



**RANGELANDS**  
NRM CLUSTER



IMPACTS & ADAPTATION  
I N F O R M A T I O N  
FOR AUSTRALIA'S NRM REGIONS



## Australian rangelands and climate change – remotely sensed ground cover



## Citation

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**Government of South Australia**

South Australian Arid Lands Natural Resources Management Board



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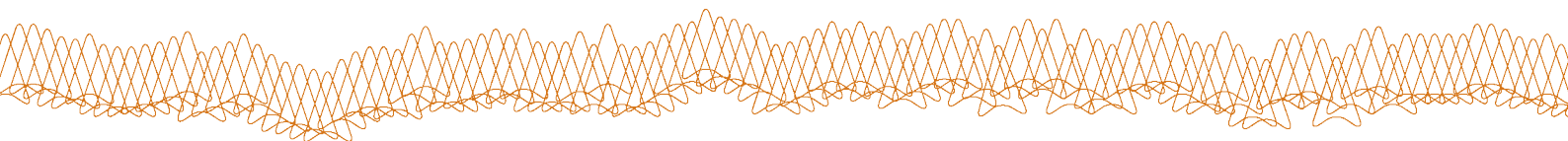
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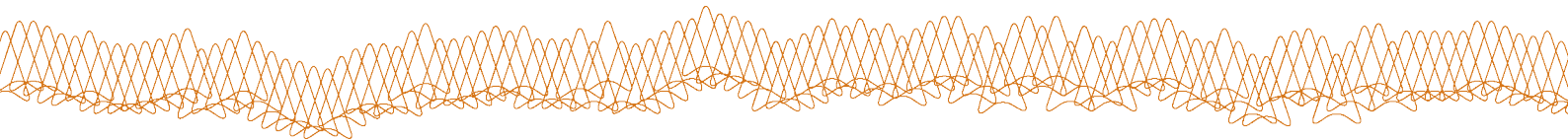
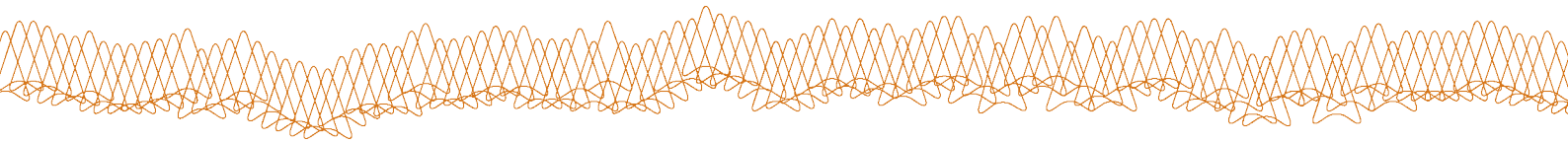


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## Key points

- Targets specifying the maintenance of minimum levels of ground cover are a common feature of regional NRM plans. Setting realistic targets for broadly different land types within each region is a challenge. Targets should be set and reviewed with climate variability, and change, in mind.
- National remote sensing capability now means that fractional cover derived from 500 m MODIS imagery, extending back to late 2000, is available. The bare soil component of fractional cover can potentially assist in setting, monitoring and reviewing regional cover targets. Knowing how amounts of bare soil have varied under recent climate variability, fire regime and grazing management provides some basis for specifying appropriate targets for broadly different land types under continuing rainfall variability and possible long-term change.
- Fractional cover images for mid-March and mid-September 2001 to 2013 were analysed to determine how the percentage area of bioregions within NRM regions varied for different threshold levels of bare soil. Threshold values of bare soil within 25 ha MODIS pixels were  $\geq 0.7$ ,  $\geq 0.6$ ,  $\geq 0.5$ ,  $\geq 0.4$  and  $\geq 0.3$ . The mid-March date represents likely maximal yearly bare soil in the southern part of the Rangelands Cluster, and the mid-September date is its equivalent in the central and northern cluster region.
- Using the former NSW Western CMA as an example, the analysis suggests that threshold levels of allowable bare soil should vary with land type (e.g. bioregion). A blanket target for an entire NRM region is not appropriate, particularly where mean annual rainfall, soil and vegetation type vary spatially within the region. Maximum allowable levels of bare soil should be lower in areas receiving higher or more reliable rainfall and where more perennial vegetation should be present. Conversely, more bare soil is permitted in arid parts of the Rangelands Cluster and where predominantly annual vegetation naturally occurs.
- Maximum threshold levels of bare soil are nominated for major bioregions within all NRM regions of the Rangelands Cluster. If the method demonstrated here for setting and monitoring maximum allowable levels of bare soil has merit, then these targets should be further investigated before being accepted.
- Targets should be periodically reviewed, as they may need to be adjusted under continuing climate variability and projected change. This will be the case where perennial grasses with the  $C_4$  photosynthetic pathway (including buffel grass) displace existing  $C_3$  herbage species due to atmospheric  $CO_2$  enrichment and continued warming. Elsewhere in the near to medium term, strategies such as patch burning to reduce extensive wildfire, improved grazing land management and control of feral herbivores should increase vegetation cover in most years. Both scenarios (climate change and improved land management) should warrant a regional lowering of the permissible level of bare soil.

Gary Bastin

CSIRO

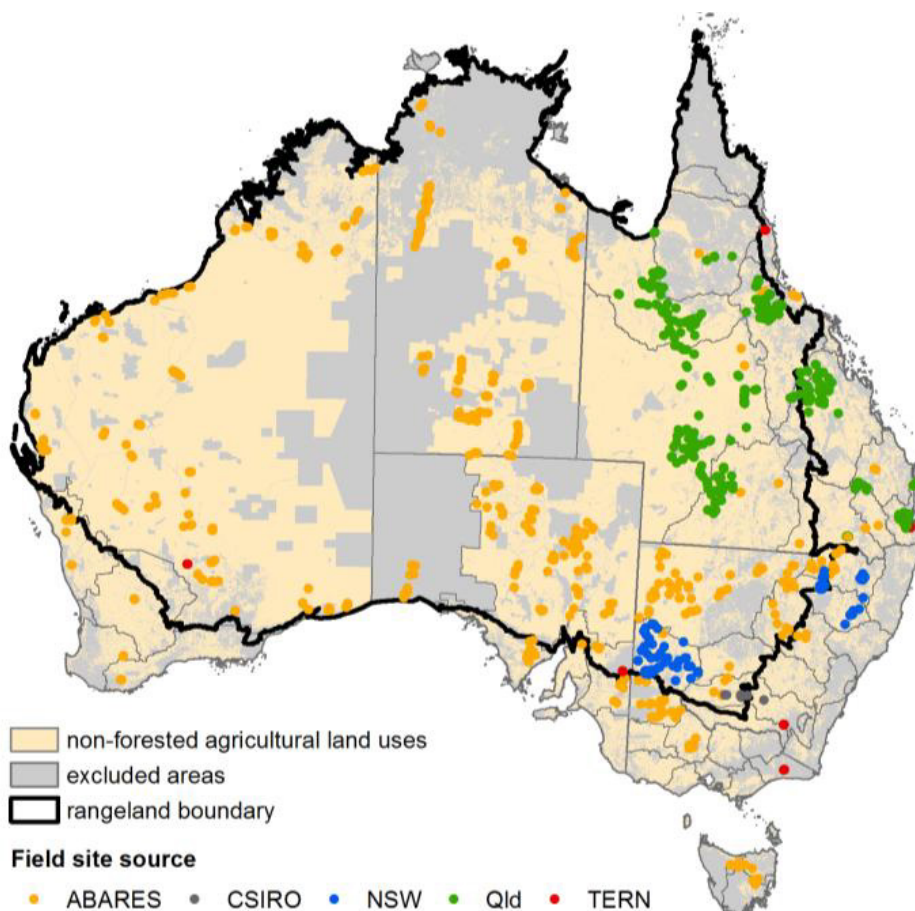
# 1. Introduction

Rainfall, fire and grazing are the principal drivers of ground cover. Fire is a more regular feature in the northern part of the Rangelands Cluster region, and its widespread occurrence in the central and southern rangelands generally follows successive wetter years (see Bastin 2014). There is little that land managers can do about the timing and amount of rainfall, but they can take steps to maximise its effectiveness when received and to manage subsequent grazing pressure so as to maintain acceptable levels of ground cover and thereby minimise the risk of erosion.

Maintaining a minimum level of ground cover is a common target in regional NRM plans. For example, the former Western CMA in NSW had a target of 40%

ground cover based on soil conservation principles. This target was useful for focusing the attention of graziers and their advisers towards good grazing management.

Setting an ecologically sensible target that can be achieved on-ground by most land managers most of the time has been a challenge. This is further complicated by practical and cost-effective monitoring methods that indicate where and when regional targets are being met. A further technical issue is defining exactly what constitutes 'ground cover': is it just plant matter (alive and dead), does it include cryptogams or should it include stone mantling? (Gibber may be a legitimate 'ground cover' component because it protects the soil surface from wind erosion and raindrop impact.)



**Figure 1.1** Locations of the ~1500 ground sites used to calibrate and validate remotely sensed fractional cover.

Source: Map courtesy of the Australian Bureau of Agricultural and Resource Economics and Sciences

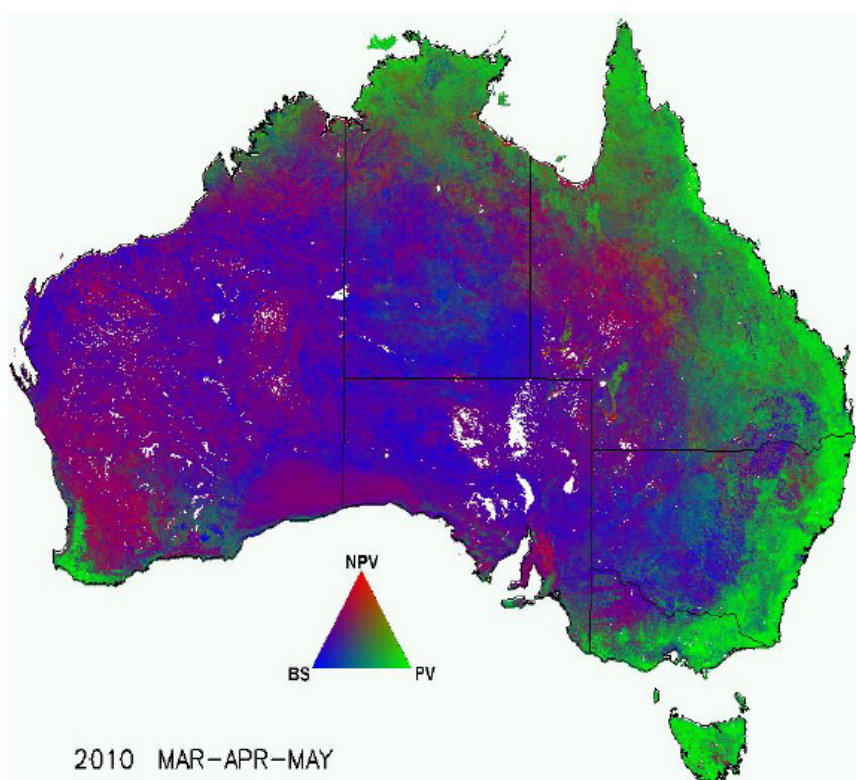


Remote sensing methods now allow vegetation cover to be routinely monitored across Australia at two spatial and temporal scales. Methods are based on:

1. Landsat Thematic Mapper (TM): 30 m pixel resolution and potentially every 16 days since 1987. Some images are missing in the archive and others are unsuitable due to cloud cover and other forms of contamination, or more recent issues of malfunctioning by the TM instrument. In effect, the Landsat record is generally used for detailed monitoring of cover at specific times, for example, recovery following wetter periods or at the driest time of the year. Techniques for deriving and validating reliable cover indices are most advanced in Queensland and NSW and are currently being extended to the NT.
2. MODIS: at 500 m pixel resolution, cloud-free composite images are available for most of Australia every eight days since late 2000.

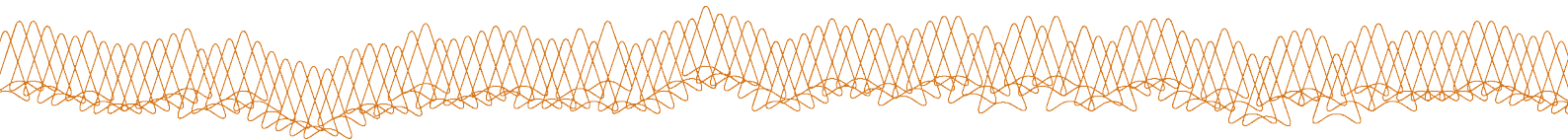
We use MODIS imagery for this analysis because a nationally led effort in recent years has collected ground data using consistent methods to suitably calibrate and validate cover estimates across the country (Figure 1.1). Also, for convenience, the larger pixel size of MODIS means smaller and more manageable image files when analysing cover dynamics across the large area covered by the Rangelands Cluster.

An unmixing technique is used to generate three components of fractional cover for each MODIS pixel: photosynthetic vegetation (PV: green), non-photosynthetic vegetation (NPV: senescent pasture and litter) and bare soil (BS) (Figure 1.2). The three components sum to one (or 100%) meaning that each 500 m by 500 m (25 ha) pixel has some proportion of PV, NPV and BS (see the legend below the example fractional cover image in Figure 1.2). This mixing is analogous to the soil texture triangle, where every soil is some mixture of sand, silt and clay.



**Figure 1.2** The autumn 2010 seasonal composite of fractional cover for Australia derived from MODIS imagery.

The photosynthetic (PV), non-photosynthetic (NPV) and bare soil (BS) components of fractional cover for each 500 m pixel are indicated by the mixing of primary colours shown in the triangle legend below the map.



Bare soil is effectively the converse of vegetation cover; that is, the more bare soil in a 500 m pixel, the less vegetation cover. An example bare-soil image is shown in Figure 1.3.

