Trends in the biodiversity of the Nullarbor region: a comparison between 1984 and 2012

October 2012

Government of South Australia

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EXECUTIVE SUMMARY

Climate change is predicted to influence the Alinytjara Wilurara region by raising average air temperature by 1.6 – 3.5 °C, and decreasing annual rainfall by 10 – 14% by 2070 (Suppiah *et al.,* 2006, Alcoe *et al.,* 2012). These changes are likely to alter the ecology of the Nullarbor landscape. Plants and animals might respond by adjusting their natural ranges and migrating towards refuges, such as the Nullarbor coastline, where the influence of the ocean reduces climate extremes. Biological surveys of the Nullarbor region that were conducted in 1984 and 2012 provide information on the environmental assets in the region at two different points in time. Data were analysed to detect trends in the cover of plants, and the abundance of mammals, birds and reptiles, and to investigate the link between temporal and spatial changes in rainfall and temperature with changes in the Nullarbor biota. Comparisons between 1984 and 2012 indicate there have been some changes in the coastal zone in terms of composition of plants and birds that characterised the HOT/DRY climate zone, but these biotic changes could not be definitively linked to changes in rainfall and temperature. Long-term monitoring programs are required to further track trends in the biota of the Nullarbor landscape and these programs should be linked directly to priority assets for the AW NRM, such as important biota or systems that are likely to be affected by climate change. This study can be enhanced and improved to provide informative trajectories of biodiversity that can then be used to inform planning and future management decisions in the Nullarbor region in accordance with the priorities of the Alinytjara Wilurara Natural Resource Management Board.

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INTRODUCTION

The Earth's surface is warming and the global climate is changing with impacts already evident to the present generation. Rising air temperatures, increased heatwaves, changing rainfall patterns, more extreme and frequent drought and flood, altered ocean temperature and chemistry and sea-level rise present potential significant risks to the economy, society and way of life (Meehal *et al.,* 2007). Future challenges include securing a reliable water supply, the effects of higher temperatures, reduced rainfall and more frequent extreme weather events on agricultural productivity and biodiversity, an increased number of heatwaves impacting human health and infrastructure and sea-level rise and storm surge impacts on coastal settlements, infrastructure and coastal ecosystems (Hughes, 2003; Steffen, 2009). Past temperature changes have affected the world, altering atmospheric and ocean circulation, rainfall and water availability, ice-cover, vegetation, ocean acidity and sea level. Indeed, past climate change shows us that global climate is sensitive to small influences and similar processes can act to amplify current human influences (Australian Academy of Science, 2010).

South Australia is becoming warmer. Southern coastal areas are now drier but rainfall is increasing in the state's northern half. The global surface temperature has increased by 0.7°C in the last century, but in Australia (0.89°C) and in particular South Australia (0.96°C) the increase has been greater. The rate of increase has become more rapid since 1950. The Commonwealth's Scientific and Industrial Research Organisation (CSIRO) has reported on climate conditions and outlined climate projections for 2030 and 2070 for South Australia (CSIRO, 2007). The CSIRO predict that South Australia will see:

- higher temperatures, including more extreme hot days, with spring and summer warming more than winter and autumn
- decreased rainfall in agricultural regions (especially in winter and spring)
- greater frequency and severity of drought
- decreased flows in water supply catchments including the Murray-Darling
- increased flood risk (despite drier average conditions)
- shifts in conditions affecting viability of crops and biodiversity
- increased incidence and severity of bushfires
- coastal hazards related to the effect of ocean warming on sea levels combined with storms of possibly increased intensity

- damage to infrastructure, for example from coastal erosion, flooding and extreme heat

Arid regions potentially provide a useful location for examining the impacts of climate change on biodiversity. Plants and animals that use these regions are typically adapted to cope with climatic extremes and it may be possible to make comparisons along broad scale climatic and environmental gradients.

Research shows that plants and animals can be negatively or positively impacted by climatic changes. Plants that have limited spatial ranges, narrow habitat requirements and poor dispersal abilities have less capability of adaption and can become extinct if the environment changes beyond their limitation (Box *et al.,* 2008). On the other hand, some woody shrubs are likely to increase in range because they have evolved to require little water, and are likely to have accelerated biomass productivity in an enriched CO_2 environment (Hughes, 2003). The contrasting findings of these researchers indicate the variable response of plants and animals to a changing climate.

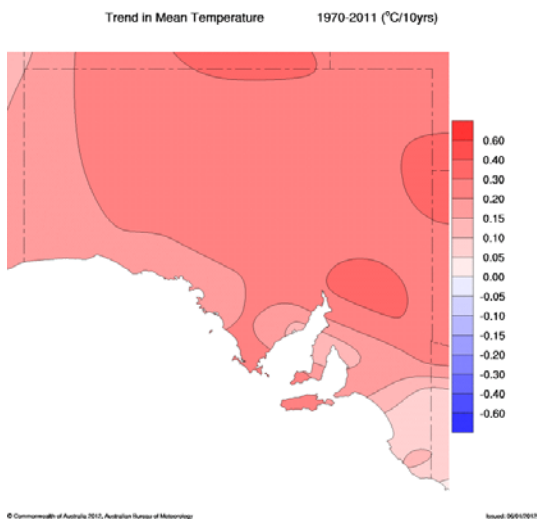

Figure 1 Trends in mean temperature for South Australia. Source: Australian Bureau of Meteorology. Note the above map shows an average temperature increase of up to 0.4°C per decade or 1.6°C over the past 40 years in South Australia.

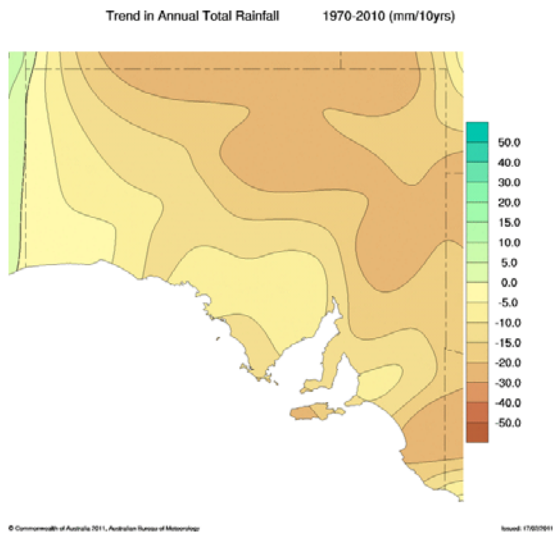

Figure 2 Trends in total annual rainfall for South Australia. Source: Australian Bureau of Meteorology Climate Change Trend Maps. Note the above map shows a decline in South Australian annual rainfall in the range of 5 to 30mm per decade.

By 2070, South Australia is expected to increase in temperature by between 1.4 - 2.85 ^{0}C (Suppiah *et al.,* 2006). In the Alinytjara Wilurara (AW) region the average air temperature is expected to rise by 1.6 – 3.5 ^{0}C between now and 2070 (Figure 1; Suppiah *et al.,* 2006). Total annual rainfall is generally predicted to decrease by 10 – 14% in the AW region (Figure 2; Alcoe *et al.,* 2012). It is likely that the change will not be distributed evenly because the AW region spans from the coast (the Nullarbor Plain) to the arid centre of Australia (Alcoe *et al.,* 2012). The coastal section of the AW region receives relatively more rainfall and has relatively lower average temperatures. As a result, the coastal region is expected to show a temperature increase and rainfall decrease toward the lower end of range for the entire AW region (approx 0.8^oC and -15 mm). Some plants and animals that are adapted to this relatively moderate coastal region may be at the edge of their climatic range and so these species provide a natural experiment to test the impacts of climate change.

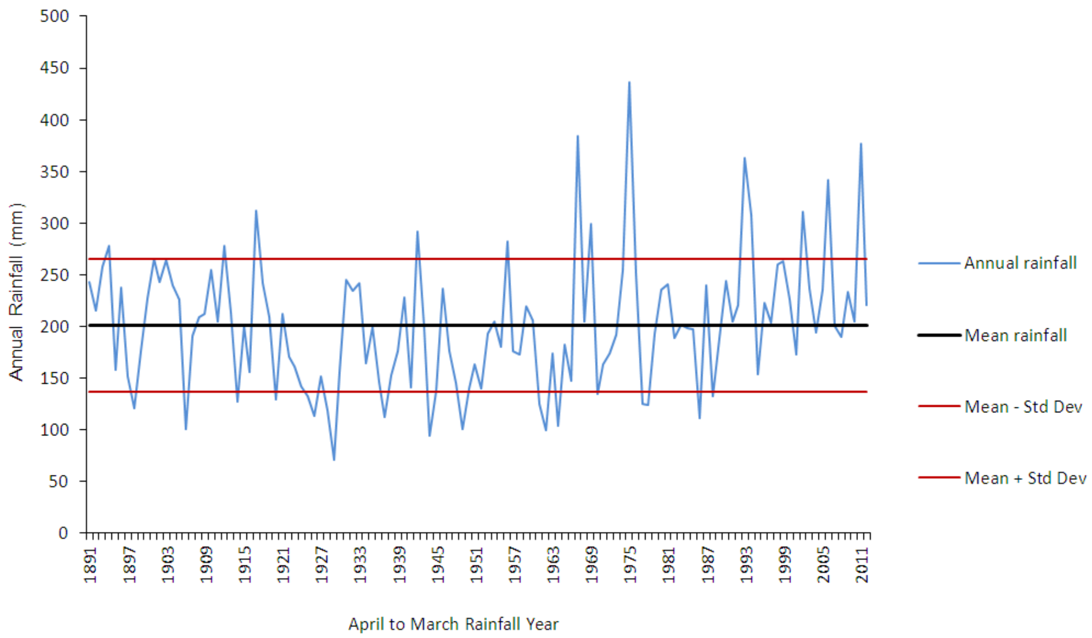

Figure 3 Annual Rainfall for the Nullarbor bioregion from 1891 to 2011. Rainfall year is April to March, for example total annual rainfall is taken from April 2011 to March 2012, inclusive. The calculated mean annual rainfall is 201 mm with a standard deviation of +/- 65.04. (Source: Bastin, 2012).

Table 1 Rainfall in the three years preceding the 2012 and 1984 surveys, with mean and standard variance. Source: Bastin 2012

Year	Total rainfall calculated from April to March (mm)	Year	Total rainfall calculated from April to March (mm)
1981	241	2009	234
1982	189	2010	205
1983	201	2011	376
Mean	210.3	Mean	271.7
Standard Variance	741.3	Standard Variance	8374.3

The climate experienced in the Nullarbor region is highly variable, with total annual rainfall ranging from 71 to 437 mm (Figure 3). Rainfall is likely to be the most important factor, limiting the ecosystem processes and functions in the Nullarbor region, where precipitation is the principal source of water (Dube & Pickup, 2001). According to climatic records for the Nullarbor (see Table 1), the rainfall 3 years prior to the 1984 survey was less than the rainfall preceding the 2012 survey. This is a direct contrast to the climate change prediction that describes a drying of the landscape. Short-term pulses of rain, and long-term trends control plant growth, carbon fixation and net primary production (Sala *et al.,* 1997). How these two different rainfall cycles interact will need to be addressed in future monitoring so that trends in biota can be linked to both short-term pulses, and long-term climatic fluctuations.

The Nullarbor region has been divided into two climate zones for this study based on predominant patterns of rainfall and temperature. These zones are approximately located south of Cook to the Nullarbor coast, - COLD/WET zone, and north of Cook to beyond the northern Nullarbor border - HOT/DRY zone. The northern climate zone experiences 200 mm mean annual rainfall and 21^{0}C mean temperate. The southern climate zone experiences 300 mm mean annual rainfall and 18^{0}C mean temperature (figure 4).

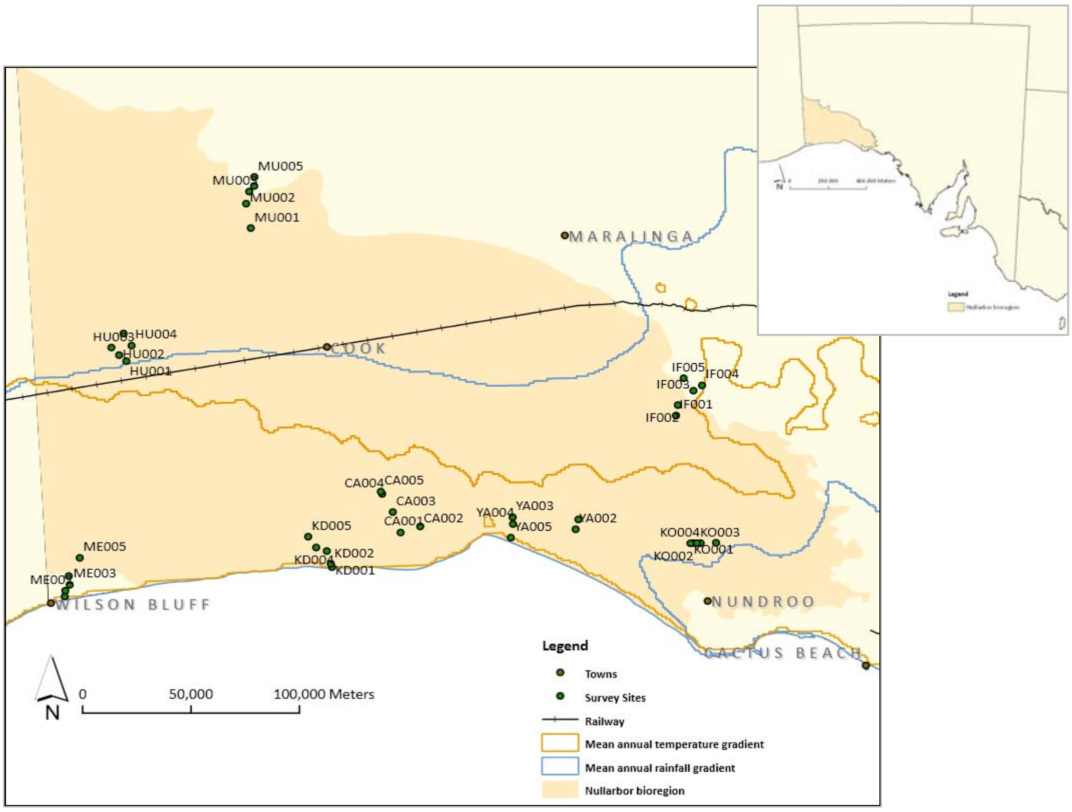

Figure 4 Average Rainfall maps based on standard 30-year climatology (1961 – 1990). Rainfall gradient is indicated with a blue line, and temperature gradient is indicated with an orange line. Note IF sites are below rainfall gradient but above temperature gradient.

Climate is a broad scale variable that influences the distribution and abundance of plants and animals but soils, landform and aspect can also be important. Temperature gradients influence the distribution of C3/C4 grass varieties (Epstein *et al.*, 1997). Consistent rainfall gradients often determine broad vegetation patterns and biomass production (Morgan *et al.*, 2008). Arid land plants have evolved to exploit intermittent and irregular rainfall events by quickly responding to rain by germinating, growing and producing seed (Westoby, 1980; Morton *et al.*, 2011). The duration of precipitation and in which season it falls is therefore an important aspect of rainfall in arid environments. Most animal species do not fluctuate in a direct relationship with rainfall. This can be due to various forms of buffering, for example fruits for birds may provide a secondary moisture resource after rainfall (Birds: Reid, 1991; Prinzinger & Schleucher, 1998. Insectivorous marsupials: Dickman *et al.*, 2001. Lizards: James, 1994). Monitoring ecosystem function and health in response to climate change needs to be well planned to answer the question: How has the ecology of the landscape changed in response to temporal and spatial changes in rainfall and temperature? (Woinarski, 2004).

A report by Bardsley and Wiseman (2012) highlighted the influence that climate change is likely to have on the AW region and made several recommendations to improve the region's capacity to adapt and flourish under climate change, in both a natural resource management and social context. Key recommendations that are addressed in this report include the repeat of biological surveys and the investigation of the relationship between biodiversity and climate. These actions will inform the AW region of possible trends in the abundance and cover or plants and animals, and assist in the selection of regional assets that should be used to define long term monitoring programs for the Nullarbor region.

Monitoring in the arid lands has been a subject of debate, particularly in areas where there is low density of biodiversity, low populations of humans and where the land is not used for agricultural production (Eyres, 2011). It is largely accepted that monitoring programs need to be clearly articulated and directed toward landscape management, rather than simply tracking the extinction and decline of ecosystems (Steffen *et al.,* 2009; Field *et al.*, 2004). A key message from Lindenmeyer *et al.* (2012) is to design monitoring programs to specifically answer management questions, rather than use monitoring to detect change with questions added post-hoc.

A common approach taken by the Feral Camel Action Plan (NRM, 2010) is to focus management on an asset, and to monitor the state of the asset in response to pressures. An asset can include systems or locations of importance, whether built or natural, for example biodiversity hotspots, water points, threatened species or ecosystems, or built structures. All monitoring programs can use this basic template to articulate regional assets and pressures, according to land-use, environmental priorities, and resources available. Making explicit predictions about how management will mitigate impacts and monitor responses is likely to assist in informing whether a management practice is effective or not and to indicate how/when alterations to management plans are needed.

Some key natural assets in the Nullarbor region, include but are not limited to, species that are regionally important, water points, and areas where biodiversity is relatively high. There are 14 species of plants and animals listed by the *EPBC Act 1999* as threatened taxa in the South Australian portion of the Nullarbor region. *Acanthiza iredalei iredalei* is one example of a significant species that is common throughout the Nullarbor landscape. There are numerous naturally occurring water points in the Nullarbor region, including dongas, paleochannels and natural rockholes that accumulate and hold water. These areas are often important because; they host relatively high numbers of plants and animals, because these biodiversity hotspots are occasionally unique to the environment surrounding them as in the case of a dongas, and because water points are often more susceptible to overgrazing, trampling, fouling, and competition.

Climate change is likely to exacerbate threatening processes that affect Australian ecosystems but many outcomes remain unforeseen (Prowse & Brooks, 2011). Key threats in the Nullarbor landscape include, but are not limited to, buffel grass and the impacts of large introduced herbivores such as camels (Biosecurity SA, 2012; Vertebrate Pest Committee, 2010). Changed fire regimes may also be an issue due to both changes in vegetation structure and composition linked to weeds and pests, as well as changed burning practices (Myers *et al.,* 2004).

The impacts that each of these pressures have in the Nullarbor region are not well recorded, but it is likely that each threat is wide-spread given the suitability and climate of the Nullarbor. Accurately quantifying the impacts of individual threats is challenging, as is defining interactions and the interrelationships between them. Climate change represents another layer of complication because it acts over large areas and its affects can be difficult to decouple from shorter term and cyclic processes. Uncertainties remain globally about how ecosystems are responding to climate change due to the high level of complexity inherent in defining causes and consequences (Prato, 2008).

