RANGELANDS NRM CLUSTER

CLIMATE CHANGE IN AUSTRALIA

IMPACTS & ADAPTATION INFORMATION FOR AUSTRALIA'S NRM REGIONS

Australian rangelands and climate change – dust

Citation

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South Australian Arid Lands Natural Resources Management Board

desert channels QUEENSLAND

RANGELAND NRM alliance

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Achieving sustainable landscapes for rural communities

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INSTITUTE FOR APPLIED ECOLOGY

Rangelands NRM Western Australia

NSW GOVERNMENT Local Land Services Western

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Acknowledgements

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Key points

- Rangelands dust is related to ground cover and fluctuates with seasonal conditions (i.e. dust is more likely to emanate from erodible soils during drought). Atmospheric dust provides a local- to regional-scale indicator of the effectiveness of grazing management in pastoral country and the recent fire regime in spinifex deserts. Land managers should endeavour to maintain critical levels of ground cover so as to minimise soil and nutrient loss via dust resulting from wind erosion in dry times.
- There have been some dramatic year-to-year changes in dust activity in the recent past, particularly between 2009 (when there was substantial dust in the atmosphere) and 2010 (minimal atmospheric dust). These changes were mainly associated with rainfall, that is, improved seasonal quality in 2010.
- It is probable that the domains and magnitudes of recent dust activity in drought periods will recur with continuing climate variability, particularly rainfall. Increased frequency and intensity of heatwaves and lower humidity may also contribute to increased dust.
- Visibility as affected by atmospheric dust can indicate wind erosion rate, although actual weather conditions, soil type, vegetation type and amount of ground cover are also important.
- Griffith University uses a Dust Storm Index (DSI) to report wind erosion activity across Australia. The index is based on historic visibility data recorded by Bureau of Meteorology observers. DSI maps indicate the likely sources of dust and their levels over time.
- In the recent past (1992–2010) within the Rangelands Cluster region, most dust appeared to emanate from within the more arid parts of the Lake Eyre Basin (particularly the Simpson–Strzelecki Dunefields and Channel Country bioregions) extending west into central Australia (the MacDonnell Ranges), north into the Mitchell Grass Downs and Mount Isa Inlier bioregions, east and south-east into the Mulga Lands and Riverina, and south into the Gawler bioregion (SA Arid Lands). The WA Rangelands were less active as a dust source.

Gary Bastin

CSIRO

1. Introduction

The level of dust in the air is related to ground cover and provides a useful indicator of wind erosion rate, although the amount of dust observed is influenced by several factors (e.g. actual weather conditions, soil type, vegetation type and amount of ground cover). Prof. Grant McTainsh and his team at Griffith University calculate a Dust Storm Index (DSI) 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.

The Australian Collaborative Rangelands Information System (ACRIS) reports annual and averaged multi-year values of the DSI as one of its indicators of environmental change in the rangelands.[1] The most recent reporting period for dust was 1992–2010, a period that covered considerable climate variability and, as such, provided a useful guide to likely locations and severity of future dust-storm events under continuing rainfall variability. Important points from ACRIS reporting are included here.

2. Data source and method

DSI values are calculated from visibility data recorded by BoM observers. A number of different wind erosion event types are evaluated by BoM, ranging from severe dust storms to local blowing dust. The intensity of these event types can be approximated by the extent to which they reduce visibility. DSI is a composite measure of the weighted contributions of local dust events, moderate dust storms and severe dust storms. Values calculated by Griffith University are spatially interpolated between stations and integrated over time to provide annual and multi-year DSI maps.

The reliability of dust storm patterns in the DSI maps depends on the observation frequency at each recording station, for example, those BoM stations recording up to eight visibility readings a day provide more reliable records of dust storm events than those with lower observation frequencies. In addition, the number of recording stations where manual observations of visibility are made has, unfortunately, declined over the years.