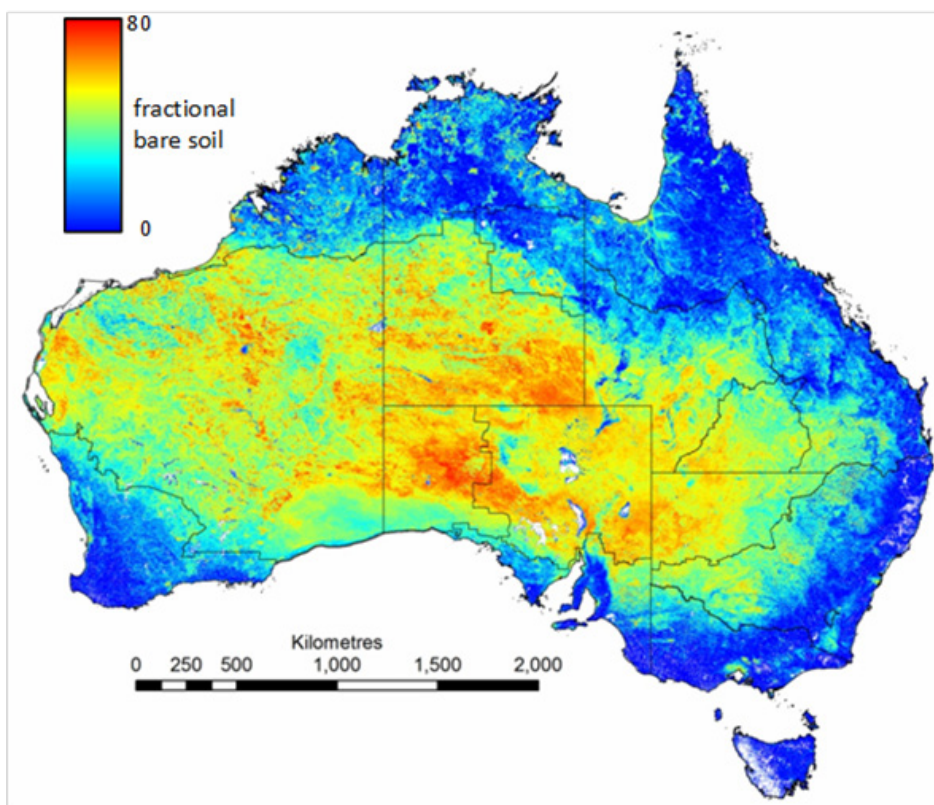
More information about fractional cover and the unmixing method is available in Guerschman et al. (2009), Stewart et al. (2013) and Malthus et al. (2013).

Images of fractional cover (bare soil, photosynthetic vegetation, non-photosynthetic vegetation) are available through TERN AusCover (<http://www.auscover.org.au/xwiki/bin/view/Product+pages/Fractional+Cover+MODIS+CLW>).

## 2. Setting a cover target

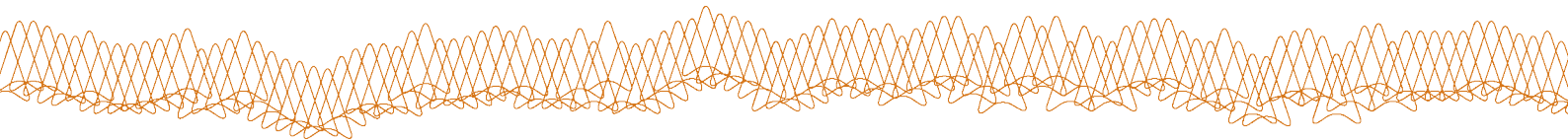
Vegetation cover or its converse, bare soil, varies spatially (Figure 1.3) and temporally, within years and between years (Figure 2.1). At specific locations, ground cover varies over time in response to rainfall (or lack of it, i.e. drought), grazing and fire. Sensible analysis of cover (or bare soil) dynamics over a large area and decadal time scales requires appropriate spatial and temporal stratification.

The spatial unit for this analysis is bioregions (IBRA v7, Department of the Environment n.d.) within NRM regions (Fig. 5-5). A bioregion is a large, geographically distinct area of land that has groups of ecosystems forming recognisable patterns within the landscape. For our purpose, bioregions group broadly similar landform, soil and vegetation types. Fractional bare soil for



**Figure 1.3** The percentage bare soil within 500 m MODIS pixels, mid-September 2009 (a particularly dry time for much of inland Australia). NRM regions within the Rangelands Cluster are also shown.

More bare soil means less vegetation cover.

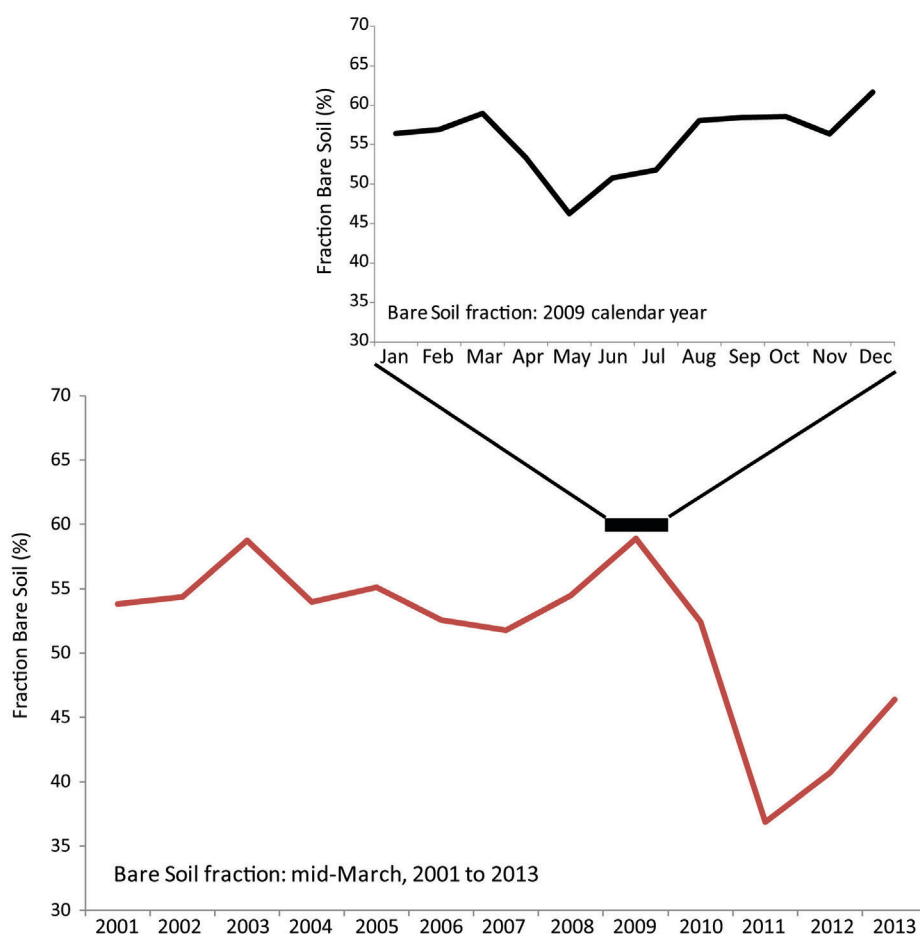


nominated times of the year (next paragraph) were spatially averaged for each bioregion in each NRM region. This stratification still has considerable internal landscape variability, but less so than averaging across the whole of each NRM region.

The soil surface is more vulnerable to erosion in dry times, notwithstanding the effects of grazing and fire. Thus it seems sensible to examine trends in bare soil at the probable driest time of each year. We have arbitrarily defined this as the middle of September for northern NRM regions (Table 2.1) where summer rainfall is more common and mid-March elsewhere where there is some chance of winter rain (but rainfall is essentially aseasonal).

The amount of bare soil also varies from year to year depending on seasonal quality (a general descriptor of yearly rainfall). This means there are two approaches to specifying a regional target: either (i) an amount of bare soil that should not be exceeded in most years, or (ii) the maximum level permissible in dry or drought years.

In this section we demonstrate the first approach and show how a regionally appropriate target varies for bioregions within NRM regions. The success in meeting our nominated regional targets between 2001 and 2013 is reported as *the percentage of bioregion area exceeding the agreed bare-soil target*.

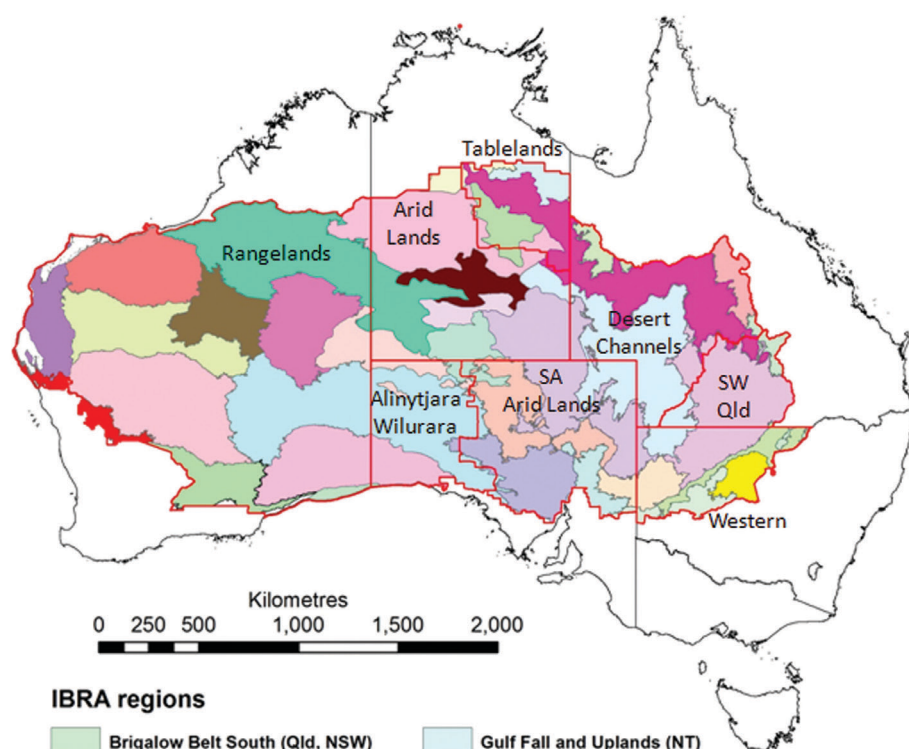


**Figure 2.1 Temporal variation in the fraction of bare soil within MODIS pixels for a 1° block (approximately 10,000 km<sup>2</sup>) centred on Broken Hill.**

The top graph shows monthly variation throughout 2009; the bottom shows variation, for mid-March, between 2001 and 2013.

Note that more bare soil means less vegetation cover (including ground cover).



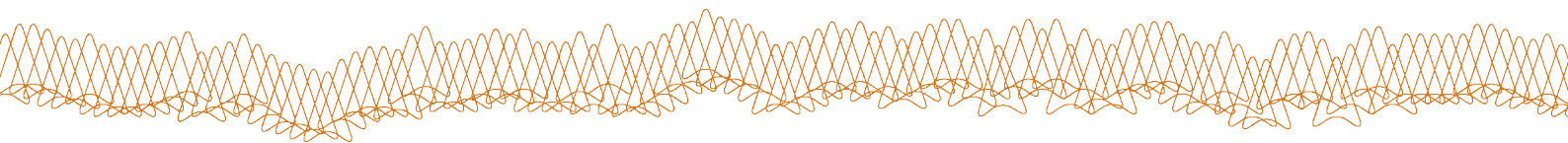


#### IBRA regions

Brigalow Belt South (Qld, NSW)	Gulf Fall and Uplands (NT)
Broken Hill Complex (NSW, SA)	Hampton (WA)
Burt Plain (NT)	Little Sandy Desert (WA)
Carnarvon (WA)	MacDonnell Ranges (NT)
Central Ranges (WA, NT, SA)	Mitchell Grass Downs (Qld, NT)
Channel Country (Qld, SA, NSW, NT)	Mount Isa Inlier (Qld)
Cobar Peneplain (NSW)	Mulga Lands (Qld, NSW)
Coolgardie (WA)	Murchison (WA)
Darling Riverine Plains (NSW)	Murray Darling Depression (NSW, SA)
Davenport Murchison Ranges (NT)	Nullarbor (WA, SA)
Desert Uplands (Qld)	Ord Victoria Plain (NT)
Einasleigh Uplands (Qld)	Pilbara (WA)
Finke (NT, SA)	Riverina (NSW)
Flinders Lofty Block (SA)	Simpson Strzelecki Dnfls (NT, SA, NSW, Qld)
Gascoyne (WA)	Stony Plains (SA)
Gawler (SA)	Sturt Plateau (NT)
Gibson Desert (WA)	Tanami (NT, WA)
Great Sandy Desert (WA, NT)	Yalgoo (WA)
Great Victoria Desert (SA, WA)	

**Figure 2.2 NRM regions and IBRA v7 bioregions in the Rangelands Cluster.**

Bioregions are briefly described in Appendix A.



**Table 2.1 Assignment of bioregions and NRM regions to summer and aseasonal rainfall zones. Bare soil levels in mid-September are analysed for summer-rainfall regions, and mid-March image dates are used elsewhere.**

MID-SEPTEMBER (SUMMER RAINFALL)		MID-MARCH (ASEASONAL/WINTER RAINFALL)	
NRM region	Bioregion	NRM region	Bioregion
		NSW: Western	All
Desert Channels Queensland	All		
Queensland: South West NRM	All		
SA: Arid Lands	Simpson Strzelecki Desert, Finke, Stony Plain, Channel Country	SA: Arid Lands	Broken Hill Complex Gawler Flinders Lofty Block
SA: Alinytjara Wilurara	Central Ranges	SA: Alinytjara Wilurara	Great Victoria Desert Nullarbor
NT: Arid Lands sub-region	All		
NT: Tablelands sub-region	All		
WA Rangelands	Pilbara, Tanami Great Sandy Desert Little Sandy Desert Gibson Desert Gascoyne, Carnarvon Central Ranges	WA Rangelands	Nullarbor, Yalgoo Coolgardie Murchison Great Victoria Desert Hampton

### 3. Method

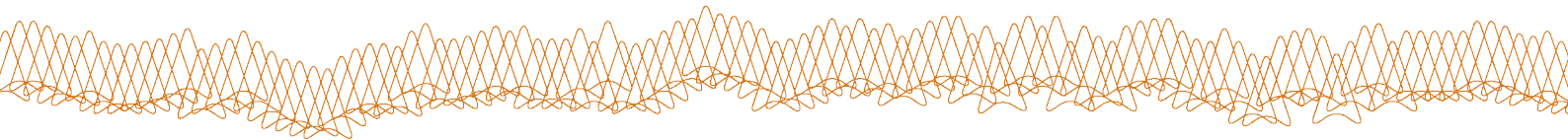
Datasets accessed and the procedure used to (i) nominate regionally appropriate maximum levels of bare soil and then (ii) monitor the success of these targets follows.

- Download archived fractional bare-soil images from the TERN AusCover portal and uncompress each image. Images included mid-March (Julian day 073) and mid-September (day 257) from 2001 to 2013.
- For each NRM bioregion, determine the number of 500 m pixels in each image having greater than 30%, 40%, 50%, 60% or 70% bare soil within the pixel (spatial analysis done in a GIS).
- Import spatial statistics to Excel and convert the pixel counts to the percentage area of corresponding bioregions within NRM regions.