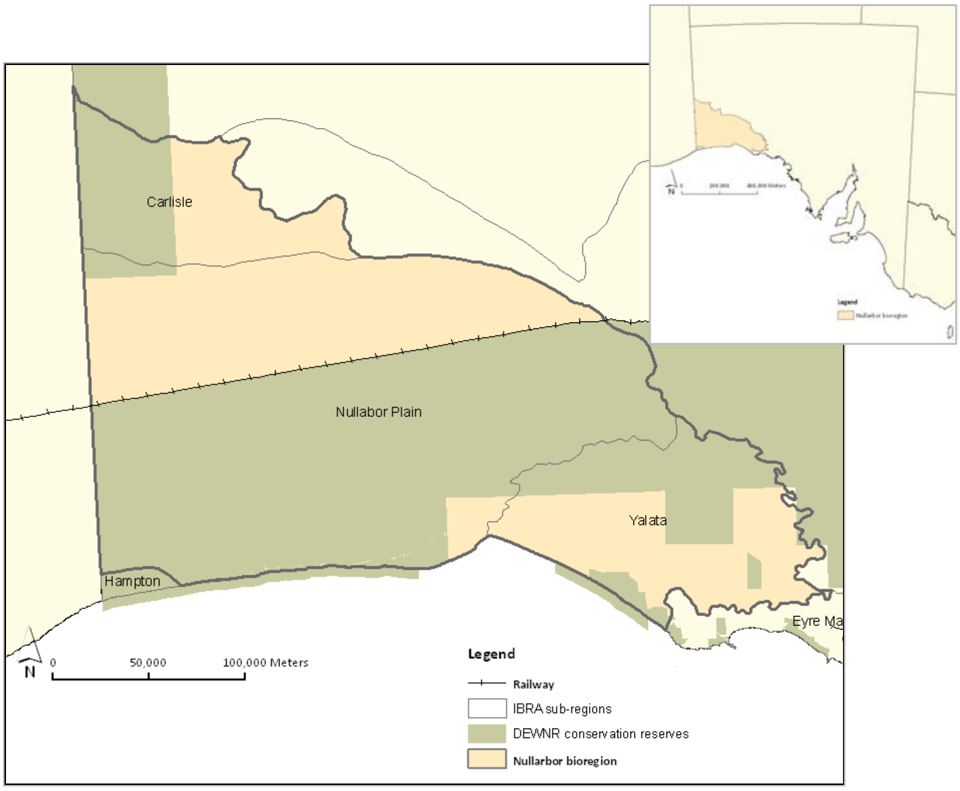

Figure 5 Nullarbor Bioregion with the IBRA subregions: Carlisle, Nullarbor Plain, and Yalata.

The arid environment in the Nullarbor region was the focus of this study to explore possible changes in biodiversity attributed to temporal and spatial changes in rainfall and temperature. As suggested by Bardsley & Wiseman (2012) a repeat of biological surveys was used to attempt to detect changes across the landscape and to then inform the selection of assets that require management and monitoring. The Nullarbor study area is defined by McKenzie & Robinson (1987) using biogeographic boundaries created for South Australia by Laut *et al.* (1977) and adapted for the Interim Bio-regionalisation of Australia (IBRA – Thackway & Creswell, 1995) (Figure 5). The South Australian section of the Nullarbor Bioregion was the study site for a biological survey in 1984 and 2012. The key aims of this project were; to detect trends in the cover of plants, and the abundance of mammals, birds and reptiles, on the basis of a comparison of an historical survey from 1984 with the current survey from 2012, and to investigate the link between temporal and spatial changes in rainfall and temperature with changes in the Nullarbor biota. Secondary to these aims were: 1) the investigation of potential for historical biological survey data to be used for monitoring trends in biodiversity over time, 2) the documentation of methods investigated and adapted for current data collection, including suggested improvements for future surveys, and 3) discussion of recommendations for future sampling and the relative value of the different monitoring actions for managers.

We predicted that some plants and animals in the coastal region may be at the edge of their climatic range, therefore, we analysed the data to compare changes at sites that were north versus south along the temperature and rainfall gradients. To make these comparisons, we classified sites to the north of the temperature and rainfall gradients as HOT/DRY (sites HU and MU) and sites to the south as COLD/WET (sites CA, IF, KD, KO, YA and ME). The IF sites were located in the *COLD/DRY* band between the average temperature and rainfall gradients and It was decided that these would be included in the COLD/WET zone because rainfall has a greater influence on plant and animal distribution in the arid zone where water availability is the predominant limiting factor.

If plants and animals are adapted to a coastal climate (COLD/WET), their available habitat may shrink as temperatures increases and rainfall decreases. In contrast, the available habitat may increase for species that are adapted to drier and hotter regions. These broad predictions provide a natural experiment to test the impacts of climate change on plants and animals in this arid environment. We tested two hypotheses to examine whether bioclimatic differences were reflected in the abundance and distribution of species. We predicted that over the last 28 years, plants and animals that characterise the HOT/DRY zone would become more abundant in the COLD/WET zone. We also predicted that species characterising the COLD/WET zone would become relatively less abundant in that zone. We examined these predictions by testing for differences in the abundance of plants and animals from the HOT/DRY zone in the COLD/WET zone in 1984 or 2012. Likewise, we tested for differences in the abundance of plants and animals from the COLD/WET zone in 1984 or 2012.

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METHODS

SAMPLING METHOD

Sites were clustered around eight disparate camps for the 1984 survey to sample an accessible array of discrete vegetation units and surface types (Figure 6). These sites formed the basis of the 2012 re-sample. The 8 camps are Catacombs (CA), Ifould (IF), Hughes (HU), Koonalda (KD), Colona (KO), Merdayerah (ME), Muckera (MU), Yalata (YA). In 1984, five sites were selected per camp (40 sites in total). In 2012 there was an additional site at each camp. Sites are 2 km by 2 km and are divided into 2 or 3 patches that are selected because they represent different vegetation communities within each site. For a full list of patches and the corresponding vegetation description see table 2. Sample patches are 100 x 100 m; some are linear and the square is adjusted to a rectangle (eg. 50 x 200 m). Naming convention for samples are camp – site – patch, for example CA – 001 – A or CA001A. Two surveys were conducted in 1984, while in 2012 only one survey was conducted. Biological data collected in autumn 1984 and autumn 2012 are used in this survey. Where plants are compared, only perennial species are included to reduce the effect of high variation in annual species. Vegetation survey methods broadly follow Heard and Channon (1997) and are detailed below. Data collected includes: site description, location details, physical description, disturbance, and soils. Not all data captured in 1984 or 2012 was consistent, due to time constraints.

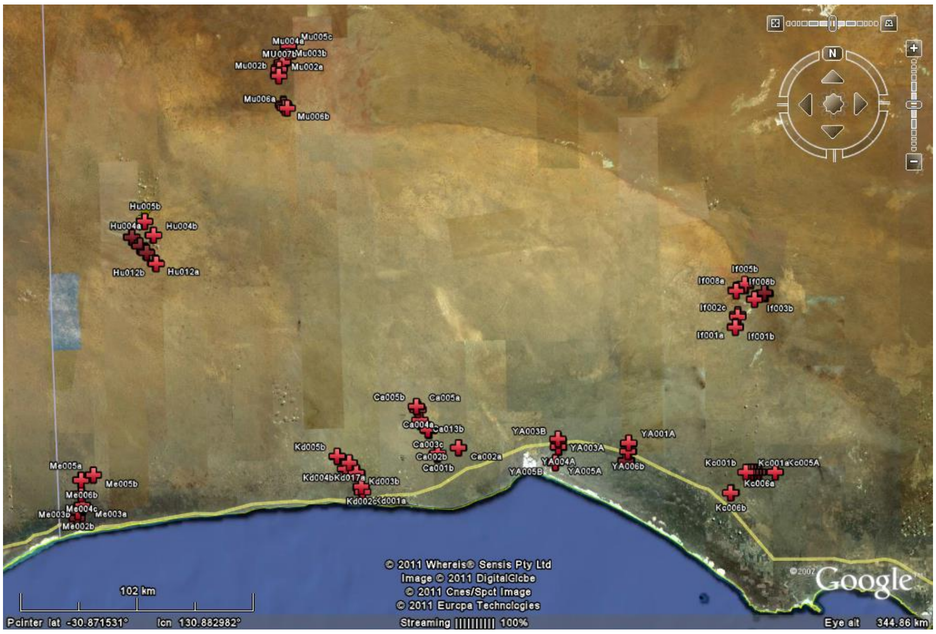

Figure 6 Overview of survey area with location of patches from all sites indicated with red crosses.

Table 2 List of patches surveyed in 1984 and 2012 in autumn. Patches may have been surveyed for vegetation, birds, and vertebrates in either or both years. The vegetation structural description and dominant vegetation species related with each patch reflects observations in 2012 only. These factors were not consistently recorded in 1984.

Patch ID	Surveyed In 2012?	Surveyed In 1984?	Vegetation Structural Description	Dominant Vegetation Species: o = overstorey, u = understorey, e = emergent.
CA001A	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Sclerolaena obliquicuspis (u), Tecticornia disarticulata (o)
CA001B		✓		
CA001C	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Dissocarpus biflorus var. biflorus (u), Tecticornia disarticulata (o)
CA002A	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Maireana sedifolia (o), Tecticornia disarticulata (o)
CA002B	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Maireana sedifolia (o), Tecticornia disarticulata (o)
CA003A	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Maireana sedifolia (o), Tecticornia disarticulata (o)
CA003B	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Maireana sedifolia (o)
CA004A	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Tecticornia disarticulata (o)
CA004B	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Sclerolaena patenticuspis (u), Tecticornia disarticulata (o)
CA005A	✓	✓	Open (Tussock) Grassland	Atriplex acutibractea ssp. acutibractea (e), Austrodanthonia sp. (o)
CA005B	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (e), Austrodanthonia sp. (u), Sclerolaena patenticuspis (o)
CA005C		✓		
CA013A	✓		Low Open Shrubland	Austrodanthonia sp. (u), Maireana sedifolia (o)
CA013B	✓		Low Very Open Shrubland	Austrodanthonia sp. (u), Maireana sedifolia (o)
HU001A	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Sclerolaena patenticuspis (u)
HU001B	✓		Low Open Shrubland	Atriplex vesicaria ssp. (o), Austrostipa nitida (u), Sclerolaena obliquicuspis (u), Sclerolaena patenticuspis (u)
HU002A	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Austrostipa nitida (u), Pittosporum angustifolium (e)
HU002B	✓		Low Shrubland	Atriplex vesicaria ssp. (o)
HU003A	✓	✓	Very Low Open Woodland	Atriplex cryptocarpa (u), Eremophila maculata ssp. maculata (u), Pittosporum angustifolium (o)
HU003B	✓		Very Low Open Woodland	Atriplex cryptocarpa (u), Eremophila longifolia (o), Eremophila maculata ssp. maculata (u), Pittosporum angustifolium (o)
HU004A	✓	✓	Low Very Open Shrubland	Sclerolaena obliquicuspis (o)
HU004B	✓	✓	Low Very Open Shrubland	Austrostipa puberula (u), Eragrostis dielsii var. dielsii (u) Sclerolaena patenticuspis (o)
HU005A	✓	✓	Open (Tussock) Grassland	Acacia oswaldii (e), Austrostipa eremophila/puberula (o), Pittosporum angustifolium (e), Rhagodia spinescens (e)
HU005B	✓	✓	Very Low Open Woodland	Acacia tetragonophylla (o), Enchylaena tomentosa var. tomentosa (u), Lycium australe (u), Pittosporum angustifolium (o), Rhagodia spinescens (u)
HU012A	✓		Low Open Shrubland	Atriplex vesicaria ssp. (o), Maireana sedifolia (o)
HU012B	✓		Low Shrubland	Atriplex vesicaria ssp. (o), Maireana sedifolia (o)

Table 2 continued: List of patches surveyed in 1984 and 2012 in autumn

IF001A	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (o), Austrostipa nitida (u), Maireana sedifolia (e), Salsola tragus (u)
IF001B	✓		Low Shrubland	Atriplex vesicaria ssp. (o), Sclerolaena patenticuspis (u)
IF002A	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (o), Enneapogon caerulescens (u), Maireana sedifolia (o), Sclerolaena obliquicuspis (u)
IF002B	✓		Open Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Maireana sedifolia (o), Sclerolaena obliquicuspis (u)
IF003A	✓	✓	Low Woodland	Acacia papyrocarpa (o), Alectryon oleifolius ssp. canescens (e), Atriplex vesicaria ssp. (u), Maireana integra (u), Maireana sedifolia (u), Maireana trichoptera (u), Rhagodia spinescens (u)
IF003B	✓	✓	Low Open Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Maireana sedifolia (u), Santalum acuminatum (u), Sclerolaena diacantha (u), Sclerolaena obliquicuspis (u)
IF004A	✓	✓	Low Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Eremophila scoparia (u), Eucalyptus oleosa ssp. ampliata (o), Scaevola spinescens (u)
IF004B	✓	✓	Low Woodland	Acacia papyrocarpa (o), Alectryon oleifolius ssp. canescens (o), Atriplex vesicaria ssp. (u), Maireana sedifolia (u), Myoporum platycarpum ssp. platycarpum (o)
IF005A	✓	✓	Open Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Austrostipa nitida (u), Maireana integra (u), Maireana sedifolia (u), Sclerolaena obliquicuspis (u)
IF005B	✓		Low Open Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Maireana sedifolia (u)
IF008A	✓		Shrubland	Atriplex vesicaria ssp. (o), Austrostipa nitida (u), Maireana sedifolia (o), Sclerolaena obliquicuspis (u), Vittadinia gracilis (u)
IF008B	✓		Shrubland	Atriplex vesicaria ssp. (o), Enneapogon avenaceus (u), Enneapogon cylindricus (u), Maireana sedifolia (o), Vittadinia gracilis (u)
KD001A	✓	✓	Low Open Shrubland	Hemichroa diandra (u), Lawrencia squamata (o), Nitraria billardierei (o), Trichanthodium skirrophorum (u)
KD001B	✓	✓	Low Open Shrubland	Frankenia sessilis (u), Lawrencia squamata (o), Nitraria billardierei (e), Trichanthodium skirrophorum (u)
KD001C		✓		
KD002A	✓	✓	Open Low Mallee	Atriplex vesicaria ssp. (u), Cratystylis conocephala (u), Eucalyptus yalatensis (o), Exocarpos aphyllus (e), Geijera linearifolia (u), Melaleuca lanceolata (o), Olearia muelleri (u)
KD002B		✓		
KD002C	✓	✓	Shrubland	Cratystylis conocephala (u), Eucalyptus socialis ssp. victoriensis (o), Eucalyptus yalatensis (o), Geijera linearifolia (u), Olearia muelleri (u), Westringia rigida (u)
KD003A		✓		
KD003B	✓	✓	Open Mallee	Atriplex vesicaria ssp. (u), Eucalyptus yalatensis (o), Maireana erioclada (u), Melaleuca pauperiflora ssp. mutica (o), Myoporum platycarpum ssp. platycarpum (e)
KD003C	✓		Low Shrubland	Atriplex vesicaria ssp. (u), Lawrencia squamata (o), Lycium australe (u), Tecticornia disarticulata (u)
KD004A	✓	✓	Shrubland	Atriplex vesicaria ssp. (u), Lawrencia squamata (u), Lycium australe (u), Nitraria billardierei (e)
KD004B	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (u), Austrodanthonia caespitosa (u), Austrostipa puberula (u), Lawrencia squamata (u)
KD005A	✓	✓	Low Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia sp. (u), Austrostipa nitida (u)
KD005B	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (o), Austrostipa eremophila/puberula (u), Austrostipa nitida (u), Maireana sedifolia (e)
KD005C		✓		

Table 2 continued: List of patches surveyed in 1984 and 2012 in autumn

KD005D		✓		
KD017A	✓		Low Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u)
KD017B	✓		Low Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u)
KO001A	✓	✓	Low Open Shrubland	Acacia papyrocarpa (e), Atriplex vesicaria ssp. (o), Tecticornia disarticulata (o)
KO001B	✓	✓	Low Shrubland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Austrodanthonia sp. (u), Tecticornia disarticulata (u)
KO001C		✓		
KO002A	✓	✓	Very Low Open Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Tecticornia disarticulata (u)
KO002B	✓	✓	Low Open Shrubland	Atriplex vesicaria ssp. (o), Tecticornia disarticulata (o)
KO003A	✓	✓	Very Low Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Cratystylis conocephala (u)
KO003B	✓	✓	Open Mallee	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Austrostipa nitida (u), Cratystylis conocephala (u), Eucalyptus oleosa ssp. ampliata (o),
KO004A	✓	✓	Very Low Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Austrostipa nitida (u), Cratystylis conocephala (u)
KO004B	✓		Low Open Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Austrostipa nitida (u), Cratystylis conocephala (u)
KO005A	✓	✓	Open Mallee	Atriplex vesicaria ssp. (u), Austrostipa platychaeta (u), Cratystylis conocephala (u), Eucalyptus oleosa ssp. ampliata (o)
KO005B	✓		Very Low Open Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Austrostipa nitida (u), Cratystylis conocephala (u)
KO006A	✓		Open (Tussock) Grassland	Acacia papyrocarpa (e), Austrostipa nitida (u), Lomandra effusa (o), Podolepis canescens (u)
KO006B	✓		Open (Tussock) Grassland	Acacia papyrocarpa (e), Lawrencia squamata (e), Podolepis canescens (u)
ME001A	✓	✓	Tall Open Shrubland	Eremophila weldii (u), Eucalyptus calcareana (o), Eucalyptus socialis ssp. viridans (o), Melaleuca pauperiflora ssp. mutica (u), Melaleuca quadrifaria (o), Rhagodia crassifolia (u), Westringia rigida (u)
ME001B	✓	✓	Tall Shrubland	Eremophila weldii (u), Eucalyptus calcareana (o), Eucalyptus gracilis (e), Eucalyptus socialis ssp. viridans (o), Melaleuca quadrifaria (o), Rhagodia crassifolia (u), Westringia rigida (u)
ME001C		✓		
ME001D		✓		
ME001E		✓		
ME002A	✓	✓	Open Low Mallee	Eremophila weldii (u), Eucalyptus gracilis (o), Eucalyptus yalatensis (o), Geijera linearifolia (u), Melaleuca lanceolata (o), Westringia rigida (u)
ME002B	✓	✓	Open Low Mallee	Eremophila weldii (u), Eucalyptus calcareana (o), Eucalyptus gracilis (o), Eucalyptus yalatensis (o), Melaleuca lanceolata (o), Pomaderris forrestiana (u), Westringia rigida (u)
ME003A	✓	✓	Open Mallee	Atriplex nummularia ssp. spathulata (u), Eremophila weldii (u), Eucalyptus calcareana (o), Eucalyptus yalatensis (o), Geijera linearifolia (u), Scaevola spinescens (u), Westringia rigida (u)
ME003B	✓	✓	Open Mallee	Eucalyptus calcareana (o), Eucalyptus gracilis (o), Eucalyptus yalatensis (o), Scaevola spinescens (u), Westringia rigida (u)
ME004A	✓	✓	Open Mallee	Acacia papyrocarpa (o), Atriplex nummularia ssp. spathulata (u), Eremophila weldii (u), Eucalyptus gracilis (o), Geijera linearifolia (u), Melaleuca lanceolata (o), Westringia rigida (u)
ME004B	✓	✓	Very Low Woodland	Acacia papyrocarpa (o), Cratystylis conocephala (u), Eremophila weldii (u), Geijera linearifolia (u), Olearia muelleri (u),Westringia rigida (u)

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Table 2 continued: List of patches surveyed in 1984 and 2012 in autumn