Manual observation frequency (MOF) is standardised such that there must be a continuous record between the start and end reporting period for the data from a recording station to be included. This reduces the risk of generating erroneously high or low mean DSI values for particular areas where a station has a discontinuous recording history. When interpreting spatial and temporal patterns in DSI (following maps), it is important also to consider the associated maps of observation frequency.

[1] See http://www.environment.gov.au/resource/acris-dust-product-update-2006-2010 and http://www.environment.gov.au/resource/update-dust-storm-index-dsi-maps-2005-2010 for the most recent ACRIS reporting.

3. Caveats

1. Interpolated DSI values indicate the relative amount and location of observed atmospheric dust, not necessarily the source of that dust.
2. Refer to the associated MOF maps as an indicator of the reliability of spatially interpolated dust levels. A higher spatial density of BoM recording stations with a higher recording frequency provides the most reliable data for spatially interpolating DSI values.

4. Findings

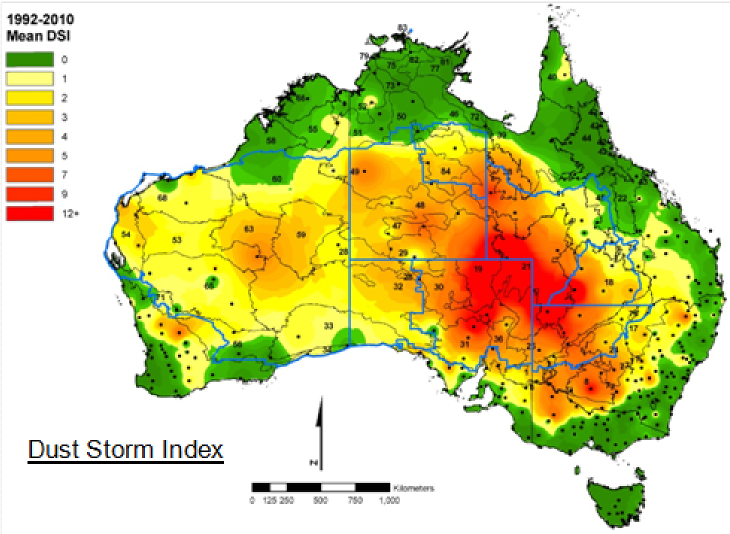
4.1 Dust Storm Index: 1992–2010

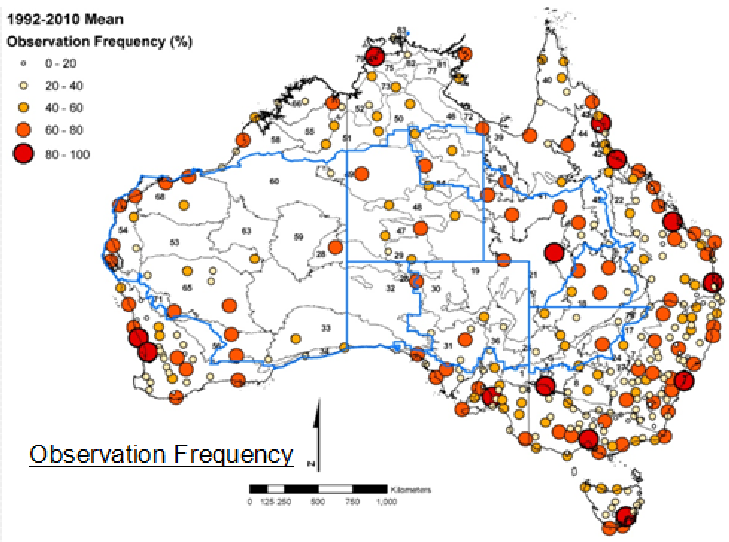
Recent change in dust activity for rangeland bioregions is presented in two ways:

1. Time-averaged DSI values for 1992 to 2010: this map shows where most of the dust is observed and partly indicates where it came from.
2. By contrasting change for two recent years in the DSI record: this map illustrates the dramatic change that occurs when good rains ended an extended drought.

