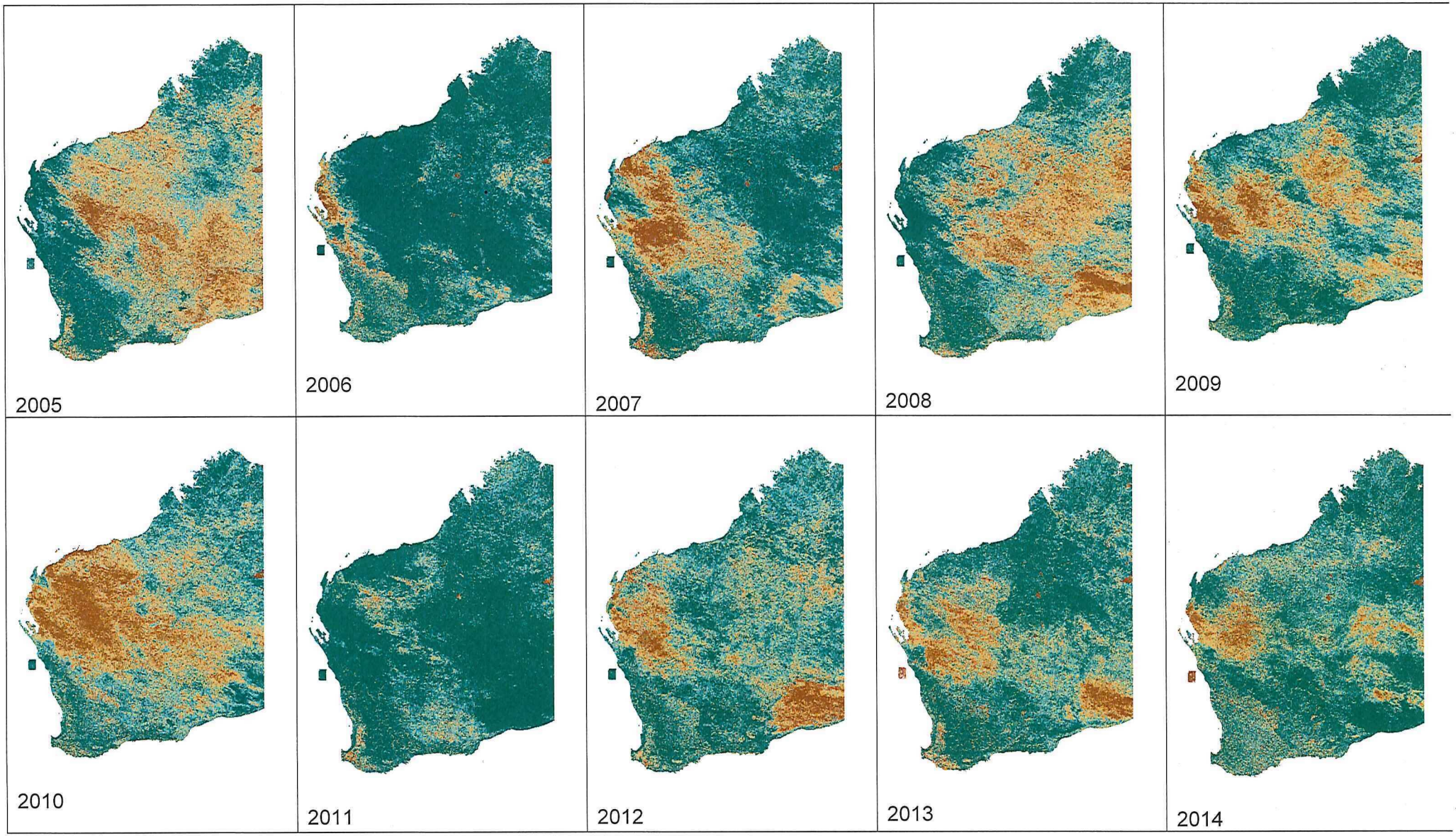
5 Conclusions

WARMS data continue to identify serious issues, these issues appearing more pronounced in LCDs south of the Kimberley in which the average stock numbers are above the Present CC The frequency (of grasses) or density (of shrubs) of desirable, perennial species is declining in many LCDs This may be, in the case of the shrubs, in part a response to changes in seasonal conditions However, in some LCDs in the Southern Rangelands in particular, it appears that stocking rates are commonly above the assessed Present CC, and in such situations rangeland condition is declining as a result

That this decline is occurring during generally favourable seasons in some districts is particularly disturbing, suggesting the desirable plants are unable to develop resilience in favourable seasons to allow survival during less favourable seasons that inevitably follow The implications of this low resilience will be that when a higher proportion of unfavourable seasons are recorded, quite dramatic declines in desirable species are likely to occur

References

Watson, IW and Novelly, PE 2012, 'Transitions across thresholds of vegetation states in the grazed rangelands of Western Australia', *The Rangeland Journal*, vol 34, pp 231–38



Appendix 1 **Seasonal greenness response based on MODIS NDVI 2005 to 2014** **Above average** **Average** **Below average** **Well below**