ME004C	✓		Very Low Woodland	Acacia papyrocarpa (o), Atriplex vesicaria ssp. (u), Austrodanthonia sp. (u), Austrostipa nitida (u), Eucalyptus calcareana (o), Geijera linearifolia (u), Olearia muelleri (u)
ME005A	✓	✓	Low Open Shrubland	Atriplex nummularia ssp. spathulata (e), Austrodanthonia sp. (u), Austrostipa eremophila/puberula (u), Enchylaena tomentosa var. tomentosa (u), Maireana sedifolia (o)
ME005B	✓	✓	(blank)	Atriplex nummularia ssp. spathulata (e), Austrostipa eremophila/puberula (u), Maireana sedifolia (o), Sclerolaena uniflora (u),
ME005C		✓		
ME006A	✓		(Tussock) Grassland	Atriplex nummularia ssp. spathulata (e), Austrodanthonia sp. (o), Austrostipa eremophila/puberula (o), Maireana sedifolia (e)
ME006B	✓		(Tussock) Grassland	Atriplex nummularia ssp. spathulata (e), Austrodanthonia sp. (o)
MU001A	✓	✓	Low Open Woodland	Chenopodium gaudichaudianum (u), Enneapogon avenaceus (u), Enneapogon cylindricus (u), Pittosporum angustifolium (o)
MU001B	✓	✓	Very Low Open Woodland	Acacia aneura var. intermedia (o), Maireana sedifolia (u), Pittosporum angustifolium (o)
MU002A	✓	✓	Low Open Woodland	Acacia aneura var. intermedia (o), Acacia ligulata (u)
MU002B	✓		Tall Shrubland	Acacia aneura var. intermedia (e), Acacia ligulata (o)
MU003A	✓	✓	Low Open Woodland	Acacia aneura var. (o), Acacia ligulata (u), Acacia ramulosa var. linophylla (u), Ptilotus obovatus (u)
MU003B	✓		Low Open Woodland	Acacia aneura var. intermedia (o), Acacia ramulosa var. linophylla (u)
MU004A	✓	✓	Low Open Woodland	Acacia aneura var. intermedia (o), Acacia ramulosa var. linophylla (u)
MU004B	✓		Low Open Woodland	Acacia aneura var. intermedia (o)
MU005A	✓	✓	Tall Open Shrubland	Acacia ligulata (o), Dicrastylis beveridgei var. lanata (u), Dodonaea viscosa ssp. angustissima (o), Eremophila willsii ssp. willsii (u)
MU005B	✓		Low Woodland	Acacia ayersiana (o), Acacia ligulata (u), Dodonaea viscosa ssp. angustissima (u)
MU005C	✓		Low Open Woodland	Acacia ligulata (u), Acacia ramulosa var. linophylla (u), Dodonaea viscosa ssp. angustissima (u), Eucalyptus youngiana (o)
MU006A	✓		Low Woodland	Acacia aneura var. intermedia (o), Chenopodium gaudichaudianum (u), Erodiophyllum elderi (u), Sclerolaena patenticuspis (u)
MU006B	✓		Low Open Woodland	Chenopodium gaudichaudianum (o), Enchylaena tomentosa var. tomentosa (u), Enneapogon avenaceus (u), Pittosporum angustifolium (o)
YA001A	✓	✓	Open Mallee	Atriplex vesicaria ssp. (u), Cratystylis conocephala (u), Eucalyptus calcareana (o), Eucalyptus gracilis (o), Eucalyptus oleosa ssp. ampliata (o), Olearia muelleri (u), Rhagodia crassifolia (u), Sclerolaena uniflora (u)
YA001B	✓		Open Mallee	Atriplex vesicaria ssp. (u), Cratystylis conocephala (u), Eucalyptus brachycalyx (o), Eucalyptus calcareana (o), Olearia muelleri (u)
YA001C	✓		Mallee	Atriplex vesicaria ssp. (u), Cratystylis conocephala (u), Eremophila scoparia (u), Eucalyptus brachycalyx (o), Eucalyptus calcareana (o), Eucalyptus gracilis (o)
YA002A	✓	✓	Mallee	Atriplex vesicaria ssp. (u), Eucalyptus brachycalyx (o), Eucalyptus calcareana (o), Myoporum platycarpum ssp. platycarpum (u), Rhagodia crassifolia (u), Sclerolaena uniflora (u)
YA002B	✓	✓	Open Mallee	Acacia oswaldii (u), Atriplex vesicaria ssp. (u), Eremophila glabra ssp. glabra (u), Eucalyptus calcareana (o), Myoporum platycarpum ssp. platycarpum (u), Pittosporum angustifolium (u)
YA002C	✓	✓	Open Mallee	Atriplex vesicaria ssp. (u), Cratystylis conocephala (u), Eucalyptus brachycalyx (o), Eucalyptus calcareana (o), Melaleuca lanceolata (u), Myoporum platycarpum ssp. (u), Pittosporum angustifolium (u)

Table 2 continued: List of patches surveyed in 1984 and 2012 in autumn

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YA002D	✓	✓		
YA003A	✓	✓	Low Open Woodland	Atriplex vesicaria ssp. (u), Cratystylis conocephala (u), Maireana erioclada/pentatropis (u), Myoporum platycarpum ssp. platycarpum (o)
YA003B	✓	✓	Low Woodland	Atriplex vesicaria ssp. (u), Austrostipa eremophila/puberula (u), Cratystylis conocephala (u), Eucalyptus brachycalyx (o), Frankenia serpyllifolia (u), Myoporum platycarpum ssp. (o)
YA003C		✓		
YA004A	✓	✓	Open Mallee	Atriplex vesicaria ssp. (u), Austrostipa eremophila/puberula (u), Cratystylis conocephala (u), Eucalyptus brachycalyx (o), Eucalyptus calcareana (o), Melaleuca lanceolata (u), Myoporum platycarpum ssp. platycarpum (o), Sclerolaena uniflora (u)
YA004B	✓	✓	Open Mallee	Atriplex vesicaria ssp. (u), Cratystylis conocephala (u), Eucalyptus brachycalyx (o), Eucalyptus gracilis (o), Frankenia serpyllifolia (u), Melaleuca lanceolata (u), Myoporum platycarpum ssp. platycarpum (o)
YA005A	✓		Low Open Shrubland	Atriplex vesicaria ssp. (o), Austrodanthonia caespitosa (u), Frankenia sessilis (u), Maireana pentatropis (u), Melaleuca pauperiflora ssp. mutica (e), Nitraria billardierei (e), Tecticornia disarticulata (o)
YA005B	✓	✓	Very Open Shrubland	Atriplex vesicaria ssp. (u), Frankenia serpyllifolia (u), Frankenia sessilis (u), Melaleuca lanceolata (o), Tecticornia disarticulata (u)
YA005C		✓		
YA005D		✓		
YA005E		✓		
YA005F		✓		
YA005G		✓		
YA005H		✓		
YA006A	✓		Low Open Shrubland	Atriplex stipitata (o), Austrodanthonia caespitosa (u), Austrostipa drummondii (u), Lomandra effusa (o), Maireana erioclada/pentatropis (u), Podolepis canescens (u)
YA006B	✓		Low Open Shrubland	Atriplex stipitata (o), Austrostipa drummondii (u), Cratystylis conocephala (e), Lomandra effusa (o), Maireana pentatropis (o), Podolepis canescens (u), Sclerolaena diacantha (u)

Vegetation sampling

Vegetation sampling was based on the Biological Survey of South Australia methods detailed in Heard and Channon (1997). All vascular plants were recorded, along with a measure of their cover/abundance and a structural classification of life form at each patch. Dominant species in both the overstorey and understorey were also noted at each patch, as well as the structural formation description of the vegetation community. In addition to the standard methods, there were more intensive cover-abundance measures for dominant perennial overstorey and understorey species, and measures of camel browsing impacts (see below).

The methods of collecting the cover/abundance measures of plants differed between 1984 and 2012. In 1984 the percent cover was recorded, where each sample patch equalled 100%. This data was stored in the Biological Database of South Australia and was transformed into a category. A category was associated to each individual according to the percent cover:

N not many, 1 – 10 individuals**
1 sparsely or very sparsely present; cover very small (less than 5%)
2 plentiful, but of small cover (less than 5%)
3 any number of individuals covering 5 – 25% of the area
4 any number of individuals covering 25 – 50% of the area
5 any number of individuals covering 50-75% of the area
6 any number of individuals covering 75 – 100% of the area
** where large shrubs or trees were involved a category to reflect the cover rather than abundance was chosen.

In 2012, the above categories were used and no definitive percent cover was allocated. Both sets of cover/abundance records from 1984 and 2012 where transformed into absolute numbers to allow for the multivariate analyses of cover. Category N = 1% cover, category 1 = 0.5% cover, category 2 = 2.5% cover, category 3 = 15% cover, and category 4 – 37.5% cover. No individuals were recorded in categories 5 and 6.

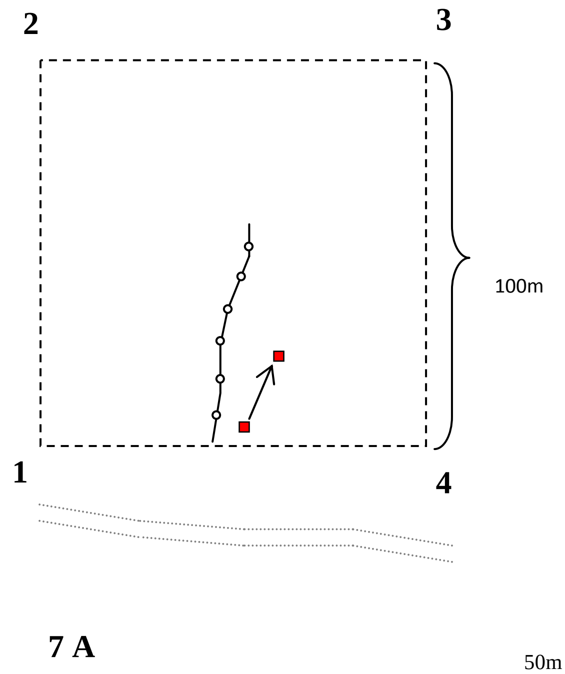
Transects/segments in the dominant cover measures and quadrats in the browse evaluations were referenced to the corners of the vegetation patch quadrat. Trap-lines and photopoints were nearer the quadrat edge and linked corners 1 & 4. The schematic plan (Figure 7) is a typical layout of the quadrats (Photopoints lay either side of trap-line and trap-line might not be contained entirely within quadrat). The location of camel browse transects in relation to the sample patch is shown in figure 9.

Dominant perennial vegetation cover

For woody species listed as overstorey/understorey dominants, cover measures were undertaken as follows:

1. For trees and tall shrubs listed as dominant overstorey/tree forms and species that are emergent: The height of each individual was recorded as the vertical distance above ground level to the highest foliage. The width of an individual was recorded in line with the main trunk for tree forms, and across the point where multi-stems meet near ground level for shrub forms. The direction of width measurement changed with each successive measure of the same species. The first observation was measured at 280 degrees, second at 310 degrees, third at 340 degrees, fourth at 10 degrees, fifth at 40 degrees, sixth at 70 degrees, the seventh returned to 280 degrees and the cycle repeated, i.e. eighth at 310, ninth at 340, and so on. Only the dominant trees/tall shrubs that were rooted inside the quadrat were measured. If the crown width extended outside the quadrat the full width was recorded (we assumed this overhang out of the quadrat matches the overhang in to the quadrat of other plants that are rooted outside).

2. For Shrubs and low shrubs listed as dominant overstorey or understorey species:
Six 4 m wide segments (A to F) were surveyed along 3 parallel strip transects, refer to figure 7B for spatial design in quadrat. Within each segment measurement of distance apart, crown, height and width were taken for six individuals of each shrub species listed as a dominant in the overstorey or understorey. Segment length varied with shrub density, and on occasions, extended outside the quadrat but were always a minimum of 50 m apart of each strip axis. Figure 8 illustrates the procedure for locating six individuals of a species.



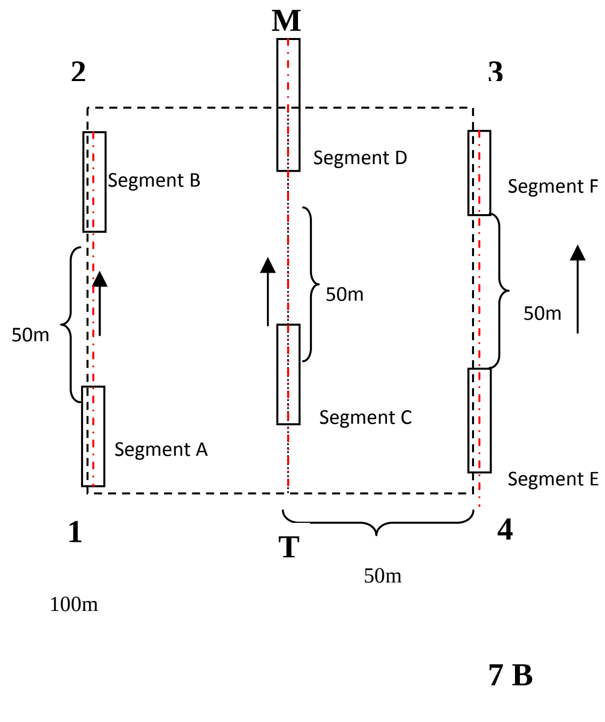


Figure 7 A shows schematic 100 x 100 m sample patch with trapline and photopoint; and quadrat corners. Track is mostly "near" side and links corners 1& 4. B shows three strip transects each with two segments for dominant perennial cover measures (this representation is a typical fit for shrub or low shrub dominants).

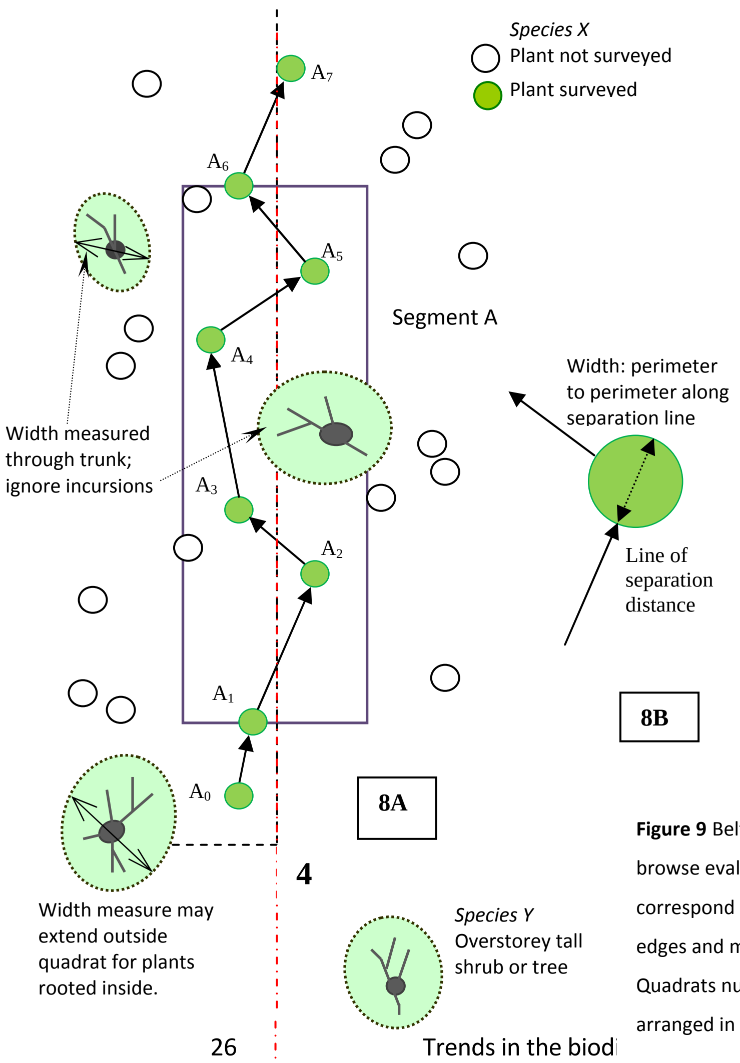


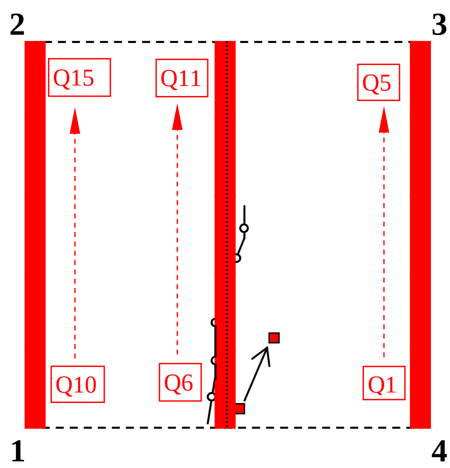
Figure 8 Construction of segments and measures on dominants around Segment A. Axis of strip transect and segment is coincident with sampling quadrat.

8 A shows small bush A_0 (of *Species X*) selected near Corner 4. Locate A_1, nearest same species along transect and within 2 m of strip axis. Measure separation distance from bush perimeter of A_0 to bush perimeter of A_1. Measure height and width of A_1. Locate A_2; the nearest individual of same species, along transect and within 2 m of strip axis. Continue until A_7. Only A_1 to A_6 are measured for height and width.

8 B shows width measure is taken along same line of separation distance from previous bush.

This figure represents a typical arrangement for shrub/low shrub dominants (relatively abundant either as Overstorey or Understorey). For some Overstorey dominants, strip transect may have to extend forward to accommodate long segment length (in small or odd-shaped vegetation patches) but should not cross track, fence or other disturbance.

Figure 9 Belt transects for camel browse evaluations also correspond to vegetation quadrat edges and mid-line transects. Quadrats numbered 1 to 15 are arranged in groups of 5 as shown.



Perennial species browse

Browse impacts of exotic herbivores (camels and rabbits) were appraised along belt transects established along the edges (1-2 / 4-3) and mid-line (T-M) of the 100 x 100 m quadrat, the same axes as the dominant species cover measures. Camel browse was recorded in 15 (20 m x 4 m) quadrats systematically located along the margins and the mid-line of a 100 x 100 m quadrat, five per belt transect. See figures 7B and 9 for a layout of the camel browse quadrats and figures 10 and 11 for a description of how to distinguish the different types and intensities of camel browse.

All woody, perennial species that were greater than 2 m and rooted within 2 m of a transect were examined including saplings, plus mistletoe below 4 m. On each 20 x 4 m browse quadrat the browse intensity above 2 m was recorded for each perennial species present. Browsing intensity can vary on a given plant so two degrees of browse class were recorded, using codes that reflected branch tip diameters as in table 3. Where camels had stripped foliage and bark from twigs, the diameter of thickest part of the stripped twig was recorded.

Table 3 Branch tip diameter classes for browse intensity

Browse Class Code	Reference Object	Branch Tip Diameter Range (mm)
IT	Intact	No browsed tip
TP	Toothpick	< 1.5 *
MS	Match	1.5 – 3
DS	Soft-Drink Straw	3.1 – 5
PC	Pencil (wooden)	5.1 – 9
LF	Little Finger (across base of fingernail)	10 – 15
TB	Thumb (across thumbnail base)	16 – 25
TB+	Thumb and finger	> 25

* This class was naturally absent from some species.

Tallies were made of the number of individuals per browse class per species for each browse quadrat.