The maps (Figures 4.1 and 4.2) show that:

- The Simpson–Strzelecki Dunefields and Channel Country bioregions (mainly Desert Channels Queensland and SA Arid Lands but also Western Catchment, NSW) had the highest time-averaged mean DSI values between 1992 and 2010 (Figure 4.1, numbered bioregions 19 and 21). Although DSI shows observed dust, it is probable that these regions were also the most active wind erosion regions. This probable high wind-erosion zone was centred on the Lake Eyre Basin and extended west into the MacDonnell Ranges (47), north into the Mitchell Grass Downs (41) and Mount Isa Inlier (38), east and south-east into the Mulga Lands (18) and Riverina (8), and south into the Gawler bioregion (31). The WA Rangelands were less active as a dust source.
- This assessment is tempered by a reduction in the number of stations with a high observation frequency (MOF of 80–100%) in the latter period. In 2010, high MOF was primarily restricted to coastal stations and capital cities. The rationalisation of BoM stations is unfortunate from a wind erosion monitoring perspective, as it is degrading the DSI record.
- Comparing among recent years, the most dramatic changes in regional DSI occurred between 2009 and 2010 (Figure 4.2; see Figure 4.3 for corresponding maps of observation frequency).
  - DSI values between 2002 and 2008 were broadly similar to those shown in Figure 4.1.
  - Dust activity in 2009 was at its highest level since 1992 (Figure 4.2, top image). The pre-existing high erosion zone centred on the Lake Eyre Basin and extended east into the western Murray–Darling Basin, increasing to an area of approximately 1 million km^2. North–south, it extended from the Channel Country (21) to the Flinders Lofty Block (36) and Broken Hill Complex (25). The Stony Plains (30) bounded the western extent with the Mulga Lands (18) forming the eastern boundary. There were secondary regions of high wind erosion in the Cobar Peneplain (24) and further east beyond the Rangelands Cluster boundary.
  - There were moderate DSI values in the western desert region (Gibson Desert [59], Little Sandy Desert [63], Great Victoria Desert [32]) in 2009. These DSI values largely resulted from spatial data interpolation, as there are very few observations from this area (Figure 4.3). Moderate DSI values in the Gulf Fall and Uplands (46) and Gulf Coastal (72) (Monsoonal North Cluster region) also resulted from observations external to each region.





Region	IBRA name
1	Murray Darling Depression
8	Riverina
17	Darling Riverine Plains
18	Mulga Lands
19	Simpson Strzelecki Dunefields
21	Channel Country
22	Brigalow Belt North
24	Cobar Peneplain
25	Broken Hill Complex
28	Central Ranges
29	Finke
30	Stony Plains
31	Gawler
32	Great Victoria Desert
33	Nullarbor
34	Hampton
36	Flinders Lofty Block
38	Mount Isa Inlier
39	Gulf Plains
40	Cape York Peninsula
41	Mitchell Grass Downs
44	Einasleigh Uplands
45	Desert Uplands
46	Gulf Fall and Uplands
47	MacDonnell Ranges
48	Burt Plain
50	Sturt Plateau
51	Ord Victoria Plains
52	Victoria Bonaparte
53	Gascoyne
54	Carnarvon
55	Central Kimberley
56	Coolgardie
58	Dampierland
59	Gibson Desert
60	Great Sandy Desert
63	Little Sandy Desert
65	Murchison
66	Northern Kimberley
68	Pilbara
71	Yalgoo
72	Gulf Coastal
73	Daly Basin
75	Pine Creek
76	Brigalow Belt South
77	Central Arnhem
79	Darwin Coastal
81	Arnhem Coast
82	Arnhem Plateau
84	Davenport Murchison Ranges

Figure 4.1 Top: mean DSI values for the 1992–2010 period; bottom: observation frequency.

Blue lines show NRM regions in the Rangelands Cluster, and black dots (top image) show BoM recording stations. Bioregions are mapped and numbered for the extent of the rangelands as defined by ACRIS (numbers refer to bioregion names listed to the right of the maps).

Source: Data and maps from Prof. Grant McTainsh, Griffith University (adapted from ACRIS reporting).