- Based on the criteria in Table 2.1 and the temporal pattern of percentage area for each bare-soil category by NRM bioregion, assign the most appropriate category as the nominated target.
- Summarise the above analysis by tabulating the percentage area of each NRM bioregion exceeding the nominated target level of bare soil between 2001 and 2013.

### 4. Data source

Analyses below used MODIS-derived images (500 m pixels) of fractional bare soil downloaded from the TERN AusCover portal. Images are available on a 16-day basis from late 2000 to 2014.



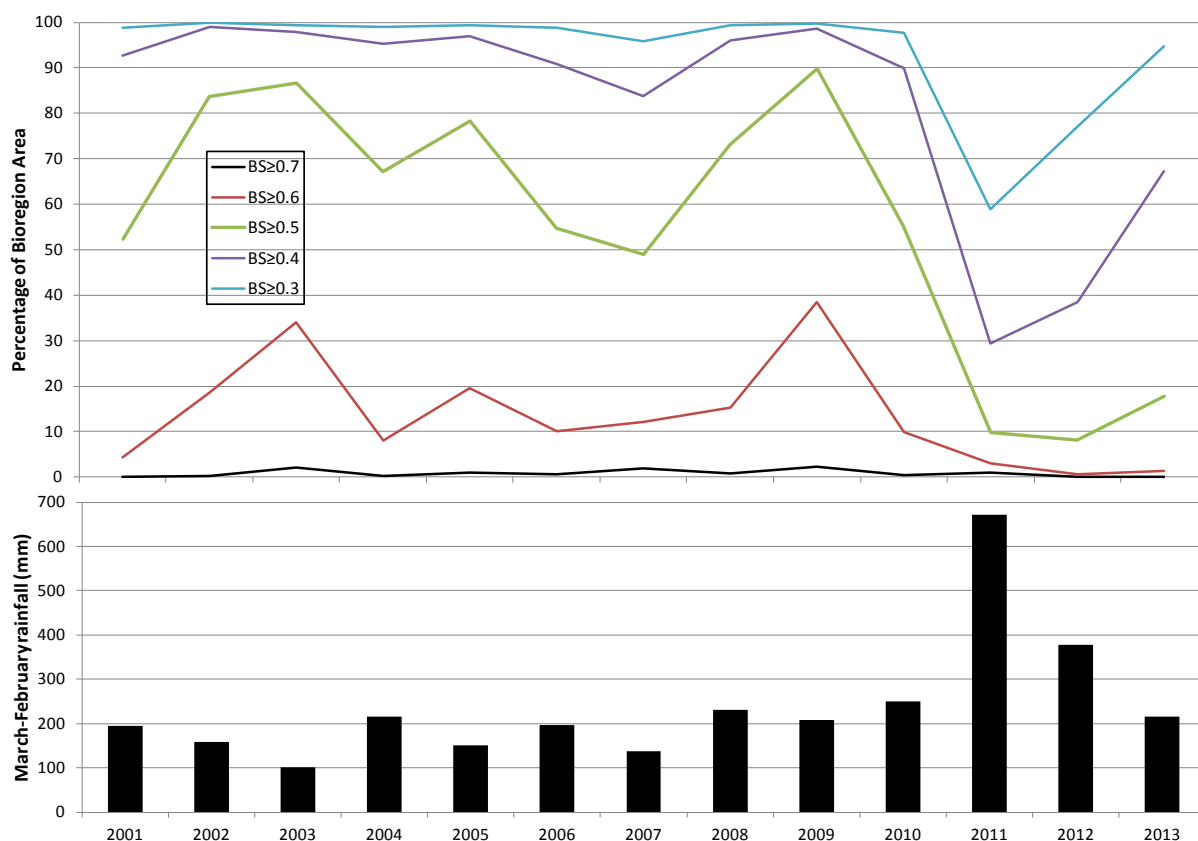
## 5. Caveats

- The algorithm for calculating fractional cover has been calibrated and validated according to rigorous ground data collected at ~1500 sites across Australia (Figure 1.1). Fractional bare soil at the scale of individual MODIS pixels may not be accurate everywhere.
- Nominated regional targets are suggestions only and should be set for the broad land types within NRM regions using the best available scientific information and stakeholder consultation.

## 6. Findings

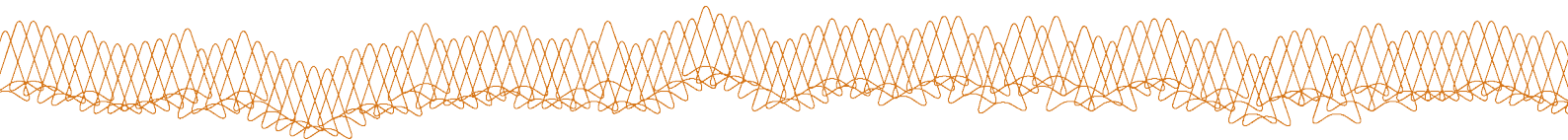
### 6.1 Broken Hill Complex, Western CMA as an example

The percentage area of the Broken Hill Complex having different levels of fractional bare soil between 2001 and 2013 is shown in Figure 6.1. This is based on a mid-March image for each year. Rainfall for the preceding 12 months (March to February) is also shown. Not surprisingly, a larger proportion of the bioregion area had intermediate levels of bare soil after the dry years of the mid to late 2000s (up to 2009), and the percentage area exceeding each bare-soil threshold declined substantially following the wetter years of



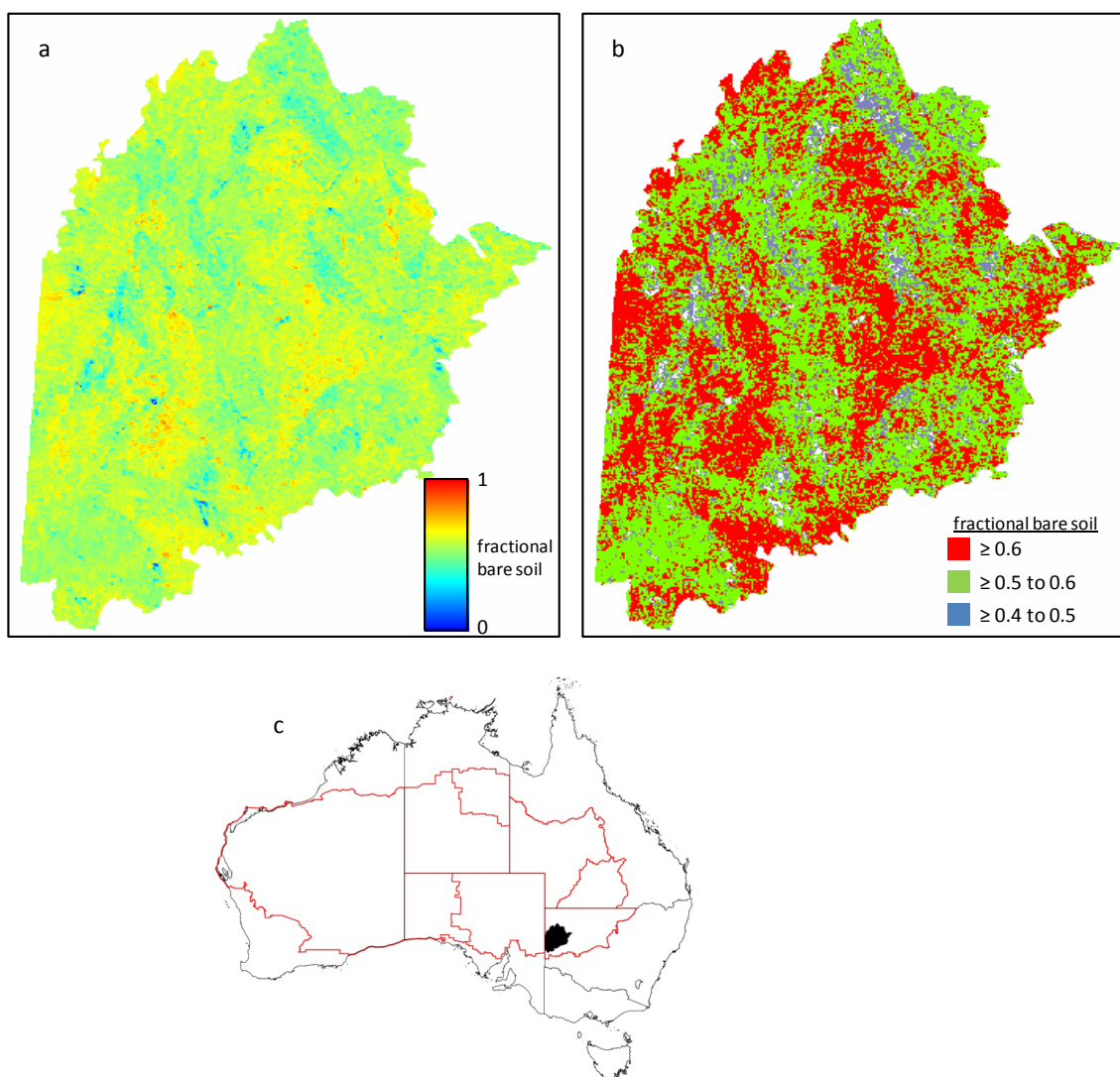
**Figure 6.1** Spatially averaged March-February rainfall between 2001 and 2013 for the Broken Hill Complex, Western CMA, and corresponding percentage areas of the bioregion exceeding specified thresholds of fractional bare soil.





2011 and 2012. The time traces of percentage area suggest that fractional bare-soil thresholds of  $\geq 0.6$  and  $\geq 0.5$  for each MODIS pixel (i.e. 25 ha area) are useful as regional targets for this land type. Correspondingly, for planning purposes, this means that we expect most of the area to have at least 50% or 60% vegetation cover (including trees and shrubs), and we will use fractional cover to monitor how much of the Broken Hill Complex achieves this target in March each year.

The spatial representation of three bare-soil thresholds is shown for mid-March of the very dry year, 2009, in Figure 6.2. Part (a) of the figure shows that fractional bare soil was between 0.4 and 0.6 in most pixels (i.e. green and yellow colours). Small areas were largely bare (i.e. red dots in parts of the image). Correspondingly for this dry time, much of the area exceeded the 0.5 and 0.6 fractional bare-soil targets (green and red colouring in part (b) of Figure 6.2).



**Figure 6.2 (a) Fractional bare soil in March 2009 for the Broken Hill Complex, Western CMA, (b) categories of bare soil mapped from the same image and (c) the location of the Broken Hill Complex in the Western CMA.**

### 6.1.1 Bare-soil targets for Western CMA bioregions

Nominated target thresholds for maximum levels of bare soil in each bioregion are highlighted near the top of Table 6.1. The percentage area of bioregions exceeding nominated targets in mid-March 2001 to 2013 is then listed in following rows of the table and graphed in Figure 6.3. (See Figure 2.2 for the location of bioregions within the Western CMA.)

The area of bioregions, along with their brief description, is available in Appendix A.

It should be clearly understood that the bare-soil thresholds listed in Table 6.1 are indicative only. If regional planners consider that the method demonstrated in this section for specifying targets and monitoring their outcomes has merit, they should undertake further evaluation to that presented here. Such evaluation could usefully include stakeholder consultation to gain consensus for sensible bare-soil targets for regional land types.

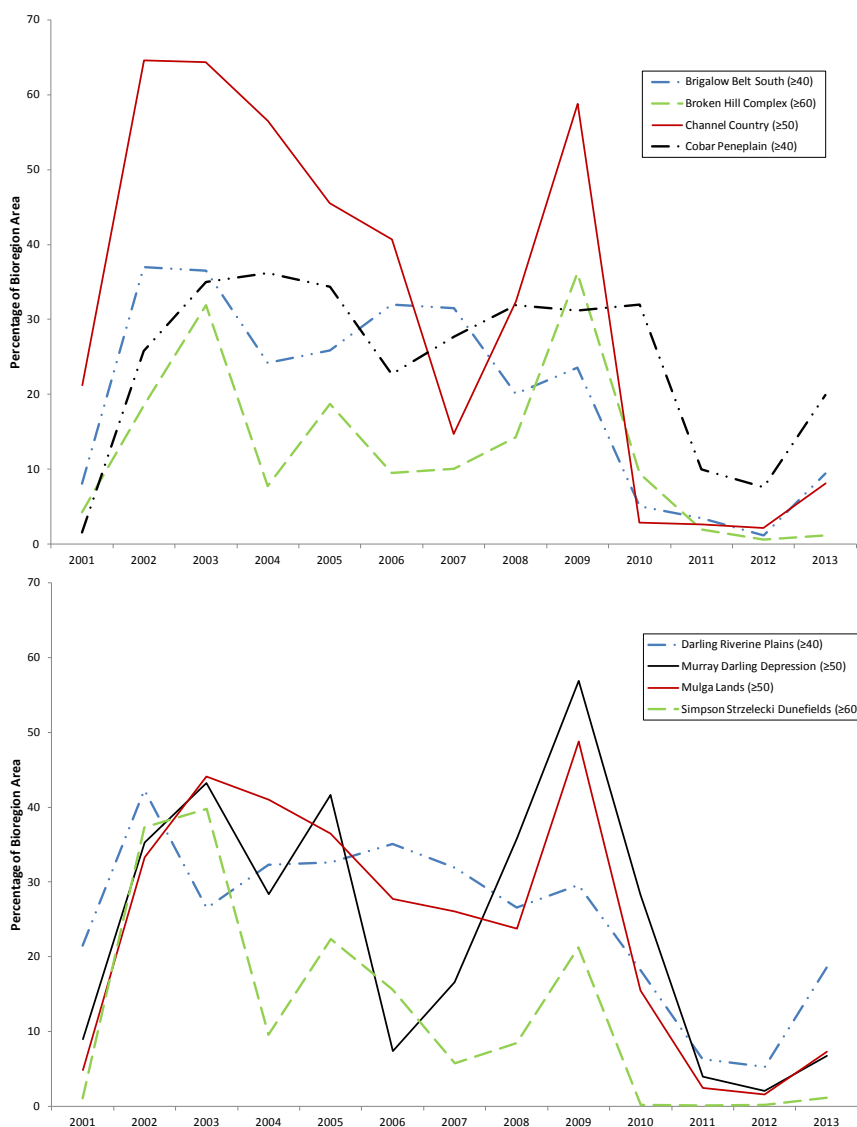
**Table 6.1 Nominated bare-soil thresholds for Western CMA bioregions and the percentage area exceeding each threshold in mid-March 2001 to 2013.**

BIOREGION								
	Brigalow Belt South	Broken Hill Complex	Channel Country	Cobar Peneplain	Darling Riverine Plains	Murray–Darling Depression	Mulga Lands	Simpson Strzelecki Dunefields
Bare soil threshold	≥40	≥60	≥50	≥40	≥40	≥50	≥50	≥60
2001	8.1	4.3	21.2	1.6	21.5	9.0	4.9	1.1
2002	37.0	18.5	64.6	25.8	42.3	35.3	33.3	37.3
2003	36.5	31.9	64.3	35.0	26.5	43.2	44.1	39.8
2004	24.2	7.8	56.5	36.2	32.3	28.4	41.0	9.6
2005	25.9	18.7	45.5	34.4	32.6	41.6	36.5	22.4
2006	32.0	9.5	40.7	22.7	35.1	7.4	27.7	15.6
2007	31.5	10.1	14.7	27.7	31.9	16.6	26.1	5.8
2008	20.1	14.3	32.4	31.9	26.6	35.8	23.8	8.5
2009	23.6	36.2	58.8	31.2	29.6	56.9	48.8	21.3
2010	5.1	9.4	2.9	32.0	18.2	28.3	15.5	0.2
2011	3.5	2.0	2.6	10.0	6.3	4.0	2.5	0.1
2012	1.2	0.6	2.2	7.6	5.3	2.1	1.6	0.2
2013	9.4	1.2	8.1	19.9	18.6	6.8	7.3	1.2

## 6.2 Bare soil targets for other Rangelands Cluster bioregions

The percentage area of major bioregions exceeding threshold levels of bare soil in other NRM regions in the Rangelands Cluster is tabulated in Appendix B. These data can be explored graphically to decide appropriate targets (e.g. Figure 6.1) and the results between 2001 and 2013 evaluated as shown in Figure 6.3.