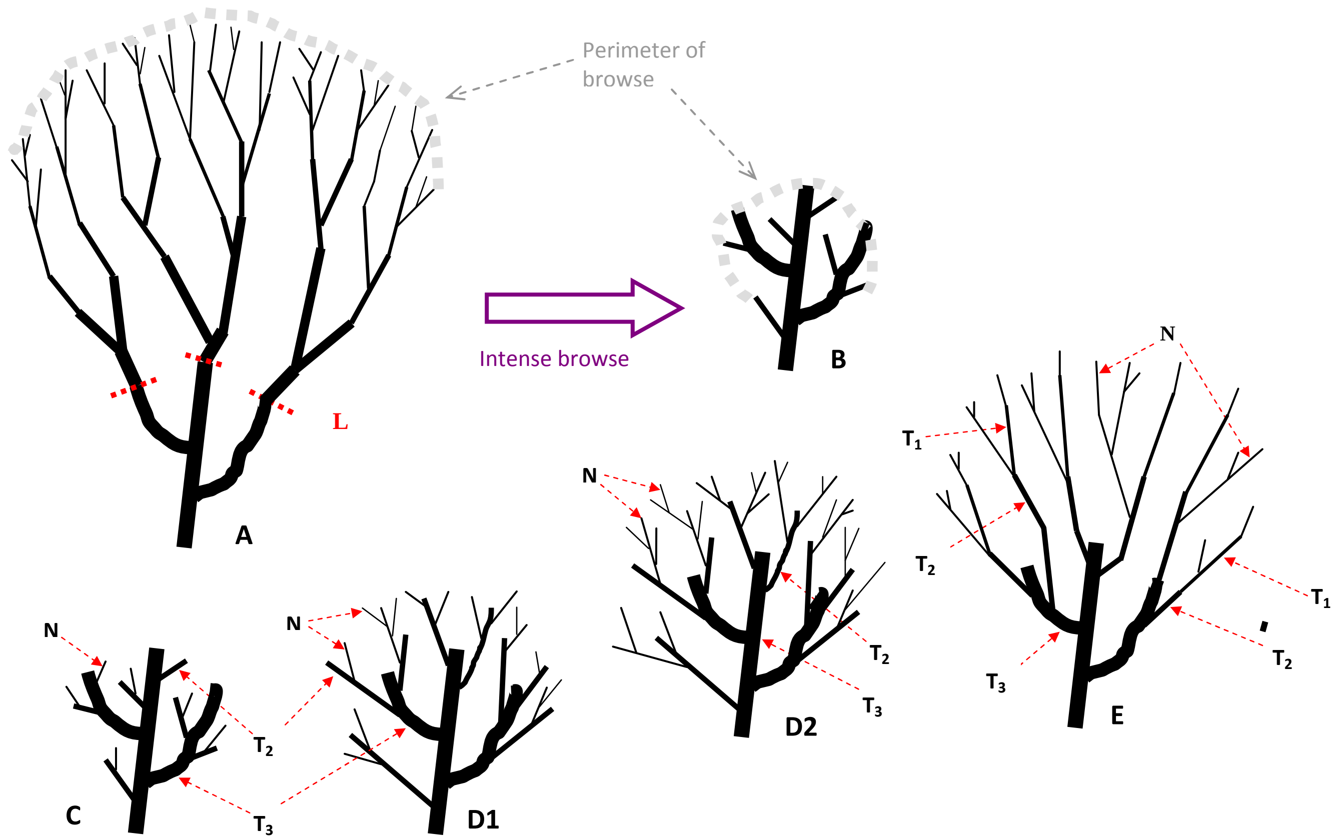


Figure 10 A. An Intact shrub or tree is browsed back to the positions marked L and forms B. Perimeters to evaluate are outlined in grey.
C. New shoots (N) only grow from very thick stems (T_3) and some thick branches (T_2), which sprouted after intense browse, but were also eaten back. All three diameters occur at the perimeter – new growth has not extended beyond an older browse episode, because of the constant or intense browse pressure. Record the diameter of T_3, and diameter of T_2. In these instances, newest shoots are inevitably browsed.
D. The earlier heavy browse episode is preserved on the bush as in C. In D1, some growth has occurred and perimeter is basically defined by browsed T_2 branches and tips of N, that don't extend much beyond T_2, so record T_2 and N diameters (N may be browsed). In D2, new shoots extend beyond T_2 size branches and even have some axillary shoots – base recording on diameter of N, which may or may not be browsed. Two episodes of past browse are preserved on this bush
E. The earlier heavy browse episode is preserved on the bush as in C, but growth has resumed undisturbed. Branch diameters taper from T_2 through T_1 to N, which also has some axillary growth. Observation records are based on the diameter of N, which may or may not be browsed.

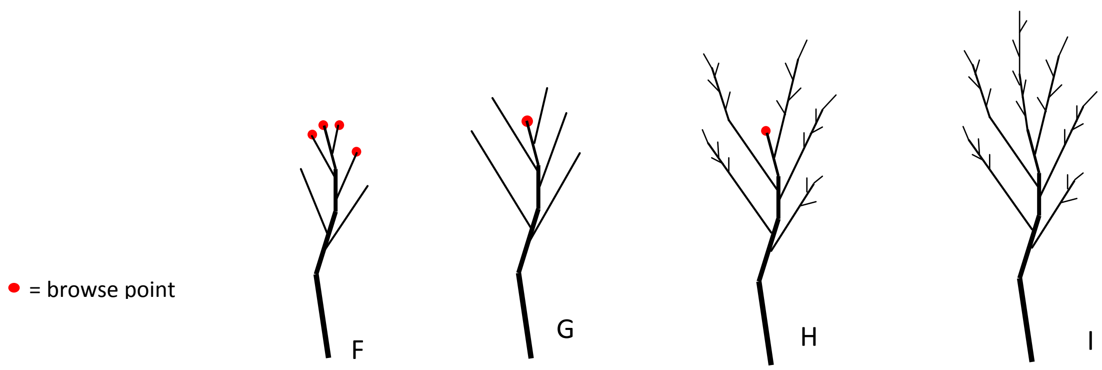


Figure 11 F, G, H, I represent the branch of a shrub or tree.
F. The branch tip and terminals of closest axillary shoots have been lightly browsed. If all branches of shrub/low tree are like this record as browsed using diameter of the shoot tips. If most branches are like this, record primarily as browsed (using diameter at the shoot tips) and secondarily as intact. Vice versa if more branches are intact (like **I)** and only a few show browse.
G. A branch tip has been bitten off, and axillary growth has become vigorous. If on most branches, axillary shoots do not much extend beyond the browsed tip, then record primarily as browsed (using the tip diameter) and secondarily as intact. If axillary shoots vigorously extend beyond the browsed tip on most branches, then record primarily as intact with some secondary browse.
H. A branch tip was browsed, and its axillary growth has generated new terminals which have extended way beyond the old browse point. New axillary shoots are vigorously growing on these new leaders. Treat this as essentially intact, with some preservation of previous browse episodes.
I. An unbrowsed branch in which branch diameters taper gradually to every tip. Twigs at end of branches have terminal leaves and any axillary growth is restricted to suppressed foliage, the inflorescence, smaller twigs that are shorter and more slender than the terminal twig.

Photopoint Surveys

Digital photographs were taken at all patches to enable visual quantitative and qualitative comparisons to be made of identical scenes over many time intervals. In 1984, 40 photopoints in total were recorded, with one photopoint associated with each site (located within the A, B, or C patchs). In 2012, photopoint positions were installed in all patches at all sites, with a total of 55 photopoints. There was no consistent relationship between trap-line and photopoint position, though generally the photopoint was slightly offset from pitfalls 1 or 2 with a bearing slightly divergent from trap-line orientation (Pitfalls in each trap-line were generally named 1 to 6, starting nearest the access track).

Photopoint orientation was generally from north (camera) to the south (target) to avoid photographing into the sun. To increase the data captured, and therefore the power of the time-sequenced comparative base, three images were taken at each location: (1) the standard survey image with the target board at the centreline of the image, (2) to the left with the target board on the far right of the image, and (3) to the right with the target board in the far left of the image. The collection of three photos provides a panoramic view for comparison with good registration of the three adjacent images for digital analysis. Each photo angle was recorded as accurately as possible using a compass, and the camera lens was set to the focal length equivalent of 50 mm in 35 mm format.

Site photos were compared over time according to the growth or decline of species seen in the field of view. Key species or vegetation structural communities were ranked according to change in cover/abundance over time, and allocated a trend using the following categories:

1 cover/abundance increase: Density and cover have increased. Or
1 cover/abundance increase: Growth has occurred, density is approximately equal.
2 cover/abundance unchanged: same individual plants still present. Or
2 cover/abundance unchanged: species population turnover, density and cover same.
3 cover/abundance decrease: Density and cover have declined. Or
3 cover/abundance decrease: Defoliation occurred, density is approximately equal.
U unable to confidently define a specific trend

The Nullarbor photopoints were assessed according to the cover, density and recruitment of low shrubs, tall trees, and grasses/herbs that were visible. Extra assessments were recorded for *Maireana sedifolia* and *Acacia aneura* where they occurred in the field of view, because they are species of interest in the area, for example; trends observed in *A. aneura* could indicate the presence and impact of camels in the area.

Results from photopoint surveys between 1984 and 2002 are discussed in this report. Photopoint data collected in 2012 were not in scope for this project.

Mammal and Reptile Surveys

Methods for trap checking, handling and animal welfare broadly conformed to the "Guidelines for Vertebrate Surveys in SA" (Owens, 2000). Specific modifications are detailed below.

Each sample patch contained a permanent pitfall trap line and an Elliott trap line. Pitfall trap lines were 50 m long, with 6 traps along a drift fence in each. The pits measured 125 mm in diameter and 600 mm deep. Elliott traplines included 15 traps. The general layout included two rows of 7 Elliott traps positioned either side of the pitfall trap-line, with a distance of 20 m between pitfall and the trap. An additional Elliott trap was placed in line with the pitfall traps (Figure 12). Traps were open for 4 consecutive nights.

Cage and funnel traps were not used in the 1984 or 2012 survey.

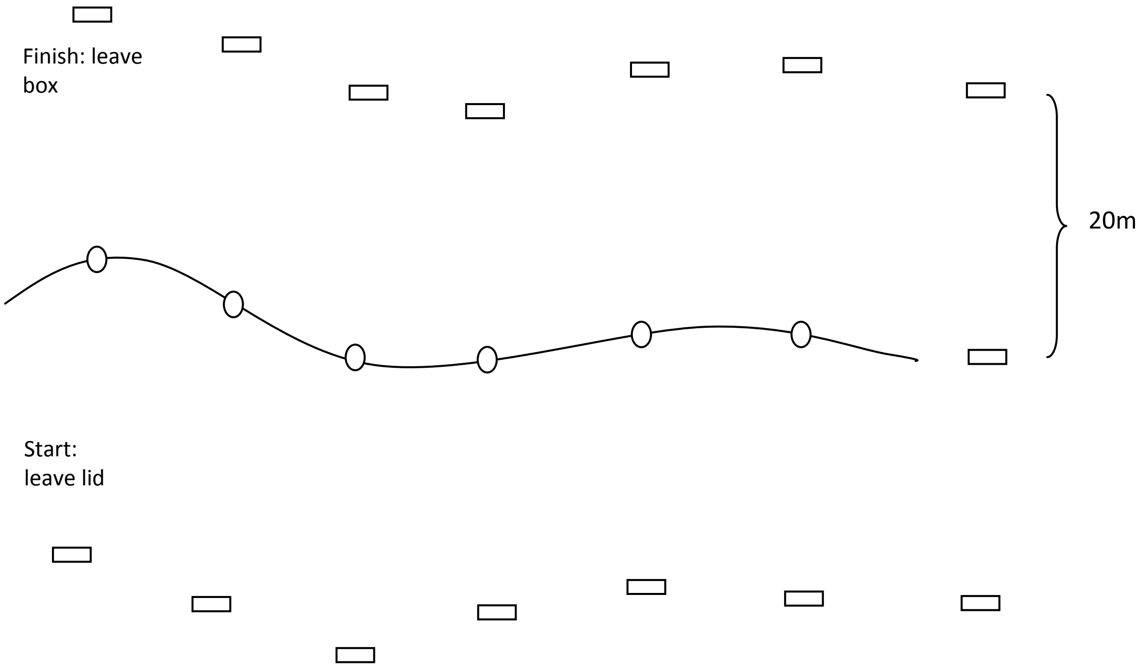


Figure 12 The arrangement of Elliot traps (rectangles) around the pit fall line (line and circles)

The 2012 survey included a survey of scats, tracks, diggings and warrens of large mammals, in particular macropods, wombats, cats, camels, rabbits, foxes, and dingos. The perimeter of each vegetation quadrat (100 x 100 m) was surveyed using a frequency measure for each sign of each mammal. The perimeter was divided into sixteen 25 m sections and the presence or absence of a sign (track, scat, digging or warren) for each mammal was recorded. Each sign was then given a frequency, by dividing the number of occurrences of that sign by the total number of sections surveyed.

Some additional mammal and reptile searches were conducted throughout the survey periods, including spotlight searches. These searches were limited to sampling quadrats and all animals observed were recorded as opportunistic sightings.

No formal trapping or netting of bats was done in 1984 or 2012. Where traps, nets or Anabats were used, the data was recorded as opportunistic sightings.

Bird Surveys

In 1984 bird surveys occurred at each site, but the boundaries of the sampling area and time spent were not documented. In addition, while birds observed in different vegetation types were recorded against the corresponding patch, it is not clear whether each patch was sampled in a consistent manner. In 2012, birds were surveyed within a 20 ha quadrat associated with each vegetation patch. Each quadrat was searched for 40 minutes, on four occasions over 4 days (twice on different mornings and twice on different afternoons).

Taxonomy

Plants and animals, where possible, were classified to the lowest taxonomic denomination in this study. In some instances, this was not possible because of identification difficulties, e.g. grasses that were not in a reproductive cycle could not be conclusively identified. Where this occurred the lowest known classification was used. Some species surveyed in 1984 have since had changes to their taxonomic classification. Corrections were made where possible, but for some plants, it was not possible to rename them. These particular species are acknowledged as non-current with (NC) proceeding the name. Caution was used when comparing the cover or abundance of non-current species or those that are not identified to lowest taxonomic denomination. Differences in cover or abundance is likely to reflect naming and identification issues rather than on-ground differences between 1984 and 2012. From here on the label species will be used in place of taxa.

STATISTICAL ANALYSES

To eliminate biases that might have been introduced by the different methods in 1984 versus 2012 surveys, the cover of plants were standardised by site, and then by climate zone. This was done by calculating the proportion of cover of each species within each site (i.e. sum of **site** cover = 100). The cover was further standardised by calculating the proportion of cover of each species within the climate zone (i.e. the sum of cover in each **climate zone** = 100. The sum of each site is now less and depends on the number of sites within each climate zone). The abundance of birds and mammals were standardised by the same process, by site, and then by climate zone. The abundance of reptiles were standardised according just to site.

Standardising by site allows differences in relative cover or abundance to be analysed. The species richness of plants and animals could not be standardised between years as sample effort in 1984 was poorly defined and not repeated in 2012, where a more systematic approach was used (comparisons have been made nonetheless). Species richness is an important aspect of biodiversity and it is generally accepted that the higher the diversity, the more stable the ecosystem. The species richness of plants, birds, and small mammals were compared between 1984 and 2012, by grouping all the sites within each climate zone. One-way ANOVA were used to test whether the change in species richness was significant.

Multivariate analyses were performed using PRIMER (PRIMER version 5.1.2, PRIMER-E Ltd., Plymouth, UK) (Catalan *et al.,* 2006). Analysis of similarity (ANOSIM) was used to define and test the difference in abundance and assemblages for birds, mammals, and reptiles in the following groups: between temperature and rainfall gradients, between and among vegetation structural communities and over time. Differences in the percent cover of vegetation were tested between temperature and rainfall gradients, between sites, and over time. ANOSIM is a non-parametric, hypothesis testing procedure, based on Bray–Curtis dissimilarities, which generates a test statistic (R), which is scaled between -1 and 1, and a probability value ($p < 0.05$ indicating significant differences) (Catalan *et al.,* 2006). Significance is determined by randomly relocating samples within classes and calculating sample R values. The percent of times that R is greater than the sample R, indicates whether the samples are significantly different. Significant R-values are typically close to 1 and indicate greater variation in plant and animal species among zones than within zones.

Significant R-values that are negative occur when outliers are present or when there are high levels of within-group variability. R values that are close to 0 and non-significant, indicate that the null hypothesis cannot be rejected (Clarke & Warwick, 1994; Quinn & Keogh, 2002).

Hierarchical cluster analysis was performed to detect significantly different groups based on similarity of cover/abundance of vegetation, birds, mammals and reptiles within and between samples (Bulman *et al.,* 2001; Jaworski & Ragnarsson, 2006). Using clusters obtained from hierarchical group-average clustering, groups of similar vegetation structural communities were identified and compared using SIMPROF analyses (Jaworski & Ragnarsson 2006).

Similarity Percentages (SIMPER, Plymouth Routines in Multivariate Ecological Research) were conducted after each ANOSIM and SIMPROF. SIMPER looks for similarities between samples and identifies the species that are contributing most to the average dissimilarity (Catalan *et al.,* 2006).

To test the hypotheses that there would be; 1)an increase in species that characterized the HOT/DRY in the COLD/WET sites, and, 2) relatively fewer COLD/WET species in the COLD/WET sites, the abundance of particular species were compared across time. The abundance and distribution of species defined by SIMPER as characterising the COLD/WET climatic zone in 1984 were compared between 1984 and 2012 in the COLD/WET zone. Likewise, the abundance and distribution of species defined by SIMPROF as characterising the HOT/DRY climatic zone in 1984 were compared between 1984 and 2012 in the COLD/WET zone. These tests were repeated for each group: vegetation, birds, mammals, and reptiles.

Means are presented as ± standard deviation and all statistical tests are two-tailed, unless stated, with the α level of statistical significance set at 0.05.

RESULTS

VEGETATION

There were 223 species of plants recorded in autumn 2012, which included 7 weed species, and 212 species of plants in autumn 1984, including 17 weed species. A full list of plants are included in appendix B, table 29 and table 30. The species richness were compared within each climate zone, between 1984 and 2012 (Table 4) using a one-way ANOVA. The difference in the HOT/DRY zone approached significance ($p = 0.08$, $F = 3.545$) and there was no difference detected in species richness in the COLD/WET zones ($p = 0.67$, $F = 0.183$).

Table 4 Species richness at each site in 1984 and 2012, with HOT/DRY zone (left) separated from COLD/WET zone (right). (Only data from Autumn in 1984 and 2012 are included)

SITEID	1984	2012
HU001	5	11
HU002	8	11
HU003	12	14
HU004	2	8
HU005	19	19
MU001	17	18
MU002	16	28
MU003	13	41
MU004	29	30
MU005	20	39
Mean	14.10	21.90
Standard Deviation	7.92	11.91

SITEID	1984	2012
CA001	19	14
CA002	21	15
CA003	14	16
CA004	9	8
CA005	23	6
IF001	5	8
IF002	19	6
IF003	10	19
IF004	20	18
IF005	12	17
KD001	17	16
KD002	26	34
KD003	25	20
KD004	16	12
KD005	14	11
KO001	18	14
KO002	11	18
KO003	18	27
KO004	16	22
KO005	15	32
ME001	38	21
ME002	2	27
ME003	31	30
ME004	31	29
ME005	19	10
YA001	25	30
YA002	34	28
YA003	31	29
YA004	25	33
YA005	35	22
Mean	19.96667	19.73333
Standard Deviation	8.892009	8.533639

ANOSIM was used to examine differences between vegetation (based on percent cover contribution), which occurred in different climates: HOT/DRY versus COLD/WET. The vegetation differed significantly (In 2012 $R = 0.6$, $p < 0.001$, in 1984 $R = 0.644$, $p < 0.001$). Tables 5 and 6 indicate the plants that contributed the greatest difference between climate zones in 2012 and 1984. The species that represented the greatest differences in 1984 form the foundation of the next analyses to test for changes between time periods.

Table 5 The plant species that contributed the greatest difference between HOT/DRY and COLD/WET zones in 2012, based on percent cover contribution. The species are grouped according to whether they had a higher proportion of cover in the HOT/DRY zone (above the line) or COLD/WET zone (below the line).

Species	Proportion of standardised cover in HOT/DRY zone	Proportion of standardised cover in COLD/WET zone	Contribution that each species made to the difference between climate zone (%)
Atriplex vesicaria	1.53	0.59	14.86
Atriplex cryptocarpa	0.69	0	5.48
Acacia ligulata	0.57	0	4.47
Sclerolaena patenticuspis	0.51	0.09	4.31
Sclerolaena diacantha	0.44	0.01	3.48
Austrostipa eremophila/puberula	0.33	0.07	3
Acacia aneura var. intermedia	0.36	0	2.85
Pittosporum angustifolium	0.34	0.01	2.7
Dodonaea viscosa ssp. angustissima	0.32	0	2.55
Enneapogon cylindricus	0.3	0	2.39
Austrostipa nitida	0.27	0.13	2.29
Aristida holathera var. holathera	0.29	0	2.26
Eremophila maculata ssp. maculata	0.27	0	2.14
Austrodanthonia caespitosa	0.23	0.02	1.81
Enneapogon avenaceus	0.22	0	1.76
Eragrostis dielsii var. dielsii	0.22	0	1.74
Enneapogon polyphyllus	0.22	0	1.7
Ptilotus obovatus	0.2	0	1.6
Austrostipa puberula	0.18	0.03	1.59
Eriochiton sclerolaenoides	0.16	0.01	1.24
Sclerolaena obliquicuspis	0.11	0.05	1.05
Acacia ramulosa var. linophylla	0.13	0	1.01
Enchylaena tomentosa var. tomentosa	0.13	0.02	0.97
Convolvulus sp. ^	0.11	0	0.86
Lycium australe	0.09	0.03	0.81
Atriplex acutibractea ssp. acutibractea	0.09	0	0.73
Dicrastylis beveridgei var. lanata	0.09	0	0.69
Eremophila willsii ssp. willsii	0.09	0	0.69
Aristida contorta	0.09	0	0.68
Rhagodia spinescens	0.08	0.01	0.67
Enneapogon caerulescens	0.07	0	0.57
Sida spodochroma	0.07	0	0.53
Acacia tetragonophylla	0.06	0	0.51
Euphorbia drummondii	0.06	0	0.45
Acacia oswaldii	0.05	0.01	0.43
Chenopodium gaudichaudianum	0.05	0	0.41
Senna artemisioides ssp. filifolia	0.05	0	0.38
Maireana erioclada	0.03	0.03	0.38
Lysiana murrayi	0.04	0	0.35
Maireana sedifolia	0.17	0.22	2.76
Austrodanthonia sp. ^	0.07	0.22	1.95
Tecticornia disarticulata	0	0.21	1.63
Acacia papyrocarpa	0	0.15	1.19
Cratystylis conocephala	0	0.14	1.13
Lawrencia squamata	0	0.09	0.74
Eucalyptus calcareana	0	0.09	0.74
Melaleuca lanceolata	0	0.06	0.5
Westringia rigida	0	0.06	0.47
Geijera linearifolia	0	0.06	0.47
Rhagodia crassifolia	0	0.05	0.41
Myoporum platycarpum ssp. platycarpum	0	0.05	0.38
Eucalyptus yalatensis	0	0.05	0.38
Eucalyptus gracilis	0	0.05	0.37
Sclerolaena uniflora	0	0.05	0.37
Nitraria billardierei	0	0.04	0.34

Table 6 The plant species that contributed the greatest difference between HOT/DRY and COLD/WET zones in 1984, based on percent cover contribution. The species are grouped according to whether they had a higher proportion of Cover in the HOT/DRY zone (above the line) or COLD/WET zone (below the line).