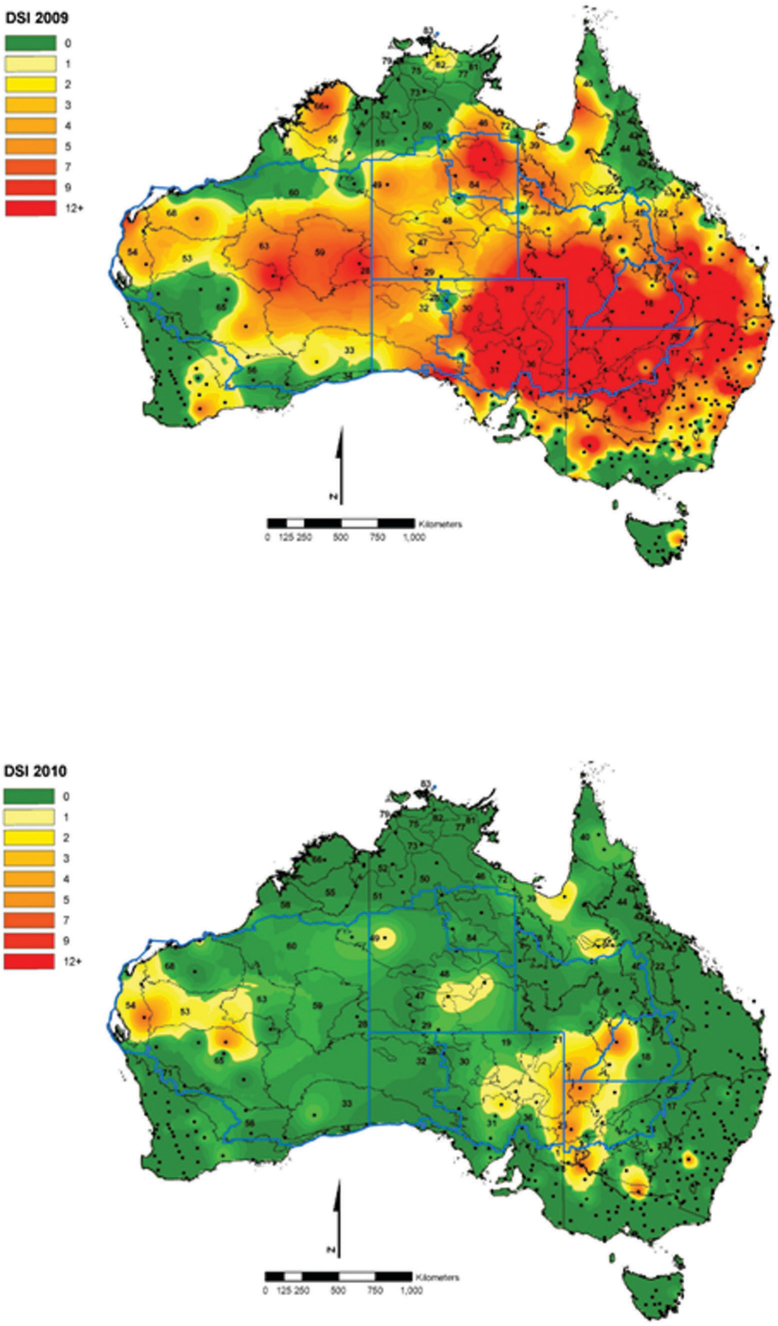


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Figure 4.2 DSI values in 2009 (top) and 2010 (bottom).

The dots and blue lines show BoM recording stations and Rangelands Cluster NRM regions respectively.

Source: Data and maps from Prof. Grant McTainsh, Griffith University (maps adapted from ACRIS reporting).