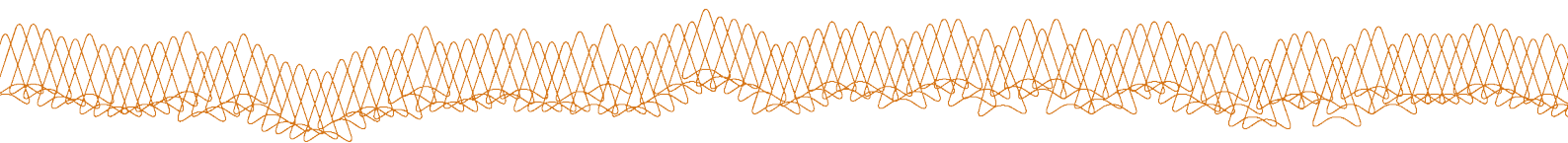
Appendix B is in two parts: the first table lists percentage areas of southern bioregions based on analysis of fractional bare soil in mid-March of each year; the second table presents corresponding results for northern bioregions using the mid-September image date. Highlighted rows in each table are our suggested threshold level of maximum bare soil for that bioregion and NRM region.



**Figure 6.3 The percentage area of bioregions in the Western CMA exceeding nominated target levels of bare soil in mid-March 2001 to 2013.**

Target levels of maximum bare soil are shown in brackets in the legend of each graph (see also Table 6.1).





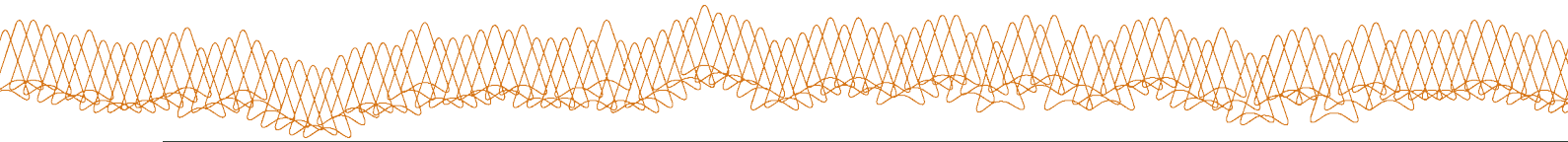
## 7. Key adaptation strategies

- Use the best sources of information, including remote sensing, and a stakeholder consultation process to set thresholds for maximum acceptable levels of bare soil (conversely, minimum vegetation cover) for the broadly different land types in each NRM region. These targets should seek to minimise the area of each land type (e.g. bioregion) that exceeds the nominated threshold in most years. Alternatively, set a target for dry/drought years that allows more bare soil, but ensure that the area exceeding this specified level of bare soil is minimised in such years. It certainly should not be approached at other times when more normal rainfall is received.
- Encourage land managers to meet these targets, perhaps by providing appropriate incentives.
- Use the now-available MODIS or Landsat TM fractional cover products to monitor the extent to which regional land-type (or bioregional) targets are being met.
- Be mindful that target values will need reviewing if vegetation composition, structure and function changes under projected climate change. Possible examples include:
  - an increased perennial component in the herbage layer as C<sub>4</sub> grasses (particularly buffel) establish: then decrease the level of acceptable bare soil
  - reduced opportunities for pasture growth with increased warming due to greater evapotranspiration: then possibly increase acceptable levels of bare soil.
- The need for revised targets will be clearer where the vegetation is changing relatively rapidly (e.g. establishment of buffel grass) but will be a much more difficult decision where slower change is immersed in year-to-year variability associated with the amount and timing of rainfall.

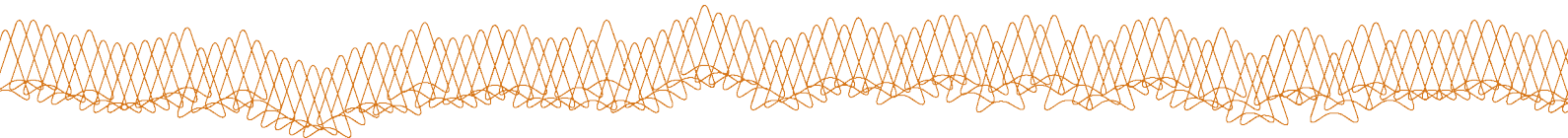
## Appendix A Bioregions and their areas

A brief description of bioregions (IBRA v7) present in the Rangelands cluster region and the area in each in each NRM region is provided in the following table.

BIOREGION	DESCRIPTION	NRM REGION	AREA (KM <sup>2</sup> )
Brigalow Belt South	The region contains mixed landscapes including undulating to hilly areas with low ridges and deep valleys as well as flat alluvial plains in the south. There is a large distance between the extreme southern sections in northern NSW and those parts in rangeland Queensland. Vegetation is predominantly mixed eucalypt woodland with areas of brigalow scrubs and open Mitchell grasslands. Tenure is mostly leasehold with cattle grazing being the major land use. Relatively small outliers of the bioregion occur in northern NSW.	Western (NSW) SW NRM (Qld) Desert Channels (Qld)	3,630 14,599 4,726
Broken Hill Complex	Land types include low ranges, rounded hills and gently undulating downs. Chenopod downs country occupies the majority of this bioregion. Tenure is mostly pastoral leasehold with some nature reserves. Grazing, by sheep and increasingly cattle, is the most extensive land use. Mining for silver, lead, zinc and copper is still important to the region's economy and tourism has grown in recent years. Broken Hill is the major population centre.	Western (NSW) Arid Lands (SA)	37,665 18,687
Burt Plain	Landscapes characterised by plains and low rocky ranges. Vegetation is predominantly mulga and other acacia woodlands with short grasses and forbs, and spinifex grasslands. The predominant land use is cattle grazing with some Aboriginal land. Communities include Aileron, Barrow Creek, Ti Tree and Yuendumu.	Arid Lands (NT)	73,797
Carnarvon	Low gently undulating landscape with open drainage. Vegetation is mainly Acacia shrublands and saltbush/bluebush shrublands with areas of tussock grassland in the north. Major land tenure is pastoral leasehold, with some conservation reserves, such as the Cape Range National Park. The region has a range of industries including extensive cattle and sheep grazing, salt mining, tourism and fishing. Major population centres are Carnarvon, Denham, Exmouth and Coral Bay.	WA Rangelands	84,302

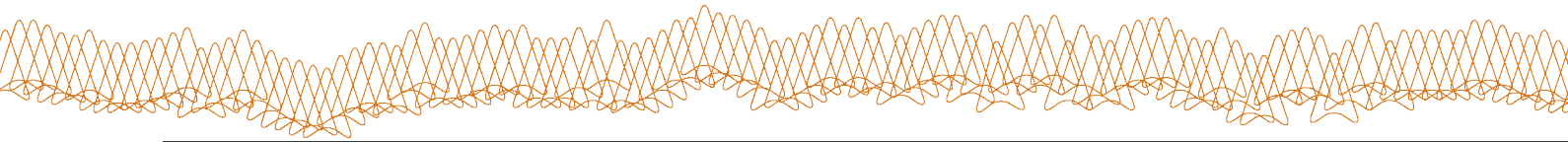


BIOREGION	DESCRIPTION	NRM REGION	AREA (KM <sup>2</sup> )
Central Ranges	Landforms dominated by rugged ranges and red sandplains. The vegetation is predominantly mulga open woodland over spinifex grasslands. The entire bioregion is Aboriginal land and there are many small Aboriginal communities in this area. Larger communities include Warburton and Warakurna in WA; Ernabella, Kaltjiti (Fregon) and Amata in SA; and Kaltukatjara (Docker River) in the NT.	WA Rangelands Arid Lands (NT) Arid Lands (SA) Alinytjara Wilurara	47,015 26,196 453 27,977
Channel Country	Vast braided, flood and alluvial plains surrounded by gravel or gibber plains, dunefields and low ranges. Vegetation is predominantly Mitchell grass, gidgee and spinifex. Major population centres are Birdsville, Windorah and Innaminka.	Desert Channels SW NRM (Qld) Arid Lands (SA) Arid Lands (NT) Western (NSW)	189,998 15,867 51,597 23,276 23,355
Cobar Penepplain	Landscapes include undulating low rounded ridges, rolling downs and plains. A large area of the bioregion is rangeland, where land tenure is predominantly leasehold (Western Division) and vegetation consists of poplar box woodlands, mulga communities and white cypress pine. The eastern-most part of the bioregion has freehold title (Central Division) and has largely been cleared for cereal cropping. The dominant land use (in terms of area) in the rangelands is sheep and goat grazing with some cattle production. Dryland cropping is also important within the eastern margins of the rangeland zone and becomes dominant further to the east. Copper mining occurs around Cobar, the major population centre.	Western (NSW)	37,037
Coolgardie	Landforms include granite rocky outcrops, low greenstone hills, laterite uplands and broad plains. Numerous salt lakes also occur through the bioregion. The Coolgardie bioregion covers the interzone between mulga/spinifex country and eucalypt environments. Land tenure includes pastoral lease, Aboriginal land and several National Parks and reserves. Gold and nickel mining are very important to the region's economy. Regional income is supplemented by pastoral activity and tourism. Major population centres are Kalgoorlie, Coolgardie and Norseman.	WA Rangelands	84,857

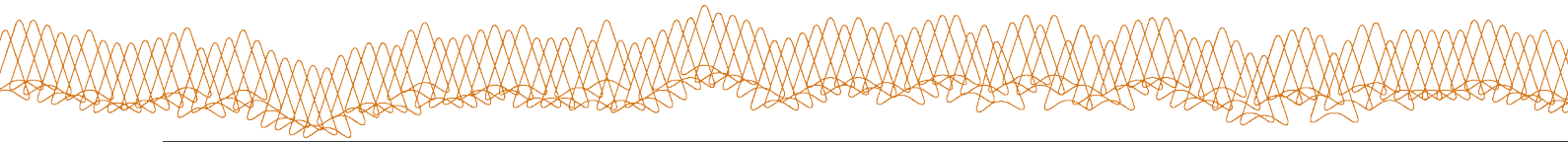


BIOREGION	DESCRIPTION	NRM REGION	AREA (KM <sup>2</sup> )
Darling Riverine Plains	The bioregion includes the extensive alluvial plains of the network of rivers and creeks that flow into the Darling River together with its floodplain. Vegetation includes river red gum, blackbox and coolibah woodlands with inliers of poplar box, belah, redbox and ironbark woodlands on higher parts of the landscape. Major tenure is leasehold in the Western Division and freehold in the Central Division of NSW. Sheep and cattle grazing is the main land use; other land uses include dryland cropping, irrigated cotton, horticulture, and at Lightning Ridge, black opal mining. Major population centres are Wilcannia, Bourke, Brewarrina, Nyngan (all in NSW) and St George (Qld).	Western (NSW) SW NRM (Qld)	38,656 539
Davenport Murchison Ranges	The bioregion is characterised by a chain of rocky ranges surrounded by lowland plains. Vegetation is predominantly eucalypt low open woodland and acacia sparse shrubland over hummock grassland. Land tenure includes Aboriginal land, pastoral leases and the Davenport-Murchison National Park. Mining for gold production occurs at Tennant Creek. Major population centres are Tennant Creek and Warrego.	Tablelands (NT) Arid Lands (NT)	49,654 8,397
Desert Uplands	Upland landforms dominated by sandstone ranges and sand plains, thickly vegetated with eucalypt woodlands with a spinifex understorey as well as acacia woodlands. Most of the bioregion is under leasehold tenure and is used for cattle grazing and some sheep grazing in the west. Major population centres are Barcaldine and Pentland.	Desert Channels (Qld)	42,146
Einiasleigh Uplands	Landforms consist of a series of rugged hills and ranges, dissected plateaus and alluvial and sand plains. The bioregion is dominated by eucalypt woodlands. Land is used extensively for grazing with some mining, cropping and horticulture. There are several nature reserves. Major population centres are Charters Towers, Georgetown and Mareeba.	Desert Channels (Qld)	48
Finke	The main land types are arid sand plains with dissected uplands and valleys, including some major rivers (Finke, Hugh and Palmer). The bioregion is dominated by mulga with various Senna, Eremophila and other Acacia species present over short grasses and forbs. Major land uses are cattle grazing and Aboriginal land management. Major population centres are Finke and Imanpa.	Arid Lands (NT) Arid Lands (SA) Alinytjara Wilurara	53,520 12,322 6,833