Species	Proportion of standardised cover in HOT/DRY zone	Proportion of standardised cover in COLD/WET zone	Contribution that each species made to the difference between climate zone (%)
Sclerolaena obliquicuspis	1.63	0.07	12.78
Acacia aneura var. intermedia	0.76	0	5.94
Atriplex sp. ^	0.65	0	5.11
Enneapogon cylindricus	0.47	0	3.72
Eremophila maculata ssp. maculata	0.39	0	3.04
Acacia ramulosa (NC)	0.39	0	3.03
Acacia tetragonophylla	0.38	0	2.99
Pittosporum angustifolium	0.38	0.02	2.96
Maireana sp. ^	0.34	0.03	2.91
Austrostipa sp. ^	0.29	0.18	2.8
Rhagodia spinescens	0.28	0.05	2.39
Aristida contorta	0.27	0	2.14
Austrodanthonia sp.	0.14	0.09	1.5
Sclerolaena diacantha	0.14	0.07	1.43
Lycium australe	0.16	0.03	1.42
Enchylaena tomentosa var. tomentosa	0.16	0.04	1.31
Eremophila longifolia	0.16	0	1.28
Sclerolaena uniflora	0.16	0	1.26
Aristida holathera var. holathera	0.15	0	1.15
Enneapogon polyphyllus	0.14	0	1.12
Eremophila glabra ssp. glabra	0.13	0.01	1.07
Rhagodia crassifolia	0.11	0.03	1.07
Enneapogon robustissimus	0.13	0	1.05
Eragrostis lanipes	0.13	0	1.05
Atriplex acutibractea ssp. acutibractea	0.13	0	0.99
Atriplex cryptocarpa	0.13	0	0.99
Atriplex eardleyae	0.11	0.01	0.9
Acacia ligulata	0.11	0	0.85
Zygophyllum sp. ^	0.1	0.01	0.81
Ptilotus obovatus	0.08	0.01	0.71
Acacia kempeana	0.08	0	0.65
Convolvulus angustissimus ssp. angustissimus	0.08	0	0.65
Santalum spicatum	0.07	0	0.59
Sida spodochroma	0.07	0	0.58
Santalum lanceolatum	0.07	0	0.58
Enneapogon caerulescens	0.06	0	0.51
Trichodesma zeylanicum var. zeylanicum	0.06	0	0.51
Lysiana murrayi	0.06	0	0.48
Sida sp. ^	0.06	0	0.46
Atriplex vesicaria	0.13	0.72	5.66
Maireana sedifolia	0.16	0.2	2.3
Tecticornia disarticulata	0	0.21	1.63
Acacia papyrocarpa	0	0.15	1.14
Cratystylis conocephala	0	0.14	1.12
Sclerolaena patenticuspis	0	0.13	0.99
Acacia oswaldii	0.03	0.07	0.68
Threlkeldia sp.^	0	0.08	0.66
Eucalyptus oleosa ssp. ampliata	0	0.08	0.63
Maireana pentatropis	0.03	0.05	0.56

^ It is important to note the taxonomic issues when comparing samples, such as “Austrostipa sp.”. These plants were only identified to genus and comparisons will indicate differences in naming or identification not true differences in cover between sites or time periods.

We expected to see an increase in the species that characterised the HOT/DRY zone in 1984, within the COLD/WET zone. We tested this prediction by comparing the cover of plant species (Table 6, above the line) between 1984 and 2012. The difference in species cover in the COLD/WET zone between 1984 and 2012 was significant ($R = 0.337$, $p < 0.001$). The species that were the main drivers of this change are shown in table 7. Note that some species have increased as predicted in the hypothesis, but others have decreased.

Table 7 The plant species that characterised the HOT/DRY zone in 1984 that contributed most to a change in cover in the COLD/WET zone between 1984 and 2012. The sum of proportion of cover is calculated across all sites within the HOT/DRY zone, e.g. all proportions of all plants in the HOT/DRY zone in 1984 equal 100. Order of species is based on how much they contributed to the difference between the time periods (Percent Contrib)

Species that characterised the HOT/DRY zone in 1984	Proportion of standardised cover in 1984	Proportion of standardised cover in 2012	Contribution that each species made to the difference between 1984 and 2012 (%)
Maireana sedifolia	0.2	0.22	21.65
Austrostipa sp. ^	0.18	0	16.34
Austrodanthonia sp. ^	0	0.22	15.2
Sclerolaena obliquicuspis	0.07	0.05	8.23
Sclerolaena uniflora	0	0.05	6.94
Sclerolaena diacantha	0.07	0.01	6.4
Lycium australe	0.03	0.03	5.51
Rhagodia spinescens	0.05	0.01	4.99
Enchylaena tomentosa var. tomentosa	0.04	0.02	4.29
Pittosporum angustifolium	0.02	0.01	3.83

Note: Variation in *Austrostipa sp., Austrodanthonia sp., Sclerolaena uniflora,* and *Sclerolaena diacantha* might reflect taxonomic naming issues rather than true differences in cover. *Austrostipa sp., Austrodanthonia sp.,* can be difficult to tell apart if they do not have mature seed, and there is debate on the difference (if any) between *Sclerolaena uniflora,* and *Sclerolaena diacantha*

We expected to see a decrease in the species, which characterised the COLD/WET zone in 1984, in the COLD/WET zone in 2012. We tested this prediction by comparing the cover of plant species (Table 6, below the line) between 1984 and 2012.There was no significant difference in species cover in the COLD/WET zone between 1984 and 2012 ($R = 0.002$, $p = 0.125$).

Similarities in plant assemblages within each vegetation structural community were investigated using cluster analyses. Structural communities were divided by climate zones and analysed separately. In the HOT/DRY zone in the 2012 survey, there were six distinct groups of vegetation structural communities (Figure 13). The species that contributed the greatest difference between the groups are described in table 8.

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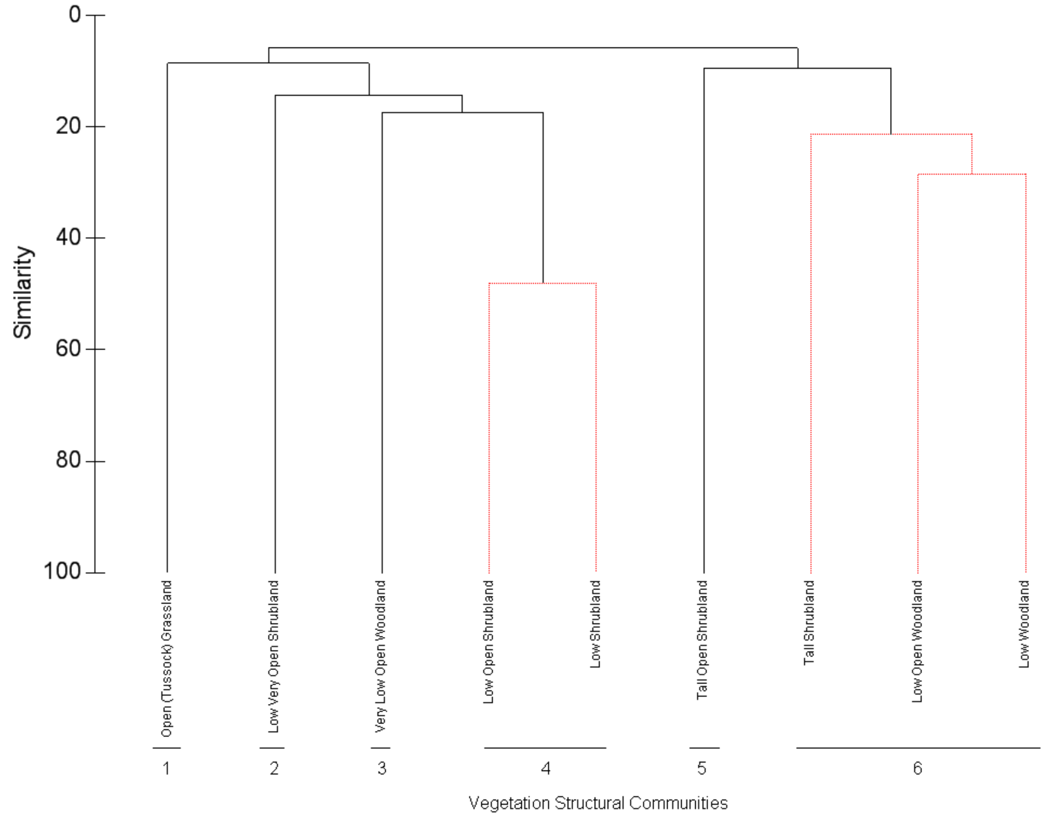

Figure 13 Bray-Curtis similarity dendrogram of the groups of plants in the HOT/DRY climatic zone in 2012. There are six significantly different groups based on the differences between the proportion of plants species and cover within each structural community. Each group is identified by a number (1-6) located underneath the structural community descriptions and by the black lines. On the y axis is the measure of similarity between sites ranging from 0 to 100. On the x axis are the vegetation structural communities that were compared.

Table 8 The plant species that differentiated each group from all others in the HOT/DRY climatic zone in 2012, based on SIMPROF analyses of species and proportion of cover. The amount that each species contributed to the difference is also shown as SIMPER%.

Group	Species	Sum of standardised cover per group	SIMPER %	Group	Species	Sum of standardised cover per group	SIMPER %
1	*Acacia oswaldii*	2.1	3.8	4	*Atriplex vesicaria*	101.8	73.9
1	*Atriplex acutibractea ssp. acutibractea*	2.1	3.6	4	*Austrodanthonia caespitosa*	4.1	1.3
1	*Austrodanthonia caespitosa*	5.2	6.4	4	*Austrodanthonia sp.*	3.4	2.4
1	*Austrostipa eremophila/puberula*	31.3	66.6	4	*Austrostipa nitida*	7.2	3.7
1	*Enchylaena tomentosa var. tomentosa*	2.1	2.7	4	*Eriochiton sclerolaenoides*	2.8	1.7
1	*Enneapogon avenaceus*	2.1	3.1	4	*Maireana sedifolia*	14.5	11.1
1	*Eremophila longifolia*	2.1	3.8	4	*Maireana turbinata*	2.8	1.4
1	*Eremophila maculata ssp. maculata*	2.1	2.2	4	*Sclerolaena obliquicuspis*	3.9	3.2
1	*Euphorbia drummondii*	2.1	2.1	4	*Sclerolaena patenticuspis*	3.6	1.3
1	*Lycium australe*	2.1	2.2		total	144.1	100.0
1	*Pittosporum angustifolium*	2.1	1.4	5	*Dicrastylis beveridgei var. lanata*	8.8	33.0
1	*Rhagodia spinescens*	2.1	2.2	5	*Dodonaea viscosa ssp. angustissima*	8.8	33.9
	total	57.3	100.0	5	*Eremophila willsii ssp. willsii*	8.8	33.0
	Table 8 continues of next page				total	26.3	100.0

Table 8 continued

Group	Species	Sum of standardised cover per group	SIMPER %	Group	Species	Sum of standardised cover per group	SIMPER %
2	*Atriplex cryptocarpa*	6.9	6.6				
2	*Austrodanthonia caespitosa*	3.5	1.7	6	*Acacia aneura var. intermedia*	15.8	10.1
2	*Austrostipa nitida*	6.9	4.9	6	*Acacia ligulata*	18.2	21.2
2	*Austrostipa puberula*	17.2	19.0	6	*Acacia ramulosa var. linophylla*	4.3	2.2
2	*Convolvulus sp.*	6.9	7.2	6	*Acacia tetragonophylla*	2.5	1.7
2	*Eragrostis dielsii var. dielsii*	20.7	22.8	6	*Aristida contorta*	2.9	2.2
2	*Sclerolaena obliquicuspis*	3.5	2.0	6	*Aristida holathera var. holathera*	9.4	6.7
2	*Sclerolaena patenticuspis*	34.5	35.8	6	*Austrodanthonia caespitosa*	3.0	0.7
	total	100.0	100.0	6	*Austrostipa nitida*	1.8	0.2
3	*Acacia aneura var. intermedia*	2.9	1.6	6	*Chenopodium gaudichaudianum*	6.2	5.4
3	*Atriplex acutibractea ssp. acutibractea*	5.2	3.1	6	*Dodonaea viscosa ssp. angustissima*	7.9	5.4
3	*Atriplex cryptocarpa*	62.5	41.2	6	*Enchylaena tomentosa var. tomentosa*	2.3	0.6
3	*Austrostipa nitida*	5.2	2.0	6	*Enneapogon avenaceus*	11.3	5.8
3	*Enchylaena tomentosa var. tomentosa*	7.7	4.6	6	*Enneapogon cylindricus*	10.7	5.9
3	*Enneapogon avenaceus*	2.9	1.2	6	*Enneapogon polyphyllus*	8.0	5.0
3	*Enneapogon caerulescens*	2.9	1.5	6	*Eriochiton sclerolaenoides*	2.7	1.4
3	*Eremophila maculata ssp. maculata*	25.0	16.5	6	*Erodiophyllum elderi*	4.7	4.6
3	*Eriochiton sclerolaenoides*	2.9	1.1	6	*Lysiana murrayi*	1.5	0.2
3	*Lycium australe*	5.2	3.1	6	*Maireana erioclada*	0.9	0.2
3	*Lysiana exocarpi ssp. exocarpi*	2.9	2.0	6	*Pittosporum angustifolium*	7.2	3.2
3	*Maireana sedifolia*	17.3	9.9	6	*Ptilotus obovatus*	5.8	3.1
3	*Pittosporum angustifolium*	10.6	6.7	6	*Sclerolaena diacantha*	14.6	8.0
3	*Ptilotus obovatus*	2.9	1.3	6	*Sclerolaena patenticuspis*	7.9	4.8
3	*Rhagodia spinescens*	6.0	3.7	6	*Senna artemisioides ssp. filifolia*	1.7	0.7
3	*Sida sp.*	2.1	0.5	6	*Sida spodochroma*	2.2	0.6
	total	164.3	100.0		total	153.5	100.0

Similarities in plant assemblages within each vegetation structural community indicated that in the COLD/WET zone in the 2012 survey, there were nine distinct groups of vegetation structural communities (Figure 14). The species that contributed the greatest difference between the groups are described in table 9.

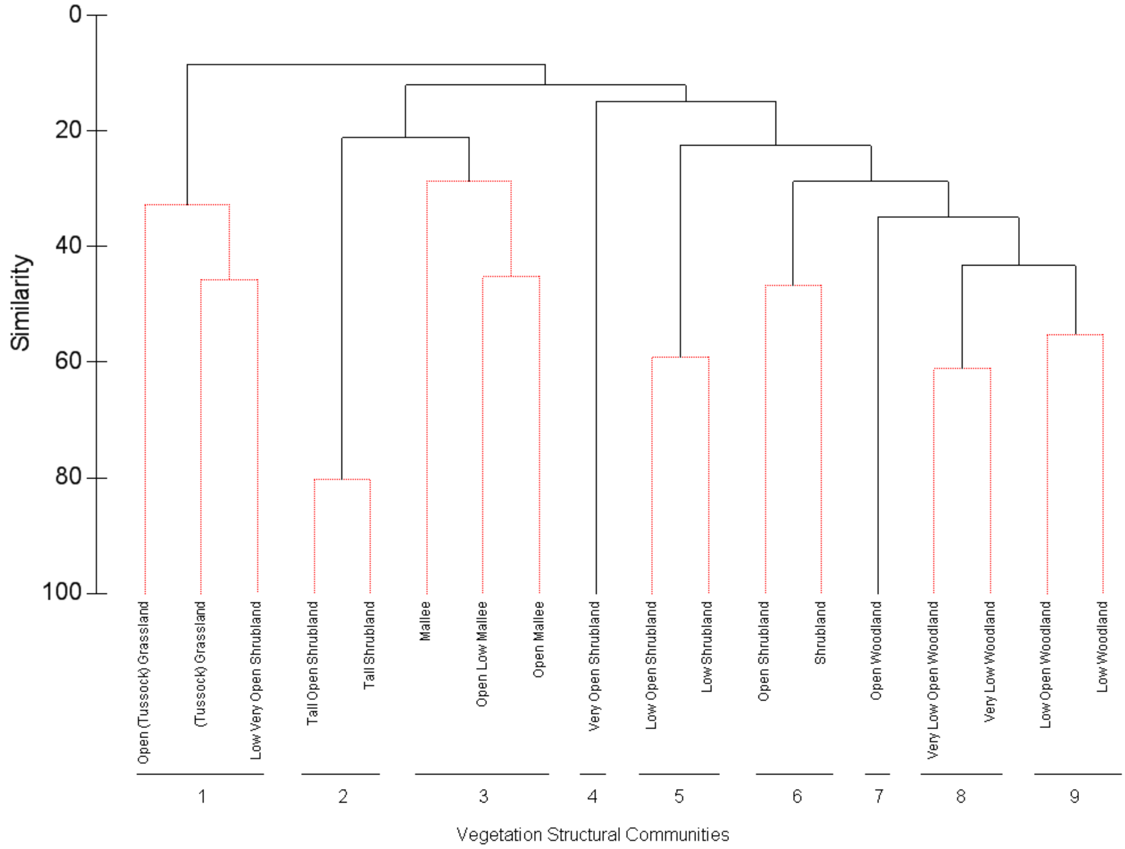

Figure 14 Bray-Curtis similarity dendrogram of plants groups in the COLD/WET climatic zone in 2012. There are nine significantly different groups based on the differences between the proportion of plant species and cover within each structural community, identified with a number below each group.

Table 9 The plant species that differentiated each group from all others in the COLD/WET climatic zone in 2012, based on SIMPROF analyses of species and proportion of cover. The amount that each species contributed to the difference is also shown as SIMPER%.