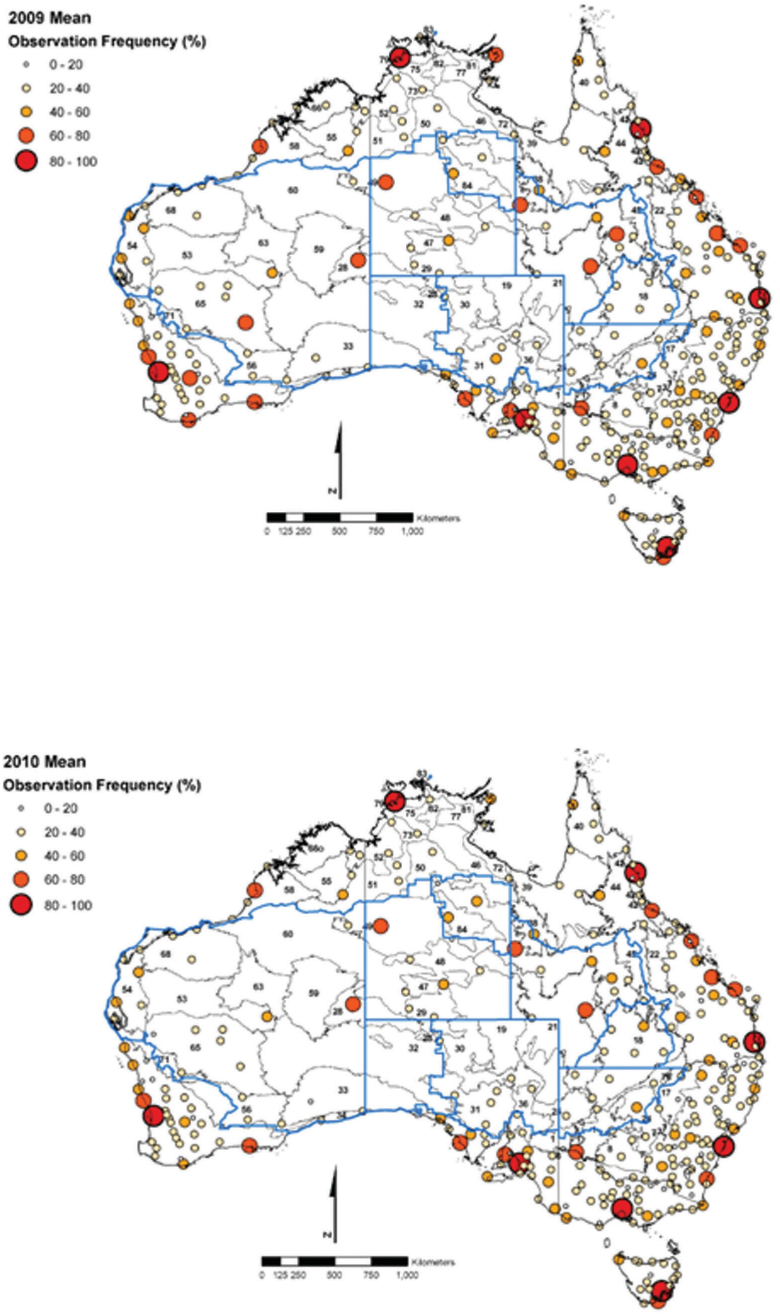

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Figure 4.3 Manual observation frequency at BoM recording stations for visibility: 2009 (top) and 2010 (bottom).

Circles show BoM recording stations, with the size and colour of the circle representing observation frequency. Blue lines show NRM regions in the Rangelands Cluster.

Source: Data and maps from Prof. Grant McTainsh, Griffith University (maps adapted from ACRIS reporting).

- In stark contrast, 2010 had the lowest wind erosion in the 1992–2010 period (Figure 4.2, bottom), and at least as far back as 1974. The only stations to record wind erosion activity were Quilpie in the Mulga Lands (18) region of Queensland, as well as Tibooburra and Broken Hill in NSW. Remarkably, the Birdsville meteorological station, which had seen dust activity every year since it started operating, did not record a single dust code (not even haze) for the entire 2010 calendar year. In WA, the only wind erosion was recorded in the northern Murchison (65) and eastern Carnarvon (54) region.