BIOREGION	DESCRIPTION	NRM REGION	AREA (KM <sup>2</sup> )
Flinders Lofty Block	The bioregion has a general pattern of mountain ranges, ridges and wide flat plains. Vegetation types are related to landforms with eucalypts on hills and ranges that receive higher rainfall, mulga in the drier areas, and sparse low shrubs or spinifex on stony areas. The area is mainly used for sheep and cattle grazing. Conservation reserves and associated tourism are also important. Coal is mined at Leigh Creek and there is limited dryland agriculture in the south and east. Major population centres are Olary, Hawker, Quorn, and Leigh Creek.	Arid Lands (SA)	38,661
Gascoyne	Low rugged ranges and broad flat valleys. Open mulga low woodlands dominate. Extensive sheep and cattle grazing is the dominant land use on pastoral leasehold in the bioregion. Mining is important to the region's economy. There are no major population centres in the bioregion. Aboriginal communities include Jigalong and Burringurrah.	WA Rangelands	180,753
Gawler	Characteristic landscapes are rounded, rocky hills, plains and salt-encrusted lake beds. Vegetation types include spinifex grasslands, open woodlands and chenopod shrubs. Sheep and some cattle grazing is the most extensive industry (in terms of area) but mining, particularly copper, uranium and gold at Olympic Dam, provides the main source of revenue. Iron ore is also extracted in the Iron Knob area. Major population centres are Whyalla, Port Augusta, Roxby Downs and Woomera.	Arid Lands (SA) Alinytjara Wilurara	113,022 4,508
Gibson Desert	Vast undulating sand plains, dunefields, and lateritic gibber plains. The vegetation is mainly mulga and other mixed shrubs over spinifex. The bioregion includes Aboriginal land, Unallocated Crown Land and conservation reserves. Conservation and Aboriginal land are the main land uses. The bioregion has a very low population with the major centres being the Kanpa, Patjarr and Tjirrkarrli Aboriginal communities.	WA Rangelands	156,289
Great Sandy Desert	Red sandplains, dunefields and remnant rocky outcrops. Vegetation is predominantly spinifex grasslands, low woodlands and shrubs. Tenure comprises Unallocated Crown Land, conservation reserves and Aboriginal land, with the main industries being tourism, mining and mineral exploration. Major population centres are Telfer (WA) and Yulara (NT).	WA Rangelands Arid Lands (NT)	295,396 99,465



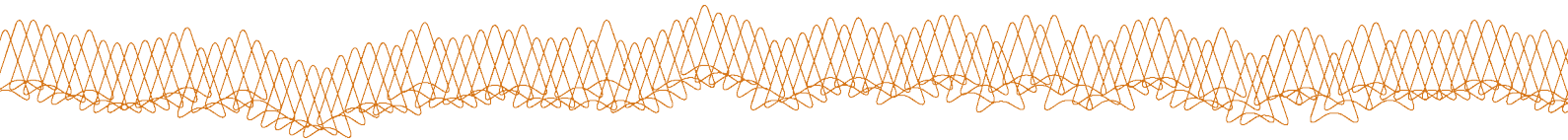
BIOREGION	DESCRIPTION	NRM REGION	AREA (KM <sup>2</sup> )
Great Victoria Desert	A desert region characterised by dunefields with playa lakes and lunettes. Vegetation is predominantly marble gum, mulga and yarldarlba over spinifex grassland. Most of the bioregion is Unallocated Crown Land, conservation reserves and Aboriginal land. As such, it has very low pastoral value and is little developed. There are no major population centres in the bioregion but there are a number of small Aboriginal communities. Cosmo Newberry is probably the best known.	WA Rangelands Alinytjara Wilurara Arid Lands (SA)	217,942 186,133 16,360
Gulf Fall and Uplands	Landscapes include spectacular gorges, water holes and dissected sandstone plateaus. Vegetation is predominantly eucalypt woodlands over spinifex grasslands. Cattle grazing and mining are the main industries. Other land uses include Aboriginal land and conservation reserves. Major population centres are Borroloola and Ngukurr.	Tablelands (NT)	37,259
Hampton	Landforms include marine dunes and limestone escarpments. Vegetation is a mix of mallee, eucalypt and myall woodlands. Tenure is mainly pastoral leasehold and Unallocated Crown Land with pastoralism as the main industry. The main population centre is Eucla.	WA Rangelands Alinytjara Wilurara	10,430 452
Little Sandy Desert	This desert region is characterised by dunefields and low ranges. Vegetation is mainly a shrub steppe of acacia over spinifex. Tenure is predominantly Aboriginal land with some Unallocated Crown Land, conservation reserves and the eastern margins of several pastoral leases. Mineral exploration is also an important industry. There are no major population centres in the bioregion. Parnngurr is one of the smaller Aboriginal communities in the region.	WA Rangelands	110,899
MacDonnell Ranges	Landforms characterised by high-relief ranges and foothills. Spinifex and acacias, particularly mulga, occur throughout the region. Land tenure is pastoral leasehold, conservation reserve and Aboriginal freehold. The main industries are cattle grazing and tourism. Alice Springs is the major population centre.	Arid Lands (NT)	39,294

## Appendix B Threshold levels of bare soil for bioregions within NRM regions

The percentage area of major bioregions (by area) exceeding threshold levels of bare soil in Rangelands cluster NRM regions is listed in the following two tables. The first table provides the percentage area of southern bioregions exceeding specified levels of bare soil based on analysis of mid-March images from 2001 to 2013. The second table presents corresponding results for northern bioregions using the mid-September image date. Highlighted rows suggest the appropriate target for each bioregion and NRM region.

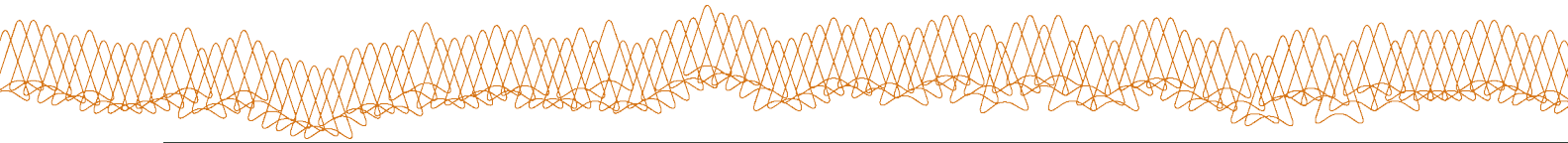
### B1. Mid-March analysis

IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
<b>NSW Western</b>														
Brigalow Belt South	≥70	0.1	0.1	1.5	1	0.1	1.2	1.4	0.5	0.3	0.1	0.2	0	0.4
	60.0-69.9	0.7	2.6	7.8	3	0.7	4.5	8.7	1.8	1	0.4	0.4	0.1	0.9
	50.0-59.9	3.5	13.9	25.9	10.3	7.4	16.2	22.9	5.6	6.3	1.7	1.1	0.3	3.2
	40.0-49.9	8.1	37	36.5	24.2	25.9	32	31.5	20.1	23.6	5.1	3.5	1.2	9.4
	30.0-39.9	23.1	34.9	21.7	32.4	37.3	30.1	26.5	37.8	44.1	20	11.8	6.1	23.2
Broken Hill Complex	≥70	0	0.2	2.1	0.2	0.9	0.6	1.9	0.9	2.3	0.5	0.9	0	0.1
	60.0-69.9	4.3	18.5	31.9	7.8	18.7	9.5	10.1	14.3	36.2	9.4	2	0.6	1.2
	50.0-59.9	48.1	65	52.6	59.2	58.7	44.6	36.9	57.8	51.4	45.1	6.9	7.5	16.6
	40.0-49.9	40.3	15.4	11.2	28.1	18.6	36.1	34.8	23.1	8.8	34.8	19.5	30.5	49.4
	30.0-39.9	6.3	0.9	1.6	3.9	2.5	7.9	12.1	3.3	1.1	7.9	29.6	38.5	27.5
Channel Country	≥70	0	0.2	0.2	0.1	0.1	0.3	1.1	0.1	0.2	0.2	0.1	0.1	0
	60.0-69.9	0.3	2.6	12	3.2	2.6	3.7	2.8	1.7	4.9	0.3	0.4	0.3	0.3
	50.0-59.9	21.2	64.6	64.3	56.5	45.5	40.7	14.7	32.4	58.8	2.9	2.6	2.2	8.1
	40.0-49.9	60.9	25.3	15	28.7	40.3	40.5	39.3	46.6	27.1	25.5	14.6	20	51.8
	30.0-39.9	10.4	4.7	4.4	6.2	7.2	9.5	25.7	13	6.2	45.7	34.5	44.8	31

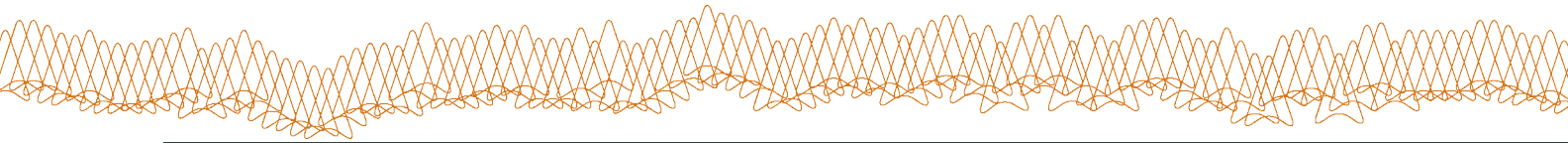


IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Cobar Penepplain	≥70	0	0	0.5	0.1	0.1	0.1	0.4	0.2	0.8	0.1	0.3	0	0
	60.0-69.9	0	0.3	4.7	1.3	2.2	0.6	1.6	1.9	7.5	0.9	1	0.1	0.3
	50.0-59.9	0.3	4.2	19.8	11.9	15.8	5.2	9	13.3	22.8	10.5	3	0.8	3.8
	40.0-49.9	1.6	25.8	35	36.2	34.4	22.7	27.7	31.9	31.2	32	10	7.6	19.9
	30.0-39.9	9.5	51.4	31	38.4	33.1	39	38.3	35.8	27.6	41.6	27.2	29.1	38.2
Darling Riverine Plains	≥70	0.1	0.7	1.6	1.1	0.6	1.5	2.6	0.4	0.4	0.1	0.5	0.3	0.1
	60.0-69.9	0.4	5.6	15.6	7.4	6.6	8	12.7	2.3	5.7	0.7	0.8	0.5	0.5
	50.0-59.9	6.7	33.5	46.2	31.6	33.3	25.6	34.7	13.2	29.3	6.5	2.2	1.7	4.8
	40.0-49.9	21.5	42.3	26.5	32.3	32.6	35.1	31.9	26.6	29.6	18.2	6.3	5.3	18.6
	30.0-39.9	31.9	13.2	7.4	15.6	17.5	20.8	13.2	24.1	22.8	18.4	14.2	13.7	26.7
Murray Darling Depression	≥70	0	0.2	1.1	0	0.4	0.1	0.9	0.3	0.4	0	0.5	0	0.1
	60.0-69.9	0.2	8.2	21.9	1.6	6.8	0.7	3.4	6.1	15	1.7	1.3	0.1	0.4
	50.0-59.9	9	35.3	43.2	28.4	41.6	7.4	16.6	35.8	56.9	28.3	4	2.1	6.8
	40.0-49.9	34.7	30.5	22.1	48	34.9	33.6	36.5	40.4	21.5	53	13.8	20.1	38.5
	30.0-39.9	27.9	20.4	9.1	17.4	12.6	40.3	30.3	14.9	5.4	15.6	28.6	44.1	40
Mulga Lands	≥70	0	0.1	0.3	0.2	0.2	0.3	1.7	0.3	0.2	0.2	0.2	0.1	0.1
	60.0-69.9	0.1	1.5	8.3	3.2	4.1	3	5.6	2.2	8	1.1	0.6	0.2	0.4
	50.0-59.9	4.9	33.3	44.1	41	36.5	27.7	26.1	23.8	48.8	15.5	2.5	1.6	7.3
	40.0-49.9	29.4	46.1	34.1	42.5	42	46.7	43	44	29.4	40.3	10.5	13.1	38.7
	30.0-39.9	37.9	17.3	10.8	10.5	14	17.5	17.7	19.9	10.3	22.8	28.7	37.5	34.4
Simpson Strzelecki Dunefields	≥70	0	0	0.2	0	0.2	0.5	0.7	0.3	0.3	0	0	0	0.1
	60.0-69.9	1.1	37.3	39.8	9.6	22.4	15.6	5.8	8.5	21.3	0.2	0.1	0.2	1.2
	50.0-59.9	63.5	59.4	56.1	79	71.6	63.8	47.4	60.5	64.7	4.8	0.6	1.7	9.2
	40.0-49.9	33.7	3.1	3.3	10.5	5.2	18.3	38	27.9	12.6	46.7	6.3	17.9	61
	30.0-39.9	1.3	0.1	0.5	0.7	0.4	1.6	6.7	2.6	0.9	42.8	31.1	54.7	27.2
<b>SA Arid Lands</b>														
Broken Hill Complex	≥70	0.1	0.1	3	1.3	1.3	0.3	1.5	2.2	3.5	0.7	2.2	0.1	0.2
	60.0-69.9	8.2	16.5	47.6	35.6	35.1	11.4	13.5	29.8	47.7	16.4	6.6	2.5	8.8