Group	Plant Species	Sum of standardised cover per group	SIMPER %	Group	Plant Species	Sum of standardised cover per group	SIMPER %
1	*Atriplex acutibractea ssp. acutibractea*	1.4	1.0	5	*Maireana erioclada/pentatropis*	6.6	0.5
1	*Atriplex acutibractea ssp. karoniensis*	1.0	0.4	5	*Maireana sedifolia*	62.9	9.1
1	*Atriplex vesicaria*	1.8	0.2	5	*Nitraria billardierei*	18.2	2.6
1	*Austrodanthonia sp.*	37.8	48.9	5	*Sclerolaena brevifolia*	5.1	0.2
1	*Austrostipa eremophila/puberula*	11.9	15.0	5	*Sclerolaena obliquicuspis*	12.0	1.7
1	*Austrostipa nitida*	12.3	13.7	5	*Sclerolaena patenticuspis*	38.6	7.6
1	*Lomandra effusa*	11.6	12.4	5	*Sclerolaena uniflora*	5.9	0.4
1	*Maireana sedifolia*	4.5	6.0	5	*Tecticornia disarticulata*	78.0	14.1
1	*Sclerolaena patenticuspis*	2.3	2.4		total	632.4	100.0
	total	84.7	100.0	6	*Atriplex vesicaria*	31.9	23.2
2	*Eremophila weldii*	6.2	12.9	6	*Austrodanthonia sp.*	2.0	1.9
2	*Eucalyptus calcareana*	6.2	13.1	6	*Geijera linearifolia*	8.3	7.4
2	*Eucalyptus socialis ssp. victoriensis*	6.2	15.3	6	*Lawrencia squamata*	12.2	11.3
2	*Melaleuca pauperiflora ssp. mutica*	3.3	7.1	6	*Lycium australe*	1.0	0.4
2	*Melaleuca quadrifaria*	10.9	26.9	6	*Maireana sedifolia*	36.1	41.6
2	*Rhagodia crassifolia*	6.2	12.0	6	*Sclerolaena obliquicuspis*	10.4	13.5
2	*Westringia rigida*	6.2	12.8	6	*Vittadinia gracilis*	1.3	0.7
	total	45.2	100.0		total	103.1	100.0

Table 9 continued

Group	Plant Species	Sum of std cover in each group	SIMPER %
3	*Acacia papyrocarpa*	2.3	0.1
3	*Atriplex nummularia ssp. spathulata*	3.9	1.3
3	*Atriplex vesicaria*	24.4	7.9
3	*Austrostipa nitida*	4.4	1.0
3	*Cassytha melantha*	1.3	0.1
3	*Cratystylis conocephala*	22.4	10.6
3	*Eremophila glabra ssp. glabra*	1.1	0.2
3	*Eremophila weldii*	6.3	3.2
3	*Eucalyptus brachycalyx*	9.3	5.7
3	*Eucalyptus calcareana*	19.7	11.6
3	*Eucalyptus gracilis*	13.6	7.7
3	*Eucalyptus oleosa ssp. ampliata*	8.8	3.2
3	*Eucalyptus yalatensis*	14.3	7.2
3	*Exocarpos aphyllus*	2.0	0.5
3	*Geijera linearifolia*	9.4	5.0
3	*Maireana erioclada*	1.5	0.1
3	*Melaleuca lanceolata*	16.0	9.3
3	*Melaleuca pauperiflora ssp. mutica*	8.9	3.3
3	*Myoporum platycarpum ssp. platycarpum*	4.7	2.3
3	*Olearia muelleri*	5.5	2.5
3	*Pittosporum angustifolium*	2.5	1.0
3	*Pomaderris forrestiana*	2.8	1.8
3	*Rhagodia crassifolia*	8.3	4.3
3	*Scaevola spinescens*	3.3	0.9
3	*Sclerolaena uniflora*	6.7	3.3
3	*Threlkeldia diffusa*	2.0	0.4
3	*Westringia rigida*	10.6	5.3
	total	215.9	100.0
4	*Atriplex vesicaria*	8.3	5.8
4	*Austrodanthonia caespitosa*	1.4	2.7
4	*Disphyma crassifolium ssp. clavellatum*	1.4	2.7
4	*Euphorbia drummondii*	1.4	3.1
4	*Frankenia serpyllifolia*	8.3	19.3
4	*Frankenia sessilis*	8.3	20.4
4	*Maireana oppositifolia*	1.4	2.5
4	*Maireana pentatropis*	1.4	1.2
4	*Melaleuca lanceolata*	8.3	18.8
4	*Sclerolaena uniflora*	1.4	1.7
4	*Senecio pinnatifolius group*	1.4	2.5
4	*Tecticornia disarticulata*	8.3	19.3
	total	51.1	100.0
5	*Acacia papyrocarpa*	7.1	1.0
5	*Atriplex stipitata*	8.8	1.1
5	*Atriplex vesicaria*	128.8	20.3
5	*Austrodanthonia caespitosa*	13.3	1.9
5	*Austrodanthonia sp.*	101.9	17.0
5	*Austrostipa drummondii*	10.8	1.6
5	*Austrostipa eremophila/puberula*	22.8	3.3
5	*Austrostipa nitida*	30.2	4.5
5	*Austrostipa puberula*	12.0	1.7
5	*Austrostipa velutina*	5.1	1.2
5	*Dissocarpus biflorus var. biflorus*	11.2	2.5
5	*Frankenia sessilis*	5.2	0.1
5	*Lawrencia squamata*	29.9	4.3
5	*Lycium australe*	10.4	2.1
5	*Maireana erioclada*	7.7	1.2

Group	Plant Species	Sum of std cover in each group	SIMPER %
7	*Acacia papyrocarpa*	9.1	33.8
7	*Atriplex vesicaria*	22.7	46.7
7	*Austrostipa nitida*	1.5	3.6
7	*Enchylaena tomentosa var. tomentosa*	1.5	3.2
7	*Euphorbia tannensis ssp. eremophila*	0.6	0.5
7	*Maireana integra*	1.5	6.8
7	*Sclerolaena obliquicuspis*	1.5	5.0
7	*Senna artemisioides ssp. X sturtii*	0.6	0.5
	total	39.1	100.0
8	*Acacia papyrocarpa*	25.0	24.2
8	*Amyema quandang var. quandang*	2.2	2.3
8	*Atriplex vesicaria*	23.5	10.3
8	*Austrodanthonia sp.*	3.2	2.8
8	*Austrostipa nitida*	11.2	10.3
8	*Cratystylis conocephala*	17.0	16.5
8	*Eremophila glabra ssp. glabra*	2.1	2.1
8	*Eremophila weldii*	3.5	2.7
8	*Eucalyptus calcareana*	1.9	1.4
8	*Geijera linearifolia*	3.5	2.7
8	*Maireana erioclada*	1.4	0.8
8	*Maireana erioclada/pentatropis*	2.1	2.1
8	*Myoporum platycarpum ssp. platycarpum*	1.4	1.2
8	*Olearia muelleri*	3.5	3.2
8	*Rhagodia crassifolia*	2.1	1.4
8	*Santalum acuminatum*	1.2	0.3
8	*Sclerolaena sp.*	1.9	2.0
8	*Sclerolaena uniflora*	2.1	1.5
8	*Tecticornia disarticulata*	8.1	9.0
8	*Threlkeldia diffusa*	0.9	0.2
8	*Westringia rigida*	3.5	2.7
8	*Zygophyllum aurantiacum ssp. aurantiacum*	0.8	0.3
	total	122.1	100.0
9	*Acacia papyrocarpa*	42.1	19.1
9	*Amyema quandang var. quandang*	1.1	0.2
9	*Atriplex vesicaria*	72.0	28.4
9	*Austrostipa elegantissima*	1.5	0.3
9	*Austrostipa eremophila/puberula*	5.2	2.1
9	*Austrostipa nitida*	8.9	3.4
9	*Cratystylis conocephala*	13.0	5.5
9	*Enchylaena tomentosa var. tomentosa*	2.3	0.5
9	*Eremophila scoparia*	3.6	1.7
9	*Eucalyptus brachycalyx*	4.0	1.6
9	*Eucalyptus oleosa ssp. ampliata*	3.6	1.5
9	*Frankenia serpyllifolia*	7.0	3.2
9	*Maireana erioclada/pentatropis*	4.2	2.4
9	*Maireana sedifolia*	25.3	11.3
9	*Myoporum platycarpum ssp.*	4.0	1.8
9	*Myoporum platycarpum ssp. platycarpum*	12.0	6.1
9	*Santalum acuminatum*	7.1	3.7
9	*Scaevola spinescens*	3.4	1.6
9	*Sclerolaena diacantha*	6.0	3.3
9	*Sclerolaena obliquicuspis*	3.7	1.6
9	*Sclerolaena uniflora*	1.6	0.4
9	*Senecio pinnatifolius group*	1.3	0.4
	total	232.8	100.0

PHOTOPOINT RESULTS

Between 1985 and 2001 there were 40 sites that were surveyed using repeat photography survey methods, some of these surveys did not cover the whole period. Trends were assigned to each photopoint according to the cover, density and recruitment of plant species that were visible in the field of view. These included low shrubs, tall shrubs and trees, grasses and herbs, *Maireana sedifolia* and *Acacia aneura*.

The results of these photopoint surveys are summarised in table 10, they show a stable trend across the landscape. An explanation of the trends at each site can be found in appendix C.

Table 10 Results of the photopoint survey. Photopoints are assessed depending on the plants that are visible, and the trend in cover, density and recruitment of these plants over time. Photopoints = pp

	No. of pp in which these plants could be assessed	Average assessment result	No. of pp that had a decreasing trend (score of 1)	No. of pp that were stable (score of 2)	No. of pp that had an increasing trend (score of 3)
Overall trend of low shrub	35	2.1	3	27	5
Overall trend of tall shrubs and trees	24	1.9	4	18	2
Overall trend of grasses and herbs	1	2	0	1	0
Trend of *Maireana sedifolia*	4	2	0	4	0
Trend of Mulga trend	1	1	1	0	0

BIRD SURVEY RESULTS

A total of 98 species of birds were recorded in autumn of 1984 and 2012. There were 8976 individuals observed in the 2012 survey and 3847 individuals observed in the 1984 survey. A full list of birds recorded in 2012 and 1984, including opportunistic records, are attached as appendix B, table 31 and 32. The species richness data recorded at each site in 1984 and 2012 (Table 11) were compared using a paired t-test, within the COLD/WET and HOT/DRY zones. Between 1984 and 2012 there was no difference detected in the HOT/DRY zone ($P = 0.23$, $F = 1.579$), but there was a significant difference in the COLD/WET zone ($P < 0.001$, $t = 12.727$).

Table 11 Species Richness at each site in 1984 and 2012, with HOT/DRY zone (left) separated from COLD/WET zone (right). (Only data from Autumn in 1984 and 2012 are included)

SITE ID	1984	2012
MU001	17	19
MU002	11	18
MU003	12	16
MU004	9	17
MU005	13	19
HU001	6	3
HU002	5	4
HU003	12	10
HU004	2	8
HU005	8	11
Mean	9.5	12.5
Standard Deviation	4.4	6.1

SITE ID	1984	2012
IF001	2	8
IF002	5	9
IF003	6	21
IF004	8	21
IF005	9	18
KD001	6	10
KD002	22	19
KD003	0	21
KD004	3	11
KD005	0	14
KO001	10	17
KO002	3	18
KO003	12	23
KO004	24	16
KO005	16	31
ME001	15	20
ME002	8	20
ME003	16	17
ME004	3	27
ME005	0	18
CA001	17	13
CA002	7	9
CA003	6	8
CA004	3	5
CA005	4	7
YA001	21	28
YA002	28	26
YA003	15	12
YA004	24	19
YA005	4	15
Mean	9.9	16.7
Standard Deviation	8.0	6.6

ANOSIM was used to examine differences between bird assemblages (based on percent abundance contribution), which occurred in different climates: HOT/DRY versus COLD/WET. The bird assemblages were significantly different (1984: R = 0.116, p = 0.044. 2012: R = 0.295, p = 0.002). Tables 12 and 13 indicate the list of species that contributed the greatest difference between gradients in 2012 and 1984. The species that represent the greatest differences in 1984 form the foundation of the next analyses to test for changes in climate zones between time periods.

Table 12 The bird species that contributed the greatest difference between HOT/DRY and COLD/WET zones in **2012** based on percent cover contribution. The species are grouped according to whether they had a higher proportion of abundance in the HOT/DRY zone (above the line) or COLD/WET zone (below the line).

Species	Proportion of standardised abundance in HOT/DRY zone	Proportion of standardised abundance in COLD/WET zone	Contribution that each species made to the difference between climate zones (%)
Malurus leucopterus	2.03	0.28	17.7
Pomatostomus superciliosus	0.96	0.14	8.1
Anthus australis	0.83	0.18	7.63
Aphelocephala leucopsis	0.75	0.09	6.5
Acanthiza uropygialis	0.7	0.02	5.97
Psephotus varius	0.67	0.04	5.63
Artamus cinereus	0.65	0.07	5.37
Calamanthus campestris	0.52	0.2	4.76
Gavicalis virescens	0.38	0.19	3.05
Cinclosoma cinnamomeum alisteri	0.24	0.11	2.53
Malurus splendens	0.28	0	2.35
Melanodryas cucullata	0.25	0.04	2.23
Daphoenositta chrysoptera	0.16	0.05	1.58
Malurus lamberti	0.18	0.01	1.55
Rhipidura leucophrys	0.15	0.04	1.33
Cinclosoma castanotum	0.14	0	1.18
Acanthiza chrysorrhoa	0.06	0.1	1.15
Melanodryas vittata	0.13	0	1.11
Falco berigora	0.14	0.03	1.09
Cracticus torquatus	0.1	0.04	1.02
Manorina flavigula	0.18	0.41	3.51
Acanthiza iredalei	0	0.16	1.32
Acanthagenys rufogularis	0	0.13	1.12
Acanthiza apicalis	0.06	0.07	0.97
Sericornis frontalis	0	0.1	0.82
Hirundo neoxena	0	0.1	0.82

Table 13 The bird species that contributed the greatest difference between HOT/DRY and COLD/WET zones in **1984** based on percent cover contribution. The species are grouped according to whether they had a higher proportion of abundance in the HOT/DRY zone (above the line) or COLD/WET zone (below the line).

Species	Proportion of standardised abundance in HOT/DRY zone	Proportion of standardised abundance in COLD/WET zone	Contribution that each species made to the difference between climate zones (%)
Malurus leucopterus	1.72	0.07	14.11
Anthus australis	1.13	0.59	10.35
Artamus cinereus	0.98	0.12	7.89
Eolophus roseicapilla	0.64	0	5.23
Corvus sp.	0.59	0.07	5.02
Psephotus varius	0.46	0.14	4.25
Corvus bennetti	0.42	0.03	3.55
Pomatostomus superciliosus	0.36	0.21	3.54
Aquila audax	0.36	0.02	2.88
Gavicalis virescens	0.33	0.09	2.68
Aphelocephala leucopsis	0.26	0.09	2.51
Melanodryas cucullata	0.29	0.03	2.4
Falco cenchroides	0.29	0.02	2.38
Colluricincla harmonica	0.22	0.05	1.95
Cacomantis pallidus	0.19	0.03	1.7
Corvus coronoides	0.16	0	1.29
Falco berigora	0.1	0.05	1.19
Epthianura aurifrons	0.13	0	1.06
Acanthiza uropygialis	0.12	0.01	1.04
Rhipidura leucophrys	0.12	0.02	1.03
Cinclosoma cinnamomeum alisteri	0.12	0.01	1
Cheramoeca leucosterna	0.08	0.03	0.82
Stiltia isabella	0.1	0	0.82
Acanthiza iredalei iredalei	0.15	0.23	2.71
Manorina flavigula	0.32	0.35	4.01
Cracticus torquatus	0.04	0.13	1.23
Acanthiza apicalis	0	0.14	1.18
Pyrrholaemus brunneus	0	0.1	0.83
Hirundo neoxena	0	0.1	0.79
Smicrornis brevirostris	0	0.08	0.68

We expected to see an increase in the species that characterised the HOT/DRY zone in 1984, in the COLD/WET zone in 2012. We tested this prediction by comparing the abundance of bird species (Table 13, above the line) between 1984 and 2012. There was a significant change is species abundance between 1984 and 2012 in the COLD/WET zone ($R = 0.135$, $p < 0.001$). The species that were the main drivers of this difference are shown in table 13.

We expected to see a decrease in the species that characterised the COLD/WET zone in 1984, in the COLD/WET zone in 2012. We tested this prediction by comparing the abundance of bird species (Table 13, below the line) between 1984 and 2012. The overall difference in the COLD/WET zone between 1984 and 2012 was not significant ($R = 0.021$, $p = 0.144$).

Table 14 The bird species that characterised the HOT/DRY zone in 1984. The order of species is based on how much they contributed to the difference over time

Species	Proportion of standardised abundance in 1984	Proportion of standardised abundance in 2012	Contribution that each species made to the difference between 1984 and 2012 (%)
Anthus australis	0.59	0.18	22
Pomatostomus superciliosus	0.21	0.14	11.68
Malurus leucopterus	0.07	0.28	11.45
Gavicalis virescens	0.09	0.19	10.23
Psephotus varius	0.14	0.04	6.81
Artamus cinereus	0.12	0.07	5.96
Aphelocephala leucopsis	0.09	0.09	5.81
Cinclosoma cinnamomeum alisteri	0.01	0.11	4.35
Falco berigora	0.05	0.03	3.66
Corvus sp.	0.07	0	3.17
Colluricincla harmonica	0.05	0.03	3.15
Melanodryas cucullata	0.03	0.04	2.58

Bird association with vegetation structural communities

Similarities in bird assemblages within each vegetation structural community were investigated using cluster analyses. Structural communities were divided into climate zones and analysed separately. There were 4 distinct groups of vegetation structural communities in the HOT/DRY zone in the 2012 survey (Figure 15). The species that contributed the greatest difference between the groups are described in table 15.

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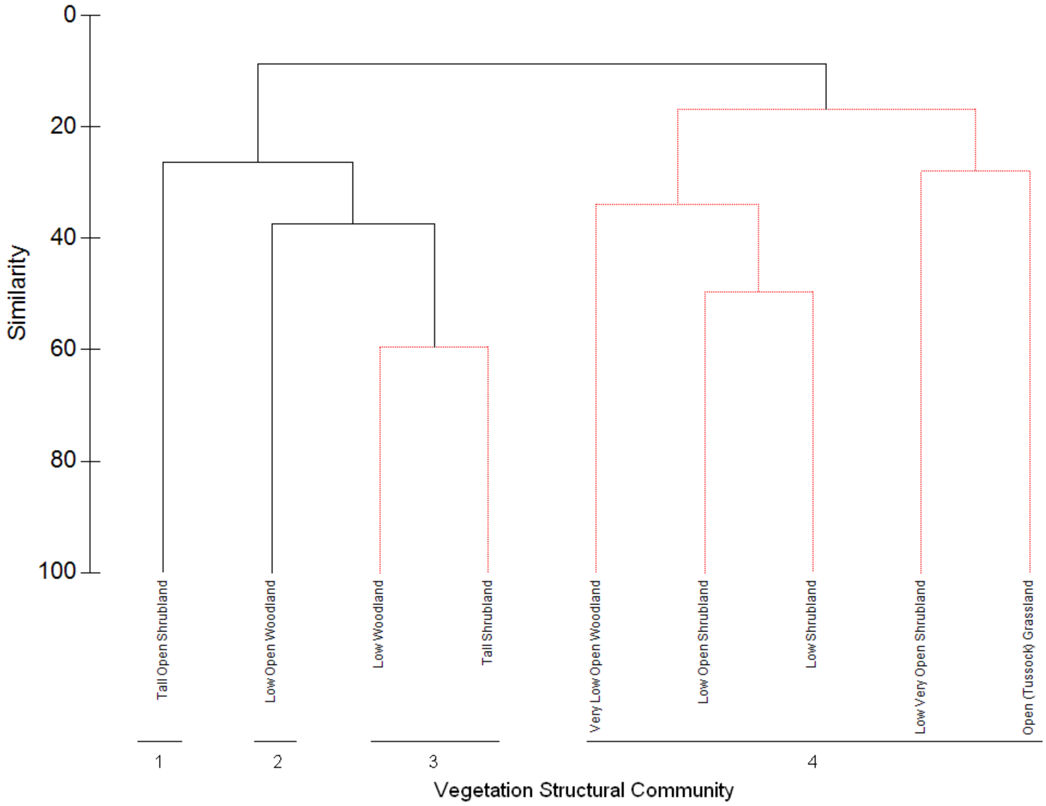

Figure 15 Bray-Curtis similarity dendrogram of bird groups in the HOT/DRY climatic zone in 2012. There are four significantly different groups of vegetation structural communities based on the differences between the bird species and abundances recorded within each community. The groups are identified by a number (1- 4) and by the black lines. On the y axis is the measure of similarity between sites ranging from 0 to 100. On the x axis are the vegetation structural community that were compared.