- Vastly improved seasonal quality in eastern and central Australia in 2010 (and continuing in many areas to 2012) likely contributed to reduced dust observations and associated wind erosion activity in 2010. It is expected that observed dust levels have again increased in the Lake Eyre Basin, neighbouring Simpson Desert, parts of central Australia, much of south-west Queensland and western NSW with the return of drier seasonal conditions (2013) and extensive wildfire in 2011 and 2012.

4.2 DustWatch

DustWatch[2] is a community program that monitors and reports on the extent and severity of wind erosion across Australia. Additionally, it raises awareness of the effects of wind erosion on the landscape and the impacts of dust on the community. DustWatch is led by scientists but relies very much on community participation. Within (or on the edge of) the Rangelands Cluster region, Dr John Leys (NSW Office of Environment and Heritage) has collaborated with an active group of landholders and other participants in the former Lower Murray Darling NRM region of NSW.

DustWatch observations can potentially contribute to the national DSI, particularly where BoM observations are sparse and/or infrequent and, increasingly, becoming more so. However, community observations have to be sufficiently consistent in quality and maintained through space and time to meaningfully contribute.

Perhaps more importantly, the DustWatch community provides ground truth and valuable local context to interpolated DSI data. That is, participants on the ground can provide powerful local interpretation of significant dust events, with this evidence often supported by contributed photos and other anecdotal information. By raising awareness of the environmental and economic damage caused by wind erosion (often combined with community hardship), these advocates are seeking to improve land management and thereby reduce the risk and impact of further events. Active community participation such as this has to be a powerful ally in planning and adapting for further climate variability and projected change.

5. Adaptation strategies

On pastoral country, the most direct strategy to minimise soil and nutrient loss through wind erosion and associated dust relates to maintaining minimum acceptable levels of ground cover for the major erodible soil types. This, in turn, relates to grazing management, particularly adjusting stocking rate as seasonal conditions become increasingly drier. Further information is provided about remotely sensed ground cover in Bastin (2014) and about pastoral production in Bastin et al. (2014).

[2] http://www.environment.nsw.gov.au/dustwatch/index.htm

Abbreviations

IN THIS REPORT	
TERM	**DEFINITION**
ACRIS	Australian Collaborative Rangelands Information System
BoM	Bureau of Meteorology
DSI	Dust Storm Index
MOF	manual observation frequency
NRM	natural resource management

IN ALL REPORTS IN THE SERIES	
TERM	**DEFINITION**
ABS	Australian Bureau of Statistics
AFCMP	Australian Feral Camel Management Project
BS	bare soil
CMA	Catchment Management Authority
DKCRC	Desert Knowledge Cooperative Research Centre
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
IBRA	Interim Biogeographic Regionalisation for Australia
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
LEB	Lake Eyre Basin
LGM	last glacial maximum
mya	million years ago
NAFI	North Australian Fire Information

IN ALL REPORTS IN THE SERIES	
TERM	**DEFINITION**
NCCARF	National Climate Change Adaptation Research Facility
NPV	non-photosynthetic vegetation: senescent pasture and litter
OH&S	occupational health and safety
PV	photosynthetic vegetation: green
RCP	Representative Concentration Pathways
SAAL	South Australia Arid Lands
SDM	species distribution modelling
SW	Surface water
TGP	total grazing pressure
TM	Thematic Mapper
Western CMA	Western Catchment Management Authority
Western LLS	Western Local Land Service

Glossary

IN THIS REPORT	
TERM	**DEFINITION**
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**
Adaptive capacity	The ability to change and therefore reduce gross vulnerability; includes issues such as mobility, financial resources and education
Bioregion	A large, geographically distinct area of land that has groups of ecosystems forming recognisable patterns within the landscape
C_3 and C_4 plants	The different methods plants use to convert carbon dioxide from air into organic compounds through the process of photosynthesis. All plants use C_3 processes; some plants, such as buffel grass and many other warm climate grasses, also use C_4 processes. C_4 plants have an advantage in a warmer climate due to their higher CO_2 assimilation rates at higher temperatures and higher photosynthetic optima than their C_3 counterparts
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)
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 *short-range endemics* or *vicariant relics*. 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

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