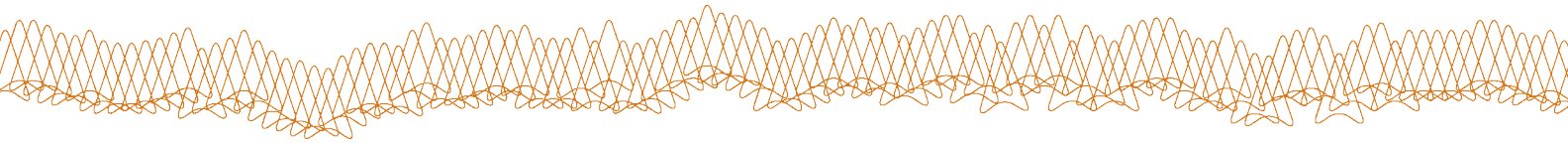




IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	50.0-59.9	69.9	63.5	44.4	55.9	59.6	64.2	51.9	53.3	44.6	57.5	21.5	26.1	51.6
	40.0-49.9	21.5	19.5	4.1	6.5	3.6	22.1	28.3	13	3.8	22.1	35.6	48.9	33.5
	30.0-39.9	0.4	0.5	0.6	0.5	0.3	1.7	4.1	1.5	0.3	2.8	22.9	19.4	5.5
Flinders Lofty Block	≥70	0.5	0.5	3.9	2.6	2.7	2.1	4	2.4	3.1	2.4	2.6	1.2	0.6
	60.0-69.9	7.7	5.4	22.9	18.6	19.5	14	15.7	17.2	22.6	22.1	8.1	6.8	7.9
	50.0-59.9	40.6	37.5	41.8	43.1	43.3	39.5	36.5	44.5	43.2	42.5	22.5	24.8	34.9
	40.0-49.9	36.5	35.8	19.3	22	20.4	26.8	26.1	23	19.7	21.5	33	37	37.1
	30.0-39.9	9.1	11.9	8.2	8.9	9.1	11.2	11.3	8.4	7.5	8.3	22	21.5	14.2
Gawler	≥70	4.5	0.5	7.4	1.8	1.3	5.8	4.9	2.7	6.1	1.5	1.9	1.8	1.6
	60.0-69.9	24.1	12.3	31.5	28.4	21.2	27.9	14.3	26.1	30.6	23.6	10.6	16.7	21.3
	50.0-59.9	30.8	33.8	33.4	37.8	42.5	31.5	31.2	35.9	32	35.8	31.5	39	41.2
	40.0-49.9	17.5	26.7	10.9	14	15.4	14.5	22.9	17.1	14	15.6	27.1	19.8	16.2
	30.0-39.9	7.7	11.6	4.5	5.1	6.2	5.9	10.2	5.9	4.3	7.5	11.2	7.2	6.1
<b>Alinytjara Wilurara</b>														
Great Victoria Desert	≥70	9.1	0.1	7.6	6.6	2.5	9.9	10	5.5	7	2.9	3.3	2.6	6.8
	60.0-69.9	22.7	10.4	30.5	35.5	22.4	34.2	25.2	25.4	28.7	21.4	17.7	13.1	22.9
	50.0-59.9	36.5	52.2	41.4	35.5	40.3	32.6	31.1	33.9	39.2	37.4	40.7	26.4	37.5
	40.0-49.9	25.1	27.9	18.4	18.9	28.4	19.5	21.7	28.2	21.9	27.7	29	37.9	27.5
	30.0-39.9	5.6	7.8	1.7	3	5.6	3.2	8.7	6.3	2.6	8.7	7.5	17.5	4.6
Nullarbor	≥70	0.1	0	0.1	0.2	0.1	0.1	1.3	0.1	0.2	0.8	0.3	0.1	0.2
	60.0-69.9	2.2	1.1	0.7	2.4	0.5	0.6	2.2	1.4	4.7	4.7	0.9	0.2	1.1
	50.0-59.9	10.8	7.7	9.4	10.6	6.6	7	6.9	8.9	11.5	9.6	4.5	0.9	10
	40.0-49.9	38.9	22.3	38.1	38.6	19.1	20.5	16.9	23.7	48.9	26.6	12.3	6.9	29.3
	30.0-39.9	45.1	59.6	49.3	46.2	61.3	59.1	33.5	53.1	32.8	47.4	36.7	31.6	49
<b>WA Rangelands</b>														
Coolgardie	≥70	0.7	0.1	0.8	0.2	1.5	0.9	0.5	0.8	0.1	1	0.5	0.4	0.4
	60.0-69.9	1.8	0.5	2.3	1.3	1.5	3	3.2	3.2	1.2	2.1	2.9	1.5	1.2
	50.0-59.9	1.8	4.4	7.4	6.9	4.2	9.1	10	10.4	7.5	7.6	11.7	6.1	5.7

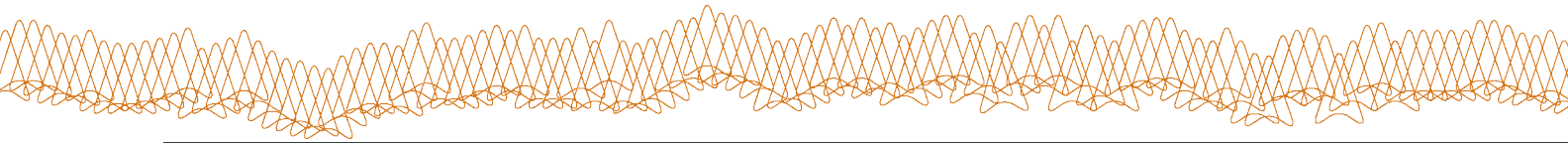


IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	40.0-49.9	5.9	14.2	18.1	17.4	12.1	19.3	20.6	20.2	17.3	16.2	23.1	18	19
	30.0-39.9	28.3	33.8	30.5	34.9	22.8	32.6	32.4	33.4	31	25.4	35.3	33.5	35.1
Great Victoria Desert	≥70	4.8	1.9	6.2	2	1.4	0.8	3.8	2.3	1.6	1.8	2.1	0.5	7.8
	60.0-69.9	10.2	6.8	13.2	9.9	5.2	5.1	8.4	5.5	7.7	7.8	9.8	1.4	12
	50.0-59.9	21	26.1	26.6	33.1	21	23.5	21.4	16.5	28.7	23.2	28.6	7.1	22.9
	40.0-49.9	34.7	36.6	33.7	35.5	38.4	43.5	33.8	34.8	41.7	36.2	39.3	26.8	33.3
	30.0-39.9	24.2	22.6	15.4	15.6	23.4	22.1	22.8	28.8	16.7	23.3	16.2	40.6	17.8
Murchison	≥70	1	0.2	1.3	0.4	0.3	0.2	0.2	0.5	0.3	0.4	0.6	0.3	0.2
	60.0-69.9	1.7	1	3.4	2.6	1.6	1.4	1.2	1.9	2.2	2.3	3	1.4	1.2
	50.0-59.9	3.3	10.2	13	16	10	9	7.9	10.4	13.4	12.7	11.7	6.7	9.3
	40.0-49.9	23.6	45.2	33.7	39.3	33	33.1	30.9	37.2	38.2	34.5	29.1	22	34.8
	30.0-39.9	47.6	33	30.3	29.5	34.2	39.6	40.3	35.2	32.4	31.2	36	38.6	36.4
Nullarbor	≥70	0	0	0	0	0.1	0	0.6	0.1	0	0.4	0.1	0.2	0.5
	60.0-69.9	0.6	0.5	0.5	0.8	0.5	0.2	1.6	0.7	1.6	3	0.6	0.9	2.4
	50.0-59.9	10.4	10.9	11.5	14.1	6.3	5.2	8.6	6.9	15.1	15.1	4.3	3.5	10.3
	40.0-49.9	16.7	26	48.7	56	37.1	32.8	30.8	34.7	49.7	37.2	17.8	12.4	32.4
	30.0-39.9	43	55.8	37	27.7	47.1	40.4	36.1	47.9	31.4	34.2	27.3	26.1	38



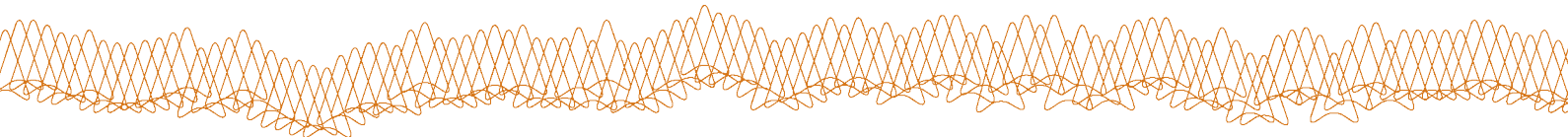
## B2. Mid-September analysis

IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
<b>South West NRM</b>														
Brigalow Belt South	≥70	0.1	0.3	0.2	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.1	0.0	0.0
	60.0-69.9	0.3	0.9	0.9	0.5	0.5	3.1	3.5	0.0	0.1	0.0	0.2	0.0	0.2
	50.0-59.9	1.1	5.6	8.0	3.8	4.2	17.9	18.9	0.7	2.5	0.1	0.3	0.1	1.0
	40.0-49.9	8.4	19.5	22.7	16.0	20.2	23.4	26.0	7.5	14.8	0.9	0.7	0.5	6.0
	30.0-39.9	24.7	24.4	23.8	22.6	31.6	19.2	21.1	22.8	21.8	4.9	4.6	3.4	24.1
Channel Country	≥70	0.0	0.8	0.1	0.2	0.1	0.4	0.1	0.1	0.5	0.4	0.0	0.0	0.0
	60.0-69.9	0.0	14.8	6.8	3.0	1.6	11.9	3.8	3.1	18.9	1.2	0.1	0.1	1.0
	50.0-59.9	17.4	50.1	63.4	58.2	49.4	62.8	49.1	53.4	57.1	7.6	0.9	2.4	18.6
	40.0-49.9	58.8	24.3	23.4	30.4	39.7	18.2	33.2	32.5	16.7	37.3	8.9	19.0	49.3
	30.0-39.9	18.5	6.5	4.6	5.5	6.4	4.7	8.5	6.1	4.6	34.6	34.5	42.3	26.0
Mitchell Grass Downs	≥70	0.0	0.0	0.3	0.1	0.1	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	60.0-69.9	0.1	1.5	6.6	3.9	1.7	8.5	8.0	0.2	0.8	0.2	0.0	0.1	0.6
	50.0-59.9	6.3	16.0	37.7	28.8	18.3	37.5	47.7	6.3	18.3	1.0	0.1	0.3	7.3
	40.0-49.9	39.7	39.2	38.3	39.9	44.1	38.4	37.0	29.8	45.7	4.7	1.8	3.6	30.5
	30.0-39.9	35.8	31.6	13.5	19.8	26.8	12.1	6.0	35.5	26.9	15.0	14.7	20.2	35.9
Mulga Lands	≥70	0.0	0.2	0.3	0.1	0.2	0.3	0.5	0.0	0.1	0.1	0.1	0.0	0.2
	60.0-69.9	0.1	3.1	8.9	3.6	3.9	6.7	12.3	1.6	3.4	0.3	0.1	0.0	1.3
	50.0-59.9	5.2	22.4	38.3	34.9	32.2	37.4	46.7	19.7	27.9	2.4	0.7	0.5	10.0
	40.0-49.9	37.2	36.9	33.0	39.0	40.9	37.4	29.7	39.8	41.0	14.4	9.1	7.4	38.4
	30.0-39.9	40.1	23.1	14.0	16.3	17.2	13.5	7.9	28.0	21.5	29.7	34.1	32.3	34.3
<b>Desert Channels Queensland</b>														
Channel Country	≥70	0.5	1.1	0.6	0.5	0.5	0.6	0.2	0.2	0.1	0.5	0.1	0.2	0.4
	60.0-69.9	0.8	6.2	7.4	8.4	5.6	10.6	5.5	5.6	5.9	2.3	0.7	2.6	5.2

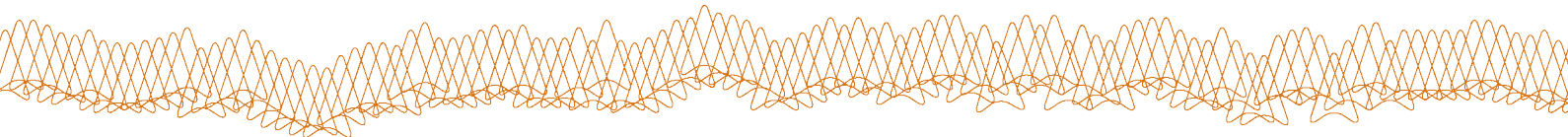


IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	50.0-59.9	12.7	34.0	39.3	39.5	38.1	43.7	34.5	41.9	36.2	14.2	5.6	14.8	29.8
	40.0-49.9	34.2	32.6	30.3	26.9	34.9	25.9	34.6	31.8	27.0	33.6	18.3	30.9	37.2
	30.0-39.9	27.2	15.2	13.8	14.2	13.4	10.4	14.6	11.7	15.2	26.5	30.7	30.1	15.9
Desert Uplands	≥70	0.1	0.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2
	60.0-69.9	0.2	1.8	4.5	0.7	0.9	0.6	0.7	0.2	0.2	0.1	0.2	0.1	1.4
	50.0-59.9	2.1	8.4	17.2	7.5	13.8	8.6	10.2	1.9	1.6	0.5	0.6	0.4	5.5
	40.0-49.9	8.7	21.4	36.4	26.9	38.6	34.5	34.6	13.0	8.3	2.0	2.5	3.1	15.0
	30.0-39.9	26.1	30.6	27.2	37.1	30.5	38.6	34.4	32.4	20.8	7.8	9.3	12.7	28.2
Mitchell Grass Downs	≥70	0.0	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.2	0.0	0.0	0.1
	60.0-69.9	0.1	1.7	3.1	1.2	2.9	4.2	6.5	4.6	0.7	1.1	0.1	0.7	2.9
	50.0-59.9	1.4	16.5	28.4	18.0	33.8	28.4	36.1	34.6	8.4	8.5	2.6	9.6	25.9
	40.0-49.9	13.6	35.6	39.7	34.7	44.4	30.5	35.6	33.2	18.3	23.0	14.2	27.4	37.9
	30.0-39.9	26.6	26.7	20.7	26.9	13.6	17.0	14.9	16.3	18.5	28.3	25.1	26.3	20.5
Mount Isa Inlier	≥70	0.2	1.7	0.1	0.0	0.1	0.1	0.1	0.7	0.0	0.1	0.0	0.9	1.6
	60.0-69.9	0.4	6.6	2.7	0.9	3.3	1.8	2.4	6.0	0.0	0.5	0.0	4.5	9.7
	50.0-59.9	1.4	14.6	19.0	9.6	20.3	11.3	14.8	23.9	0.1	4.3	0.4	13.3	25.9
	40.0-49.9	4.2	25.3	34.9	26.5	30.9	22.7	27.6	27.6	1.9	19.5	2.9	27.1	28.2
	30.0-39.9	16.9	25.1	25.3	32.0	23.9	29.2	27.9	20.8	12.6	35.0	17.3	26.2	19.6
Mulga Lands	≥70	0.0	0.1	0.2	0.1	0.0	0.1	0.2	0.1	0.1	0.3	0.0	0.0	0.0
	60.0-69.9	0.1	2.0	3.3	2.5	1.4	2.6	5.8	2.7	2.5	1.2	0.0	0.1	0.5
	50.0-59.9	5.8	20.4	26.1	24.3	21.4	24.8	33.2	25.8	26.4	8.1	0.4	1.7	9.3
	40.0-49.9	38.7	36.0	35.6	37.8	40.2	35.9	32.0	36.4	37.1	29.6	9.1	20.0	38.7
	30.0-39.9	30.9	22.6	19.8	21.6	22.9	21.5	17.5	21.3	21.0	35.1	39.0	42.3	27.3
Simpson Strzelecki Dunefields	≥70	0.0	7.1	4.7	5.3	1.0	1.7	0.1	0.2	0.2	0.2	0.1	1.1	2.3
	60.0-69.9	0.1	18.5	22.5	25.8	28.6	43.7	8.9	16.6	20.9	1.3	0.3	15.5	32.3
	50.0-59.9	27.4	48.9	62.6	65.2	63.3	50.9	48.1	68.8	57.2	25.9	1.5	38.5	43.4
	40.0-49.9	49.2	23.7	9.2	3.5	6.4	3.4	38.8	13.8	20.1	57.9	19.0	30.2	19.8
	30.0-39.9	22.2	1.6	0.6	0.2	0.4	0.2	3.7	0.4	1.5	12.5	50.5	12.3	1.9