Table 15 The bird species that differentiated each group from all others in the HOT/DRY climatic zone in 2012, based on SIMPROF analyses of species and proportion of abundance. The proportion that each species contributed to the difference is also shown (SIMPER%).

Group	Species	Sum of standardised abundance per group	SIMPER %	Group	Species	Sum of standardised abundance per group	SIMPER %
1	*Acanthiza apicalis*	0.16	20.86	3	*Acanthiza uropygialis*	0.65	2.65
1	*Acanthiza uropygialis*	0.65	29.54	3	*Aphelocephala leucopsis*	1.36	19.26
1	*Cinclosoma castanotum*	0.16	7.93	3	*Artamus cinereus*	0.27	2.57
1	*Malurus lamberti*	0.22	7.98	3	*Gavicalis virescens*	0.30	2.98
1	*Malurus splendens*	0.44	21.19	3	*Malurus lamberti*	0.39	4.07
1	*Manorina flavigula*	0.27	12.51	3	*Malurus splendens*	0.39	1.75
	Group 1 total	1.90	100	3	*Manorina flavigula*	0.35	3.79
2	*Acanthiza chrysorrhoa*	0.52	1.64	3	*Melanodryas cucullata*	0.42	6.59
2	*Acanthiza uropygialis*	3.55	12.97	3	*Melanodryas vittata*	0.21	2.41
2	*Aphelocephala leucopsis*	3.79	13.58	3	*Oreoica gutturalis*	0.15	1.67
2	*Artamus cinereus*	1.15	3.92	3	*Pomatostomus superciliosus*	1.67	25.21
2	*Cinclosoma castanotum*	0.88	3.39	3	*Psephotus varius*	0.22	23.98
2	*Cracticus torquatus*	0.87	3.69	3	*Rhipidura leucophrys*	0.28	3.04
2	*Daphoenositta chrysoptera*	1.70	7.20		Group 3 total	6.66	100
2	*Gavicalis virescens*	1.30	4.64	4	*Acanthiza iredalei*	0.67	7.81

2	*Malurus lamberti*	1.12	3.73	4	*Anthus australis*	1.38	18.58
2	*Malurus splendens*	1.37	4.54	4	*Artamus cinereus*	0.85	9.64
2	*Manorina flavigula*	1.09	3.60	4	*Calamanthus campestris*	1.13	11.99
2	*Melanodryas cucullata*	1.69	6.43	4	*Cinclosoma cinnamomeum alisteri*	0.70	7.66
2	*Microeca fascinans*	0.55	2.33	4	*Gavicalis virescens*	0.37	3.27
2	*Pomatostomus superciliosus*	5.96	22.35	4	*Malurus leucopterus*	3.72	35.09
2	*Psephotus varius*	1.45	5.98	4	*Psephotus varius*	0.80	5.95
	Group 2 total	26.99	100		Group 4 total	9.62	100

Similarities in bird assemblages within each vegetation structural community indicated that in the COLD/WET zone in the 2012 survey, there were nine distinct groups of vegetation structural communities (Figure 16). The species that contributed the greatest difference between the groups are described in table 16.

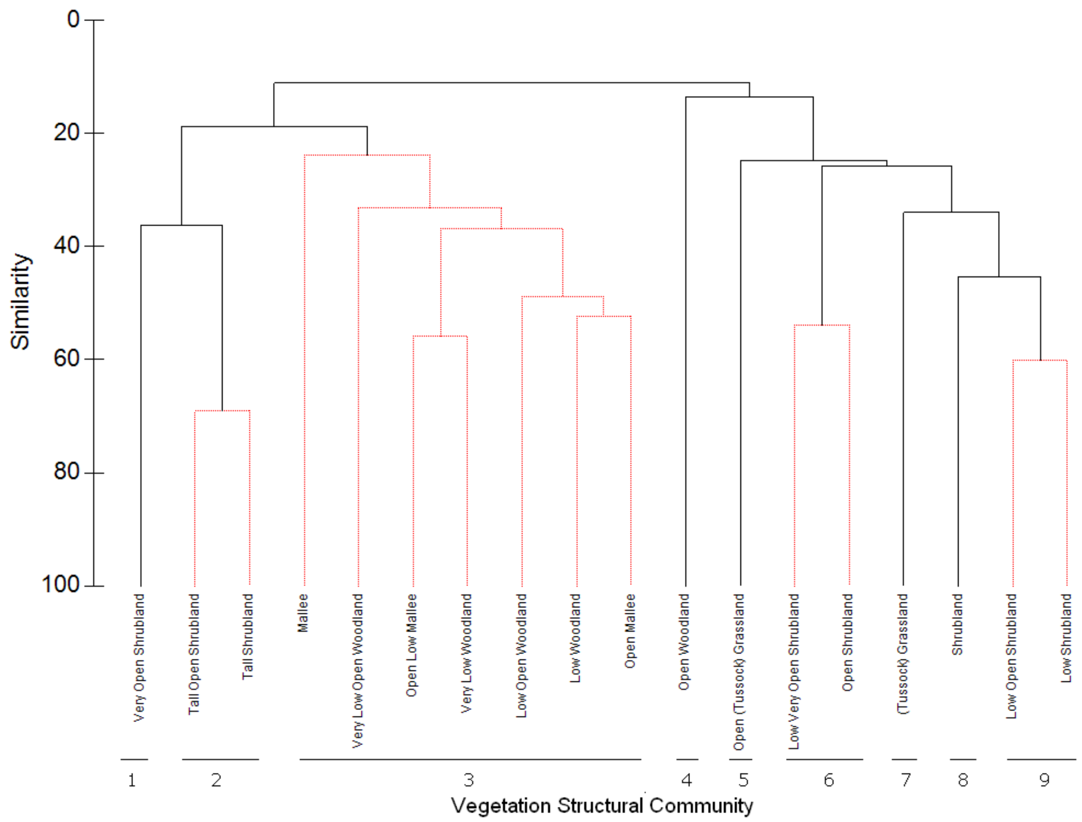

Figure 16 Bray-Curtis similarity dendrogram of bird groups in the COLD/WET climatic zone in 2012. There are nine significantly different groups of vegetation structural communities based on the differences between the bird species and abundances recorded within each community. The groups are identified by a number (1- 9) and by the black lines. On the y axis is the measure of similarity between sites ranging from 0 to 100. On the x axis are the vegetation structural community that were compared.

Table 16 The bird species that differentiated each group from all others in the COLD/WET climatic zone in 2012, based on SIMPROF analyses of species and proportion of abundance. The proportion that each species contributed to the difference is also shown (SIMPER%).

Group	Species	Sum of standardised abundance per group	SIMPER %	Group	Species	Sum of standardised abundance per group	SIMPER %
1	*Anthus australis*	0.40	28.24	4	*Artamus cinereus*	0.16	26.00
1	*Calamanthus campestris*	0.17	9.78	4	*Daphoenositta chrysoptera*	0.08	11.93
1	*Falco berigora*	0.07	2.93	4	*Gavicalis virescens*	0.06	4.28
1	*Gavicalis virescens*	0.27	16.89	4	*Malurus leucopterus*	0.22	23.56
1	*Gymnorhina tibicen*	0.27	26.48	4	*Manorina flavigula*	0.04	1.51
1	*Hirundo neoxena*	0.07	1.08	4	*Melanodryas cucullata*	0.12	23.28
1	*Sericornis frontalis*	0.10	4.92	4	*Psephotus varius*	0.08	9.44
1	*Zosterops lateralis*	0.13	9.68		Group 4 total	0.76	100
	Group 1 total	1.48	100	5	*Anthus australis*	1.30	28.58
2	*Acanthagenys rufogularis*	0.19	16.16	5	*Calamanthus campestris*	0.52	10.75
2	*Acanthiza apicalis*	0.05	2.26	5	*Cinclosoma cinnamomeum alisteri*	0.69	16.35
2	*Corvus coronoides*	0.05	1.06	5	*Corvus coronoides*	0.45	10.61
2	*Gavicalis virescens*	0.25	14.40	5	*Corvus sp.*	0.26	6.95
2	*Pardalotus striatus*	0.09	7.44	5	*Cracticus torquatus*	0.26	6.25
2	*Purnella albifrons*	0.21	21.23	5	*Eolophus roseicapilla*	0.51	13.89
2	*Sericornis frontalis*	0.11	5.40	5	*Hirundo neoxena*	0.19	2.79
2	*Zosterops lateralis*	0.23	19.64	5	*Myiagra inquieta*	0.13	2.24
2	*Zosterops sp.*	0.13	12.42	5	*Petrochelidon nigricans*	0.13	1.59
	Group 2 total	1.31	100		Group 5 total	4.44	100
3	*Acanthagenys rufogularis*	0.30	5.67	8	*Acanthagenys rufogularis*	0.10	1.46
3	*Acanthiza apicalis*	0.23	4.52	8	*Acanthiza chrysorrhoa*	0.61	12.96
3	*Acanthiza chrysorrhoa*	0.19	2.87	8	*Acanthiza iredalei*	0.88	14.38
3	*Acanthiza uropygialis*	0.08	1.15	8	*Anthus australis*	0.61	9.19
3	*Anthochaera carunculata*	0.14	2.77	8	*Aphelocephala leucopsis*	0.54	10.08
3	*Aphelocephala leucopsis*	0.06	1.02	8	*Calamanthus campestris*	0.16	1.29
3	*Artamus cinereus*	0.08	0.49	8	*Cinclosoma cinnamomeum alisteri*	0.10	0.93
3	*Artamus cyanopterus*	0.13	3.00	8	*Corvus coronoides*	0.14	1.60
3	*Barnardius zonarius*	0.15	2.60	8	*Gavicalis virescens*	0.08	0.33
3	*Colluricincla harmonica*	0.09	0.89	8	*Hirundo neoxena*	0.33	5.72
3	*Cracticus torquatus*	0.11	1.38	8	*Malurus lamberti*	0.14	2.97
3	*Daphoenositta chrysoptera*	0.16	3.05	8	*Malurus leucopterus*	0.88	15.31
3	*Gavicalis virescens*	0.35	6.90	8	*Manorina flavigula*	0.64	12.85
3	*Hirundo neoxena*	0.08	1.34	8	*Petrochelidon nigricans*	0.22	4.08
3	*Malurus leucopterus*	0.05	0.51	8	*Pomatostomus superciliosus*	0.10	0.73
3	*Malurus pulcherrimus*	0.05	0.21	8	*Sericornis frontalis*	0.29	6.12
3	*Malurus sp.*	0.08	1.79		Group 8 total	5.82	100
3	*Manorina flavigula*	1.34	24.86	9	*Acanthagenys rufogularis*	0.38	2.96
3	*Melanodryas cucullata*	0.11	2.27	9	*Acanthiza chrysorrhoa*	0.89	5.64
3	*Petrochelidon nigricans*	0.15	1.99	9	*Acanthiza iredalei*	1.75	10.80
3	*Pomatostomus superciliosus*	0.61	11.36	9	*Anthochaera chrysoptera*	0.12	0.12
3	*Psephotus varius*	0.12	2.43	9	*Anthus australis*	1.77	10.07
3	*Ptilotula ornata*	0.29	5.95	9	*Aphelocephala leucopsis*	0.70	5.10
3	*Purnella albifrons*	0.21	3.70	9	*Artamus cinereus*	0.45	2.75
3	*Sericornis frontalis*	0.25	4.18	9	*Calamanthus campestris*	2.19	14.15
3	*Smicrornis brevirostris*	0.15	2.14	9	*Cinclosoma cinnamomeum alisteri*	1.03	7.33
3	*Zosterops lateralis*	0.07	0.93	9	*Corvus coronoides*	0.32	1.77
	Group 3 total	5.63	100	9	*Falco berigora*	0.22	1.82

Table 16 continues on next page

table 16 continued

Group	Species	Sum of standardised abundance per group	SIMPER %	Group	Species	Sum of standardised abundance per group	SIMPER %
6	*Acanthiza iredalei*	0.32	19.10	9	*Gavicalis virescens*	0.79	4.95
6	*Calamanthus campestris*	0.43	25.16	9	*Gymnorhina tibicen*	0.14	0.24
6	*Cinclosoma cinnamomeum alisteri*	0.24	16.09	9	*Hirundo neoxena*	1.10	6.29
6	*Malurus leucopterus*	0.61	38.05	9	*Malurus leucopterus*	2.83	19.53
6	*Petrochelidon nigricans*	0.05	1.60	9	*Manorina flavigula*	0.26	1.67
	Group 6 total	1.65	100	9	*Petrochelidon nigricans*	0.34	1.99
7	*Acanthiza iredalei*	1.00	41.77	9	*Pomatostomus superciliosus*	0.15	0.66
7	*Anthus australis*	0.29	14.78	9	*Rhipidura leucophrys*	0.31	2.16
7	*Aphelocephala leucopsis*	0.39	32.67		Group 9 total	15.74	100
7	*Artamus cinereus*	0.43	35.97				
7	*Calamanthus campestris*	0.08	3.14				
7	*Corvus coronoides*	0.08	2.75				
7	*Malurus leucopterus*	0.20	5.85				
7	*Psephotus varius*	0.10	3.98				
7	*Rhipidura leucophrys*	0.08	2.13				
	Group 7 total	2.65	100				

MAMMAL SURVEY RESULTS

A total of 9 mammal species were recorded in the autumn surveys of 1984 and 2012. With 1328 individuals captured in the 2012 and 161 individuals captured in 1984. A full list of mammals observed, including opportunistic records, is in appendix B, table 33 and 34. The species richness data recorded at each site in 1984 and 2012 were compared using a paired t-test, with HOT/DRY and COLD/WET data separated (Table 17). The difference between 1984 and 2012 was significant in both the HOT/DRY and COLD/WET zones (HOT/DRY: P = 0.02, F = 7.2. COLD/WET P = 0.01, F = 8.2)

Table 17 Species Richness at each site in 1984 and 2012, with HOT/DRY zone (left) separated from COLD/WET zone (right). (Only data from Autumn in 1984 and 2012 is included)

SITE ID	1984	2012
MU001	1	3
MU002	1	4
MU003	1	4
MU004	1	3
MU005	2	4
HU001	1	1
HU002	1	1
HU003	2	1
HU004	1	1
HU005	1	2
Mean	1.2	2.4
Standard Deviation	0.133	0.427

SITE ID	1984	2012
IF001	2	1
IF002	2	3
IF003	2	3
IF004	2	2
IF005	1	1
KD001	1	1
KD002	1	2
KD003	1	1
KD004	1	1
KD005	1	1
KO001	1	1
KO002	2	2
KO003	1	1
KO004	1	2
KO005	1	1
ME001	1	1
ME002	2	4
ME003	1	3
ME004	1	3
ME005	2	1
CA001	1	1
CA002	0	1
CA003	1	1
CA004	2	1
CA005	1	1
YA001	0	2
YA002	1	2
YA003	1	3
YA004	1	3
YA005	0	2
Mean	1.2	1.7
Standard Deviation	0.108	0.165

ANOSIM was used to examine differences between mammal assemblages (based on percent abundance contribution), which occurred in different climates: HOT/DRY versus COLD/WET. The mammal assemblages were significantly different (2012: R = 0.833, p < 0.001, 1984: R = 0.210, p = 0.033). Tables 18 and 19 indicate the mammal species that contributed the greatest difference between gradients in 2012 and 1984. The species that represent the greatest differences in 1984 are essential to the next analyses, to test for changes in climate zones between time periods.

Table 18 The mammal species that contributed the greatest difference between HOT/DRY and COLD/WET zones in 2012 based on percent cover contribution. Note that all species had a higher proportion of relative abundance in the HOT/DRY zone.

Species	Proportion of standardised abundance in HOT/DRY	Proportion of standardised abundance in COLD/WET	Contribution that each species made to the difference between climate zones in 2012 (%)
Mus musculus	7.7	2.96	65.76
Notomys alexis	1.15	0	15.04
Pseudomys hermannsburgensis	0.76	0.04	9.94

Table 19 The mammal species that contributed the greatest difference between HOT/DRY and COLD/WET zones in 1984 based on percent cover contribution. The species are grouped according to whether they had a higher proportion of abundance in the HOT/DRY zone (above the line) or COLD/WET zone (below the line).

Species	Proportion of standardised abundance in HOT/DRY	Proportion of standardised abundance in COLD/WET	Contribution that each species made to the difference between climate zones in 1984 (%)
Mus musculus	9.43	2.63	80.88
Sminthopsis crassicaudata	0.5	0.14	7.32
Notomys mitchellii	0	0.48	5.71

We expected to see an increase in the mammal species that characterised the HOT/DRY zone in 1984, in the COLD/WET zone in 2012. We tested this prediction by comparing the abundance of mammal species (Table 19, above the line) between 1984 and 2012. There was a significant change is species abundance between 1984 and 2012 in the COLD/WET zone (R = 0.245, p < 0.001). *Mus musculus* was the main driver of this change, contributing 92.8% of the difference between 1984 and 2012.

We expected to see a decrease in the species that characterised the COLD/WET zone in 1984, in the COLD/WET zone in 2012. We tested this prediction by comparing the abundance of mammal species (Table 19, below the line) between 1984 and 2012. The difference in the COLD/WET zone between 1984 and 2012 was not significant (R = -0.011, p = 0.464).

Mammal associations with vegetation structural communities

The similarities in mammal assemblages within each vegetation structural community indicated that there were two distinct groups of vegetation structural communities detected in the HOT/DRY zone in the 2012 survey (Figure 17). The species that contributed the greatest difference between the groups are described in table 20.

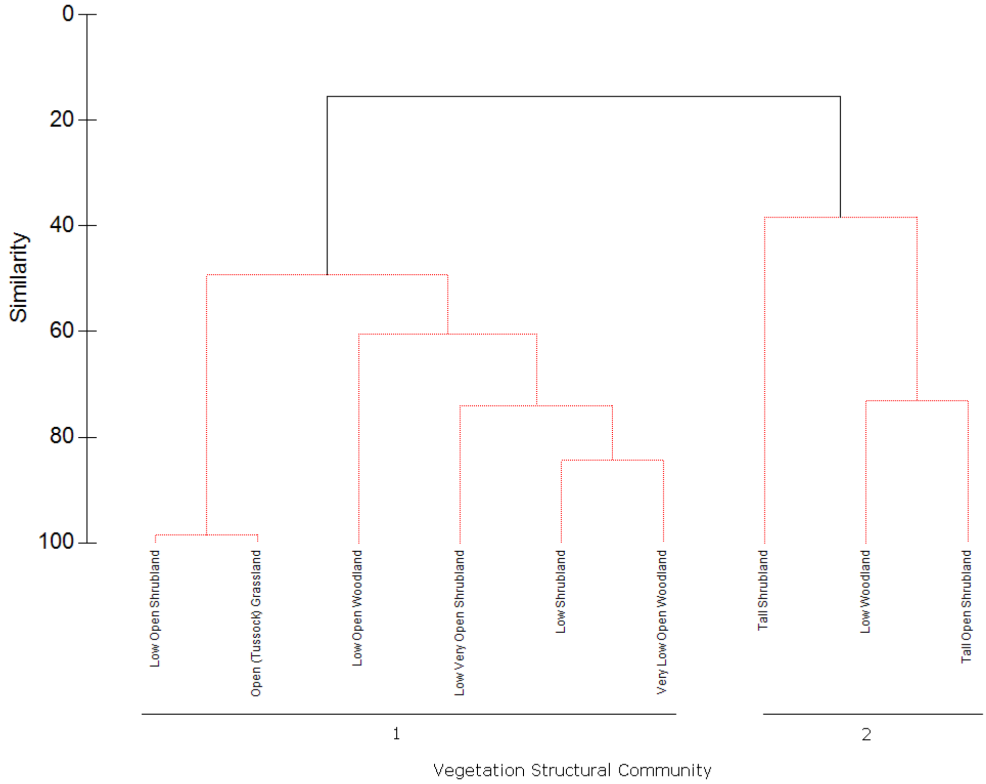

Figure 17 Bray-Curtis similarity dendrogram of mammal groups in the HOT/DRY climatic zone in 2012. There were two significantly different groups of vegetation structural communities based on the differences in the mammals recorded in each community. Groups are identified by a number (1-2) located underneath the structural community descriptions and by the black lines. On the y axis is the measure of similarity between sites ranging from 0 to 100. On the x axis are the vegetation structural community that were compared.