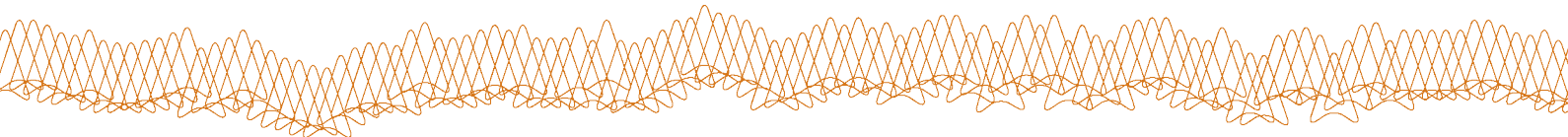




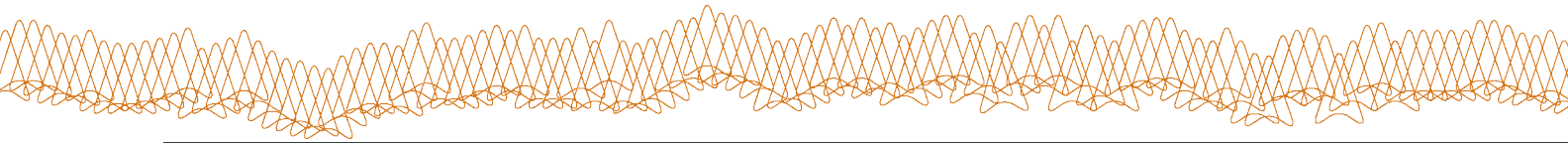
IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
<b>SA Arid Lands</b>														
Channel Country	≥70	0.1	0.6	0.3	0.5	0.2	0.4	0.3	0.2	0.3	1.5	0.3	0.2	0.3
	60.0-69.9	3.5	13.8	9.3	11.2	6.5	15.1	9.8	9.0	14.3	5.8	2.4	3.3	6.9
	50.0-59.9	42.1	52.2	59.3	61.2	62.5	63.6	47.4	55.5	55.9	20.3	8.8	16.3	37.1
	40.0-49.9	41.2	24.3	25.7	19.0	25.9	17.5	32.0	27.9	17.6	34.1	18.7	33.7	39.8
	30.0-39.9	6.9	5.2	3.7	3.7	3.3	2.3	5.4	5.0	4.0	16.8	27.8	31.3	11.6
Finke	≥70	0.0	0.0	0.0	0.1	0.6	0.6	2.3	4.7	1.6	0.2	0.4	0.0	2.7
	60.0-69.9	6.1	0.0	5.4	15.4	29.4	30.6	53.7	67.4	45.7	12.2	2.9	1.2	24.6
	50.0-59.9	45.4	14.1	64.4	63.7	59.4	57.9	41.8	27.1	48.6	61.2	13.9	16.1	59.9
	40.0-49.9	45.2	48.3	28.3	20.1	10.1	10.2	2.1	0.7	3.9	24.4	48.3	56.4	12.5
	30.0-39.9	3.2	30.0	1.7	0.5	0.4	0.5	0.1	0.0	0.2	1.8	31.1	23.6	0.2
Simpson Strzelecki Dunefields	≥70	0.0	0.2	0.1	0.1	0.1	0.3	0.2	0.5	0.5	1.3	0.1	0.0	0.1
	60.0-69.9	0.7	13.3	6.7	9.0	6.2	18.2	17.9	21.3	20.4	9.7	0.5	0.9	7.5
	50.0-59.9	38.3	57.5	52.0	62.0	56.4	61.2	47.4	60.9	56.9	38.3	9.6	24.2	47.9
	40.0-49.9	45.8	17.4	27.3	16.4	23.7	9.5	22.5	6.3	9.9	30.5	28.5	43.5	30.3
	30.0-39.9	3.2	3.3	3.4	2.3	3.0	2.9	4.5	3.1	2.1	6.1	28.6	18.9	5.8
Stony Plains	≥70	0.4	0.5	0.6	0.2	0.7	1.3	0.7	1.6	0.9	1.4	0.1	0.1	0.1
	60.0-69.9	4.4	9.1	7.9	7.3	11.1	13.8	14.9	16.8	9.2	13.1	2.4	2.9	5.7
	50.0-59.9	37.7	43.4	47.6	44.1	50.3	52.7	54.3	54.4	51.2	44.9	23.5	26.4	44.4
	40.0-49.9	39.7	29.5	30.5	33.5	26.5	21.9	20.3	17.9	26.7	25.2	39.9	43.1	36.4
	30.0-39.9	12.7	12.5	9.4	10.5	7.6	6.8	6.5	6.0	7.8	9.5	23.6	19.3	9.3
<b>Alinytjara Wilurara</b>														
Central Ranges	≥70	1.2	12.1	7.7	0.8	3.2	1.8	3.6	12.3	0.9	6.4	3.4	9.4	2.7
	60.0-69.9	8.6	10.7	28.0	13.1	20.4	25.8	30.8	34.1	20.5	35.0	5.9	10.3	11.5
	50.0-59.9	30.4	19.8	42.7	44.7	46.2	43.2	40.4	35.6	54.1	40.4	24.7	22.0	39.1
	40.0-49.9	37.7	29.4	16.6	28.2	21.6	18.6	17.2	12.6	17.7	11.9	39.5	36.6	33.9
	30.0-39.9	16.7	18.1	4.0	10.5	6.3	7.7	6.1	3.9	5.0	4.5	18.5	16.7	10.1
<b>NT Arid Lands</b>														



IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Burt Plain	≥70	6.5	1.9	2.2	1.4	2.8	2.5	1.5	8.0	5.1	0.1	3.2	1.9	5.6
	60.0-69.9	5.4	2.9	8.9	9.3	17.6	11.7	8.0	20.7	18.9	2.5	3.5	7.1	19.3
	50.0-59.9	8.0	10.6	25.1	34.5	45.5	27.4	26.8	39.5	41.8	18.1	5.1	17.1	37.7
	40.0-49.9	13.3	24.3	35.7	37.6	26.5	33.5	32.3	23.3	25.6	43.4	9.0	32.0	27.9
	30.0-39.9	29.6	35.3	21.1	14.4	5.9	20.0	24.0	6.4	6.7	28.4	23.7	30.2	7.4
Central Ranges	≥70	2.3	17.7	22.1	1.4	1.9	1.9	2.6	3.3	2.7	7.2	1.4	6.5	7.1
	60.0-69.9	11.4	10.1	34.0	14.5	25.0	19.2	28.7	22.3	36.3	47.5	3.8	9.6	19.9
	50.0-59.9	25.8	12.3	27.9	41.5	50.3	43.5	47.5	45.4	46.4	36.5	35.5	23.3	45.4
	40.0-49.9	44.7	25.0	12.7	34.1	18.3	29.1	17.5	23.2	11.3	6.5	48.6	44.1	23.7
	30.0-39.9	14.6	25.3	2.8	7.7	3.7	5.3	3.0	4.7	2.5	1.8	8.9	14.4	3.1
Channel Country	≥70	3.1	1.1	1.4	4.0	2.4	1.5	0.0	0.4	0.2	0.0	1.7	1.5	4.8
	60.0-69.9	1.8	4.7	11.6	39.4	40.0	31.8	1.6	15.8	7.7	0.1	2.0	12.1	32.2
	50.0-59.9	1.8	12.8	34.1	41.3	45.0	51.2	18.6	52.6	43.7	4.0	4.3	31.7	39.0
	40.0-49.9	4.2	23.3	34.7	12.4	10.4	13.0	43.0	26.1	37.7	33.9	4.6	33.9	18.5
	30.0-39.9	21.2	27.7	13.7	2.5	1.9	2.0	26.9	4.4	9.2	44.4	15.3	16.1	4.6
Finke	≥70	0.2	6.9	10.4	5.7	5.9	8.7	7.0	19.7	5.3	3.6	4.2	1.1	2.4
	60.0-69.9	1.3	5.3	27.6	36.3	39.7	42.0	45.4	49.9	43.2	28.0	5.4	5.4	29.3
	50.0-59.9	22.4	10.7	39.9	44.6	41.5	39.0	41.1	27.1	44.1	43.5	16.3	26.3	51.3
	40.0-49.9	63.0	28.8	19.0	12.0	11.3	9.2	5.9	2.8	6.6	19.6	38.6	43.6	15.6
	30.0-39.9	11.9	37.6	2.6	1.0	1.2	0.8	0.4	0.4	0.6	4.5	28.4	20.2	1.0
Great Sandy Desert	≥70	7.6	12.2	14.2	2.7	4.6	1.2	1.9	3.3	3.2	3.5	11.2	5.1	7.3
	60.0-69.9	9.6	14.0	24.2	16.1	24.7	14.1	21.1	25.1	25.0	24.2	8.9	10.2	28.4
	50.0-59.9	16.8	20.3	27.7	44.2	46.0	41.4	43.9	45.5	44.9	45.0	22.1	24.5	46.8
	40.0-49.9	38.8	25.7	21.2	28.2	18.7	32.3	26.3	20.5	21.4	20.6	37.1	40.4	13.5
	30.0-39.9	20.5	20.0	8.6	5.7	3.5	7.3	4.5	3.3	3.2	4.1	15.0	16.1	1.8
MacDonnell Ranges	≥70	0.7	5.4	2.5	2.2	2.8	4.6	3.3	6.0	4.5	0.3	6.7	0.9	2.0
	60.0-69.9	1.4	5.9	12.4	16.4	18.0	21.3	20.1	23.7	22.0	3.4	6.7	3.5	14.4
	50.0-59.9	4.6	11.7	27.4	35.7	33.3	31.1	33.7	30.7	33.9	19.9	7.0	15.8	35.1

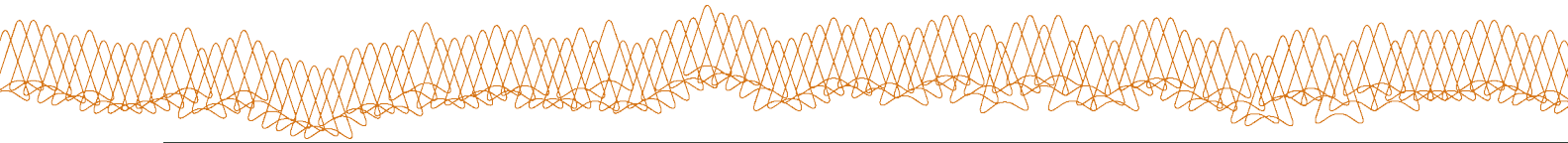


IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	40.0-49.9	23.4	26.0	31.1	31.2	26.4	24.6	27.8	23.2	25.8	37.8	11.5	33.1	31.0
	30.0-39.9	47.4	33.7	19.2	11.9	14.1	13.7	12.1	12.5	11.1	29.4	25.8	30.9	14.1
Simpson Strzelecki Dunefields	≥70	0.0	14.0	16.2	15.8	8.4	17.3	2.1	5.2	7.9	0.2	2.5	5.5	11.8
	60.0-69.9	7.7	27.6	46.9	68.9	71.7	64.9	41.9	61.2	61.7	9.9	4.1	25.6	54.7
	50.0-59.9	34.3	34.9	30.6	13.5	17.6	16.0	42.5	31.0	27.6	50.8	12.8	43.0	27.4
	40.0-49.9	34.9	17.0	5.3	1.5	1.8	1.6	11.6	2.3	2.6	30.1	29.2	20.5	5.4
	30.0-39.9	18.6	5.3	0.9	0.3	0.3	0.2	1.6	0.2	0.2	7.1	35.7	4.3	0.7
Sturt Plateau	≥70	34.5	0.0	0.1	0.0	11.5	0.0	0.1	3.4	0.0	0.1	24.5	4.5	0.4
	60.0-69.9	10.6	0.4	0.7	0.0	29.1	0.0	0.4	26.6	0.0	0.4	16.6	5.1	2.9
	50.0-59.9	10.7	4.7	4.1	0.2	22.8	0.3	1.0	30.6	5.2	8.3	13.3	11.7	8.8
	40.0-49.9	12.0	22.3	12.6	1.9	16.9	9.8	3.0	12.8	37.0	37.3	9.5	30.6	21.2
	30.0-39.9	11.9	23.9	29.2	11.7	14.9	31.9	16.2	10.2	23.4	32.5	12.0	25.1	32.0
Tanami	≥70	15.5	4.8	2.4	1.9	10.7	0.8	12.8	7.5	1.5	0.8	25.6	6.2	5.7
	60.0-69.9	8.5	6.8	11.1	6.0	24.0	3.0	9.0	22.2	11.0	4.9	9.5	15.7	19.8
	50.0-59.9	16.1	15.0	24.4	21.8	31.9	14.7	18.2	32.0	31.1	28.3	9.6	26.6	31.2
	40.0-49.9	19.6	24.8	31.5	33.8	25.0	32.0	29.4	26.1	35.0	43.2	16.8	25.1	28.4
	30.0-39.9	17.6	24.7	21.4	25.4	7.3	30.6	22.8	9.7	17.3	18.8	20.6	16.6	11.8
<b>NT Tablelands</b>														
Davenport Murchison Ranges	≥70	13.3	1.5	0.3	0.3	9.1	0.3	7.3	9.7	0.1	0.0	8.6	0.9	2.6
	60.0-69.9	10.1	3.0	2.1	1.2	15.2	1.5	6.9	16.4	2.9	0.9	5.9	3.6	7.7
	50.0-59.9	12.3	10.0	8.8	7.0	27.0	6.3	8.5	20.8	12.3	7.9	7.2	17.8	23.4
	40.0-49.9	16.1	22.1	25.3	23.9	28.4	16.9	17.3	24.0	21.1	27.8	7.4	26.3	34.6
	30.0-39.9	14.8	28.7	33.4	35.8	15.8	36.5	30.1	20.4	30.6	42.5	11.7	22.1	20.9
Gulf Fall & Uplands	≥70	0.7	0.0	0.1	0.1	0.2	0.0	0.2	0.1	0.0	0.1	0.1	1.3	0.1
	60.0-69.9	2.5	0.3	0.4	0.3	2.8	0.0	0.9	1.8	0.0	0.3	0.4	3.0	0.9
	50.0-59.9	6.5	1.7	1.7	0.7	10.0	0.0	3.5	8.2	0.4	0.6	1.2	6.7	3.6
	40.0-49.9	9.6	8.5	4.2	1.9	19.1	0.4	7.9	15.8	2.1	2.3	3.3	10.2	10.3
	30.0-39.9	8.7	21.2	12.3	7.0	25.7	5.7	15.5	21.7	11.8	8.4	6.6	14.5	23.3



IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Mitchell Grass Downs	≥70	0.5	0.1	0.0	0.1	0.3	0.0	0.1	0.2	0.0	0.0	0.1	0.1	0.3
	60.0-69.9	0.6	0.4	0.5	1.3	3.6	0.4	0.6	6.0	0.0	0.5	0.7	0.8	5.8
	50.0-59.9	0.8	2.9	2.6	8.3	19.6	6.1	8.0	32.6	0.3	4.3	1.8	4.8	25.5
	40.0-49.9	1.0	8.6	7.7	12.6	27.5	7.9	26.3	30.4	3.0	14.4	1.2	12.4	29.4
	30.0-39.9	1.6	16.8	17.4	12.4	22.1	10.2	28.0	16.0	7.1	25.2	2.2	20.9	19.2
WA Rangelands														
Carnarvon	≥70	2.2	2.9	4.4	3.4	1.0	1.4	3.0	0.6	1.6	4.4	0.2	2.6	3.0
	60.0-69.9	6.1	15.7	19.0	12.9	5.5	13.6	13.2	6.1	13.8	25.6	4.1	11.0	16.4
	50.0-59.9	31.3	43.7	43.1	33.4	20.3	41.3	37.2	17.9	41.2	44.9	15.9	32.6	42.9
	40.0-49.9	37.6	24.4	21.8	34.5	42.1	28.2	30.7	32.4	28.8	14.8	25.7	32.8	24.0
	30.0-39.9	14.4	7.3	5.9	9.6	20.7	8.7	9.1	28.6	7.8	4.5	27.0	12.7	6.8
Central Ranges	≥70	1.7	9.5	18.0	1.0	3.7	0.2	1.4	3.0	3.8	15.0	0.2	3.7	5.5
	60.0-69.9	12.2	11.0	33.1	10.5	22.6	5.5	11.4	20.9	25.5	39.6	7.2	3.7	18.7
	50.0-59.9	22.3	21.5	32.3	39.7	46.2	34.0	41.1	42.1	43.9	34.3	42.8	11.8	45.4
	40.0-49.9	35.8	31.6	12.1	34.4	21.1	40.7	34.9	25.8	20.5	7.9	37.9	40.3	24.9
	30.0-39.9	22.6	19.5	3.3	11.6	5.1	15.7	9.4	6.3	4.9	2.5	9.4	32.1	4.4
Gascoyne	≥70	0.6	0.9	1.3	0.8	1.6	0.1	0.6	0.9	1.0	2.4	0.6	0.5	1.0
	60.0-69.9	2.6	7.8	9.1	6.8	11.0	2.5	6.8	8.6	10.3	16.7	5.2	5.3	9.2
	50.0-59.9	13.3	28.7	28.9	26.4	35.4	14.3	27.0	30.0	34.6	37.8	23.0	17.9	31.9
	40.0-49.9	44.7	38.8	39.0	41.0	35.0	35.0	44.0	40.0	37.0	30.9	43.6	37.4	39.3
	30.0-39.9	31.5	18.1	17.1	19.8	13.3	32.1	17.7	16.7	13.7	9.8	22.0	29.9	15.0
Gibson Desert	≥70	0.7	2.5	3.9	0.4	0.7	0.1	1.0	1.5	1.1	1.6	0.1	2.3	2.2
	60.0-69.9	7.7	4.7	11.1	4.9	6.3	0.8	4.8	7.1	7.2	12.7	2.0	2.9	11.6
	50.0-59.9	15.0	16.0	23.7	21.8	25.6	9.8	13.9	22.7	26.2	32.4	17.4	7.7	28.6
	40.0-49.9	29.8	30.1	28.7	33.7	35.1	30.6	31.3	31.9	34.0	29.5	34.7	26.0	32.2
	30.0-39.9	27.5	28.0	21.2	25.4	22.5	33.1	28.2	22.7	21.6	17.9	26.8	29.5	17.5
Great Sandy Desert	≥70	2.2	5.2	3.2	0.3	2.5	2.4	1.9	2.2	2.1	3.2	1.8	6.9	3.3
	60.0-69.9	7.6	11.1	12.2	3.6	11.9	2.5	9.9	9.3	10.5	16.3	3.4	7.9	14.3





IBRA	Bare soil threshold	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	50.0-59.9	20.8	19.3	26.2	22.2	32.7	14.6	21.5	27.8	31.5	41.2	16.9	16.7	34.5
	40.0-49.9	31.2	29.7	32.6	37.9	36.4	35.0	34.2	34.9	35.1	29.6	37.3	28.4	30.7
	30.0-39.9	23.7	24.0	18.7	25.6	12.9	29.9	23.8	18.7	15.7	7.0	28.5	24.6	12.5
Little Sandy Desert	≥70	5.4	3.1	4.6	0.9	2.6	0.4	1.7	3.4	4.1	4.7	0.4	3.0	3.6
	60.0-69.9	18.0	13.5	20.8	11.6	17.1	6.4	7.6	11.7	18.2	26.1	6.3	3.1	16.2
	50.0-59.9	25.5	27.4	36.7	41.5	43.9	36.7	35.7	40.9	44.0	45.1	36.7	11.5	33.1
	40.0-49.9	33.2	31.8	24.9	30.6	25.3	36.0	38.5	33.1	25.4	18.0	42.7	37.7	34.4
	30.0-39.9	13.8	18.1	9.3	11.3	7.9	14.7	12.4	7.9	5.9	4.0	10.8	33.7	9.6
	≥70	1.7	4.1	4.5	1.8	2.5	0.5	2.8	2.3	1.8	6.5	1.2	1.5	1.3
Pilbara	60.0-69.9	5.4	11.8	13.7	7.7	12.0	1.9	9.0	10.4	9.7	20.4	7.2	4.2	6.5
	50.0-59.9	15.1	20.8	25.0	20.3	29.7	8.7	19.2	23.6	22.3	27.3	20.6	13.0	18.2
	40.0-49.9	24.1	24.0	26.9	30.1	28.8	23.2	25.6	27.7	27.2	23.4	31.3	25.6	29.8
	30.0-39.9	25.9	20.2	18.1	24.3	17.5	31.3	24.5	21.3	21.8	14.4	24.9	28.7	27.0
	≥70	1.7	4.1	4.5	1.8	2.5	0.5	2.8	2.3	1.8	6.5	1.2	1.5	1.3

# Abbreviations

IN THIS REPORT	
TERM	DEFINITION
BS	bare soil
CMA	Catchment Management Authority
IBRA	Interim Biogeographic Regionalisation for Australia
NPV	non-photosynthetic vegetation: senescent pasture and litter
NRM	natural resource management
PV	photosynthetic vegetation: green
TM	Thematic Mapper

IN ALL REPORTS IN THE SERIES	
TERM	DEFINITION
ABS	Australian Bureau of Statistics
ACRIS	Australian Collaborative Rangelands Information System
AFCMP	Australian Feral Camel Management Project
BoM	Bureau of Meteorology
DKCRC	Desert Knowledge Cooperative Research Centre
DSI	Dust Storm Index
EI	Ecoclimatic Index
EMU	Ecosystem Management Understanding™
ENSO	El Niño Southern Oscillation
FIFO	fly in, fly out
GAB	Great Artesian Basin
GCM	General Circulation Model
GDM	Generalised Dissimilarity Modelling
GHG	greenhouse gas
GW	Groundwater
GWW	Great Western Woodlands
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
LEB	Lake Eyre Basin
LGM	last glacial maximum

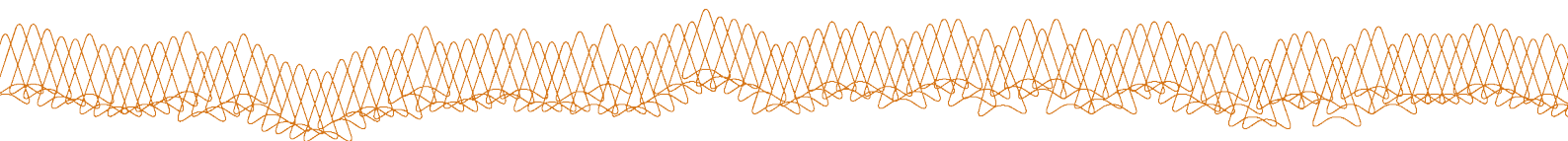
IN ALL REPORTS IN THE SERIES	
TERM	DEFINITION
MOF	manual observation frequency
mya	million years ago
NAFI	North Australian Fire Information
NCCARF	National Climate Change Adaptation Research Facility
OH&S	occupational health and safety
RCP	Representative Concentration Pathways
SAAL	South Australia Arid Lands
SDM	species distribution modelling
SW	Surface water
TGP	total grazing pressure
Western CMA	Western Catchment Management Authority
Western LLS	Western Local Land Service

# Glossary

IN THIS REPORT	
TERM	DEFINITION
Bioregion	A large, geographically distinct area of land that has groups of ecosystems forming recognisable patterns within the landscape
C <sub>3</sub> and C <sub>4</sub> plants	The different methods plants use to convert carbon dioxide from air into organic compounds through the process of photosynthesis. All plants use C <sub>3</sub> processes; some plants, such as buffel grass and many other warm climate grasses, also use C <sub>4</sub> processes. C <sub>4</sub> plants have an advantage in a warmer climate due to their higher CO <sub>2</sub> assimilation rates at higher temperatures and higher photosynthetic optima than their C <sub>3</sub> counterparts

IN ALL REPORTS IN THE SERIES	
TERM	DEFINITION
Adaptive capacity	The ability to change and therefore reduce gross vulnerability; includes issues such as mobility, financial resources and education
Contentious species	A species that presents special challenges for determining the adaptation response to climate change, because it is both a threat and a beneficial species (Friedel et al. 2011, Grice et al. 2012)
Dust Storm Index (DSI)	The Dust Storm Index is based on visibility records made by Bureau of Meteorology (BoM) observers. The DSI provides a measure of the frequency and intensity of wind erosion activity at continental scale. It is a composite measure of the contributions of local dust events, moderate dust storms and severe dust storms using weightings for each event type, based upon dust concentrations inferred from reduced visibility during each of these event types.
DustWatch	DustWatch is a community program that monitors and reports on the extent and severity of wind erosion across Australia and raises awareness of the effects of wind erosion on the landscape and the impacts of dust on the community.

IN ALL REPORTS IN THE SERIES	
TERM	DEFINITION
Ecological refugia	Refugia defined according to the water requirements of the species they protect. The conservation significance of ecological refugia, and the priority assigned to their conservation, depends on the level of knowledge available for the species they support.
Evolutionary refugia	Those waterbodies that contain <i>short-range endemics</i> or <i>vicariant relics</i> . Evolutionary refugia are most likely to persist into the future and should be accorded the highest priority in NRM adaptation planning.
Generalised Dissimilarity Modelling (GDM)	A method of modelling based on compositional turnover of a group of species at a location; it considers whole biological groups rather than individual species
Gross vulnerability of a system	The combination of exposure and sensitivity of system
Heatwave	Continuous period beyond a week when a particular threshold temperature is exceeded
Hyporheic water flows	Below-surface flows
Indicators of exposure	Factors such as days above a certain temperature, days without rainfall, population density
Indicators of sensitivity	How sensitive a system is to hazards; indicators include the types of dwellings people live in and the percentage of the population with certain health characteristics
'No regrets' strategies	These strategies yield benefits even if there is not a change in climate
Novel ecosystem	Species occurring in combinations and relative abundances that have not occurred previously within a given biome (Hobbs et al. 2006)
Rainfall event	One or more closely spaced rainfalls that are large enough to produce a significant vegetation response



#### IN ALL REPORTS IN THE SERIES

TERM	DEFINITION
Refugia	Habitats that biota retreat to, persist in and potentially expand from under changing environmental conditions
Return period	The number of days from the end of one rainfall event to the start of the next
Reversible strategies	Flexible strategies that can be changed if predictions about climate change are incorrect
Safety margin strategies	Strategies that reduce vulnerability at little or no cost
Species Distribution Modelling (SDM)	A species-specific approach whereby observational records are used to model the current potential distribution of a species
Short-range endemics	Species that occur only within a very small geographical area
Soft strategies	Strategies that involve the use of institutional, educational or financial tools to reduce species vulnerability to climatic change
Species invasiveness	A species that causes environmental or socioeconomic impacts, is non-native to an ecosystem or rapidly colonises and spreads (see Ricciardi and Cohen 2007). In the Invasive animals report it refers to non-native species (that is, those introduced to Australia post-1788) that have caused significant environmental or agricultural changes to the ecosystem or that are believed to present such a risk.
Strategies that reduce time horizons	Strategies that reduce the lifetime of particular investments
Vicariant relicts	Species with ancestral characteristics that have become geographically isolated over time



## References

- Department of the Environment (n.d.) *Australia's bioregions (IBRA)*. Australian Government. Canberra.
- Bastin G (2014) *Australian rangelands and climate change – fire*. Ninti One Limited and CSIRO, Alice Springs.
- Guerschman JP, Hill MJ, Renzullo LJ, Barrett DJ, Marks AS and Botha EJ (2009) Estimating fractional cover of photosynthetic vegetation, non-photosynthetic vegetation and bare soil in the Australian tropical savanna region: upscaling the EO-1 Hyperion and MODIS sensors. *Remote Sensing of Environment* 113(5), 928–945.
- Malthus TJ, Barry S, Randall LA, McVicar T, Bordas VM, Stewart JB, Guerschman JP and Penrose L (2013) Ground cover monitoring for Australia: Sampling strategy and selection of ground cover control sites. CSIRO, Australia. Available at [www.daff.gov.au/abares/publications](http://www.daff.gov.au/abares/publications), accessed 27 January 2014.
- Stewart JB, Rickards JE and Randall LA (2013) *Ground cover monitoring for Australia: Progress report July 2011 to June 2012*, ABARES Technical report 13.5, Canberra. CC BY 3.0. Available at [www.daff.gov.au/abares/publications](http://www.daff.gov.au/abares/publications), accessed 27 January 2014.



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