Table 20 The mammal species that differentiated each group from all others in the HOT/DRY climatic zone in 2012, based on SIMPROF analyses of species and proportion of abundance. The proportion that each species contributed to the difference is also shown (SIMPER%).

Group	Species	Sum of standardised abundance per group	SIMPER %
1	Mus musculus	12.39	100
2	Notomys alexis	2.29	100

Similarities in mammal assemblages within each vegetation structural community were investigated using cluster analyses. Structural communities were divided into climate zones and analysed separately. There were two distinct groups of vegetation structural communities detected In the COLD/WET zone in the 2012 survey (Figure 18). The species that contributed the greatest difference between groups are described in table 21.

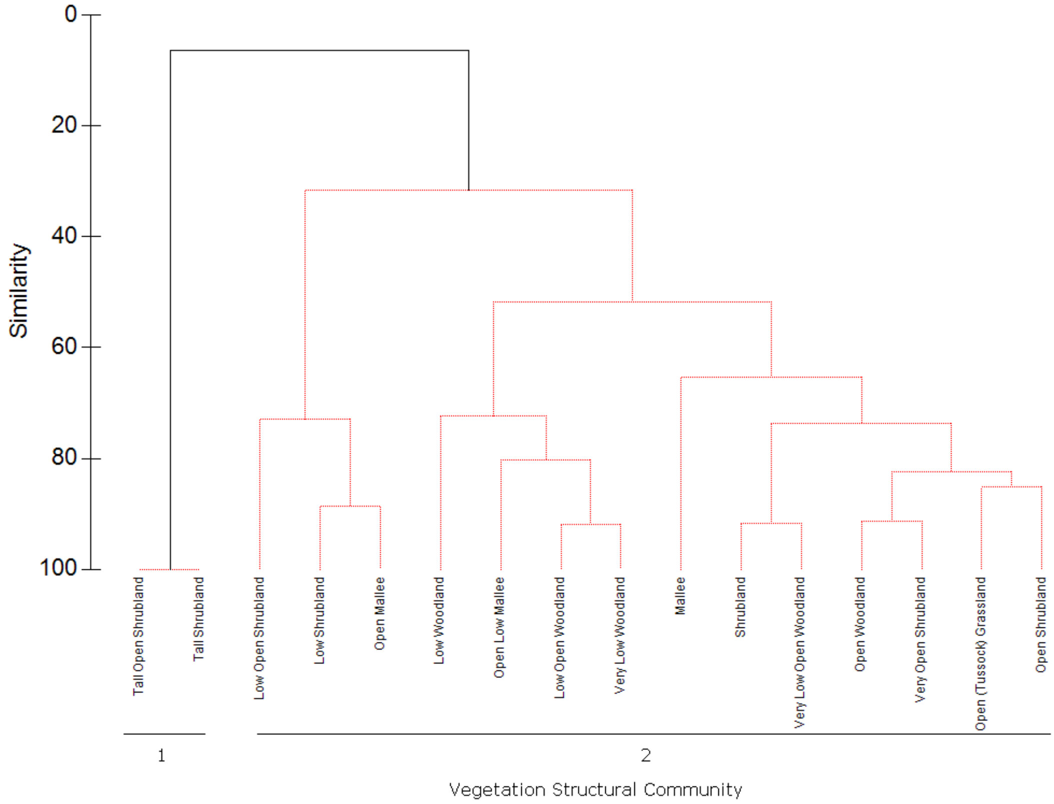

Figure 18 Bray-Curtis similarity dendrogram of mammal groups in the COLD/WET climatic zone in 2012. There were two significantly different groups of vegetation structural communities based on the differences in the mammals recorded in each community. Groups are identified by a number (1-2) located underneath the structural community descriptions and by the black lines. On the y axis is the measure of similarity between sites ranging from 0 to 100. On the x axis are the vegetation structural community that were compared.

Table 21 The mammal species that differentiated each group from all others in the COLD/WET climatic zone in 2012, based on SIMPROF analyses of species and proportion of abundance. The proportion that each species contributed to the difference is also shown (SIMPER%).

Group	Species	Sum of standardised abundance per group	SIMPER %
1	*Mus musculus*	6.33	100
2	*Cercartetus concinnus*	1.67	100

Presence of large mammals in 2012, estimated using frequency counts of scats.

The relative impacts of large herbivores were measured using counts of scats in the HOT/DRY and COLD/WET climate zones in 2012. No difference was detected in the frequency of scats between vegetation structural communities in the HOT/DRY zone (Figure 19). The species that contributed the greatest similarity within the group are rabbits and cats (Table 22).

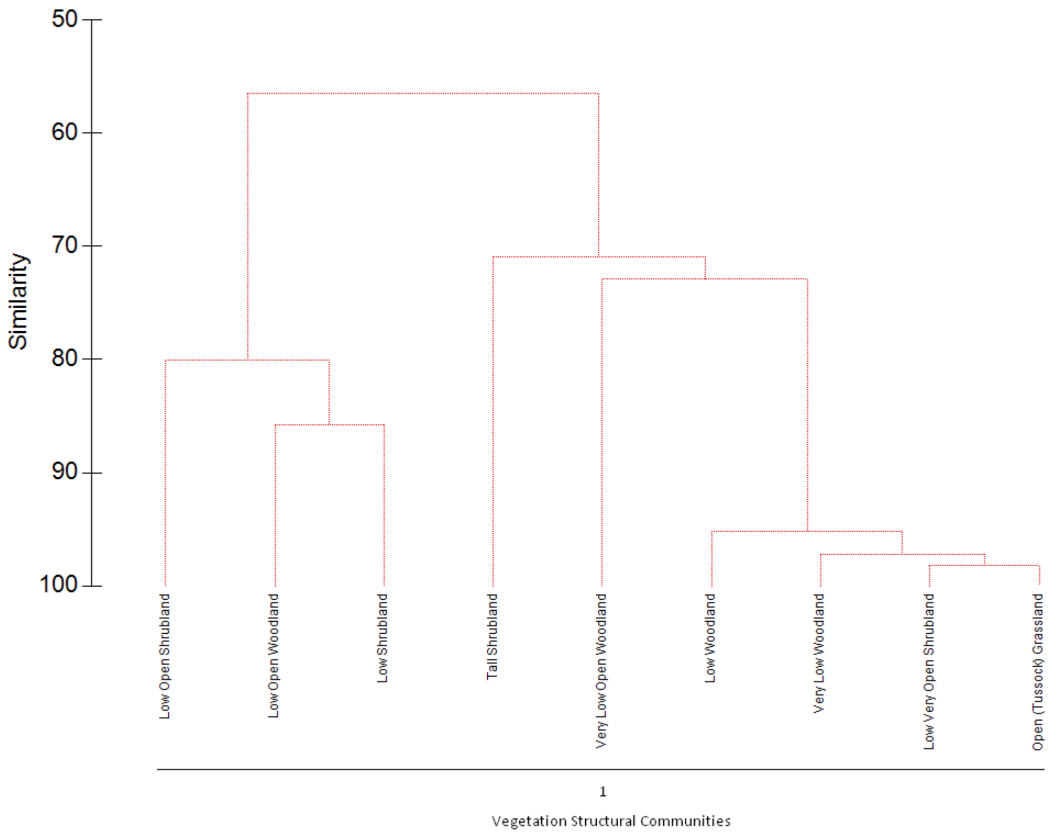

Figure 19 Bray-Curtis similarity dendrogram of large mammal groups in the HOT/DRY climatic zone in 2012. The structural communities are not significantly different, based on the difference in the frequency of scats in each community, and form 1 group. On the y axis is the measure of similarity between the frequency of scats ranging from 0 to 100. On the x axis are the vegetation structural community that were compared.

Table 22 The large mammal species that contributed the greatest similarity within each group. The proportion that each species contributed to the similarity is also shown (SIMPER%).

Group	Herbivore species	Frequency of quadrats with scats present	SIMPER %
1	rabbit scats	12.4	83.7
1	cat scats	5.6	16.3
	total	18.0	100

There were differences in the numbers of large mammals recorded between vegetation structural communities in the COLD/WET zone in 2012. Cluster analyses detected three significantly different groups (Figure 20): Group 1 included (tussock) grassland communities that had no records of any of the large mammals. Group 2 included tall shrubland communities and was identified by SIMPER by having a single record of fox scats. Group 3 included the remaining vegetation structural communities and identified camels, macropods and rabbits contributed the greatest difference between this group and the other (Table 23).

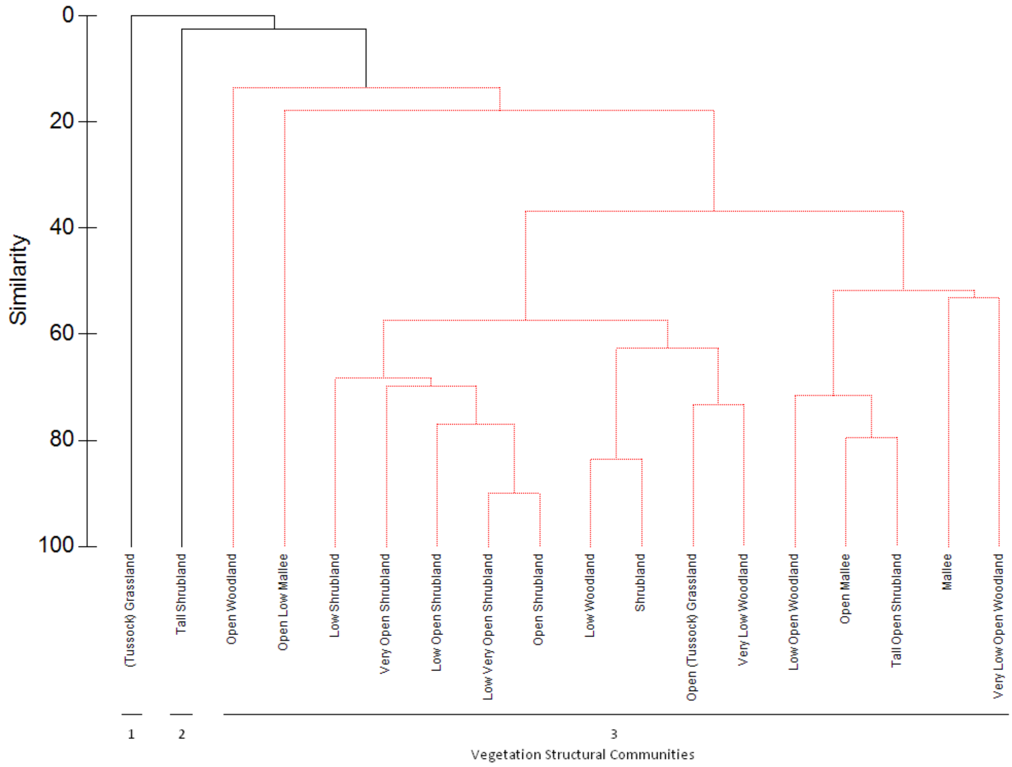

Figure 20 Bray-Curtis similarity dendrogram of large mammal groups in the COLD/WET climatic zone in 2012. There are three significantly different groups of vegetation structural communities based on the differences in the frequency of scats recorded in each community. Each group is identified by a number (1 – 3) and by the black lines. On the y axis is the measure of similarity between the frequency of scats ranging from 0 to 100. On the x axis are the vegetation structural community that were compared.

Table 23 The large mammal species that contributed the greatest similarity within group 1. The proportion that each species contributed to the similarity is also shown (SIMPER%).

Group	Herbivore species	Frequency of quadrats with scats present	SIMPER %
1	no scats recorded from all species		
2	fox scats	1	100
	total	1	100
3	camel scats	1.44	15.86
3	macropod scats	3.67	36.85
3	rabbit scats	5.55	47.29
	total	10.66	100

REPTILE SURVEY RESULTS

There were 43 species of reptiles recorded in the surveys of 1984 and 2012. There were 366 individuals recorded in 2012, and 544 individuals recorded in 1984. A full list of reptiles recorded, including opportunistic sightings, is in appendix B, table 35 and 36. The species richness data recorded at each site in 1984 and 2012 (Table 24) were compared within the HOT/DRY and COLD/WET zones using a paired t-test. The difference between 1984 and 2012 was highly significant ($p < 0.001$, $F = 88.2$)

Table 24 Species Richness at each site in 1984 and 2012 (no separation from the COLD/WET & HOT/DRY zones because no difference between zones in 1984, see below) (Only data from Autumn in 1984 and 2012 is included).

SITE ID	1984	2012	SITE ID	1984	2012
MU001	1	3	KD001	1	4
MU002	0	3	KD002	2	3
MU003	0	0	KD003	2	4
MU004	2	4	KD004	3	6
MU005	1	4	KD005	0	5
HU001	1	2	KO001	1	5
HU002	0	4	KO002	4	4
HU003	0	4	KO003	1	5
HU004	1	1	KO004	1	6
HU005	1	1	KO005	1	3
CA001	1	5	ME001	2	1
CA002	1	7	ME002	1	6
CA003	3	5	ME003	2	2
CA004	2	4	ME004	0	3
CA005	0	3	ME005	2	0
IF001	1	6	YA001	1	5
IF002	3	3	YA002	0	5
IF003	0	1	YA003	1	3
IF004	2	3	YA004	1	3
IF005	1	3	YA005	1	5
			Mean	0.8	3.7
			Standard Deviation	0.157	0.267

ANOSIM was used to examine differences between reptile assemblages (based on proportion of standardised abundance), which occurred in different climates: HOT/DRY versus COLD/WET. The reptile assemblages were not significantly different within 1984 ($R = 0.048$, $p = 0.249$). Because assemblages did not change respective of the climatic gradient, the hypotheses that HOT/DRY species would increase and COLD/WET species would decrease cannot be tested. Instead, we examined overall reptile assemblages between 1984 and 2012.

There was a significant change in reptile species abundance between 1984 and 2012 ($R = 0.285$, $p < 0.001$). The species identified as the main drivers of this change are listed in table 25.

Table 25 The reptile species that contributed 90% of the difference between 1984 and 2012. The species are ordered according to the percent that each species contributed to the overall difference. Note the change in the proportion of relative abundance over time periods.

Species	Proportion of standardised abundance in 1984	Proportion of standardised abundance in 2012	Contribution that each species made to the difference between climate zones in 2012 (%)
Nephrurus milii	2.86	0.37	16.74
Ctenotus schomburgkii	0.38	1.52	11.46
Ctenophorus pictus	0.38	0.42	6.49
Tympanocryptis houstoni	0.56	0.22	5.89
Diplodactylus calcicolus	0.19	0.43	4.59
Diplodactylus vittatus complex (NC)	0.50	0.00	4.50
Ctenophorus fordi	1.05	0.00	4.46
Varanus gouldii	1.05	0.00	4.46
Morethia adelaidensis	0.44	0.08	4.34
Tiliqua rugosa	0.38	0.18	4.26
Ctenotus regius	0.70	0.25	4.17
Ctenotus euclae	0.38	0.10	4.12
Lucasium damaeum	0.32	0.16	4.10
Menetia greyii	0.13	0.57	4.09
Lerista labialis	0.35	0.16	2.25
Drysdalia mastersii	0.19	0.05	2.10
Ctenotus sp.	0.19	0.00	1.69
Lerista baynesi	0.19	0.00	1.69

Reptile Association with vegetation structural communities

Similarities in reptile assemblages within each vegetation structural community were investigated using cluster analyses. There were 2 distinct groups of vegetation structural communities in the 2012 survey (Figure 21). The species that contributed the greatest difference between the groups are described in table 26. (Note that reptile associations are not analysed with HOT/DRY separated from COLD/WET. There was no difference according to ANOSIM analyses and, as such, the reptiles are treated as one assemblage Nullarbor-wide).

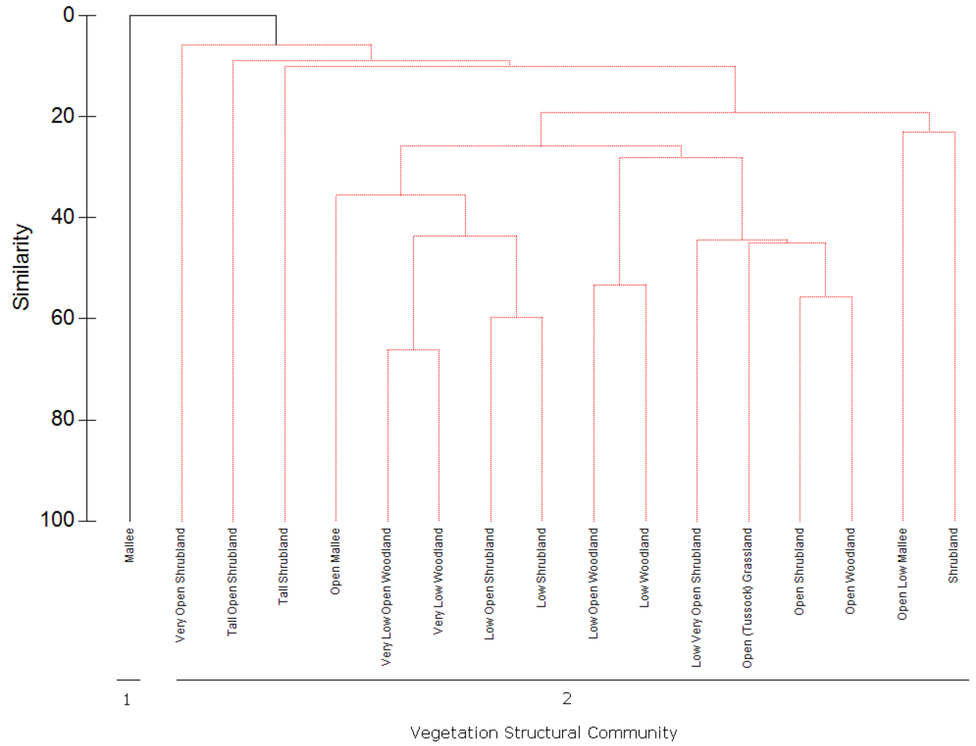

Figure 21 Bray-Curtis similarity dendrogram of reptile groups in 2012. There were two significantly different groups of vegetation structural communities based on the reptile species and abundances recorded in each community. The groups are identified by a number (1-2) located underneath the structural community descriptions. On the y axis is the measure of similarity between sites ranging from 0 to 100. On the x axis are the vegetation structural community that were compared.

Table 26 The reptile species that differentiated group 1 from group 2 in 2012, based on SIMPROF analyses of relative abundance. The amount that each species contributed to the difference is SIMPER%.

Group	Species	Sum of std abundance per group	SIMPER %
1	*Cryptoblepharus australis*	0.58	52.63
1	*Delma australis*	0.53	47.37
	Group 1 total	1.11	100
2	*Ctenotus schomburgkii*	1.33	29.09
2	*Diplodactylus calcicolus*	0.64	13.07
2	*Ctenophorus pictus*	0.76	12.35
2	*Menetia greyii*	0.44	9.59
2	*Nephrurus milii*	0.52	6.88
2	*Lucasium damaeum*	0.29	4.82
2	*Tiliqua rugosa*	0.14	3.53
2	*Ctenotus regius*	0.14	3.44
2	*Morethia obscura*	0.15	3.25
2	*Tympanocryptis houstoni*	0.31	2.99
2	*Ctenotus orientalis*	0.24	2.84
2	*Drysdalia mastersii*	0.10	2.20
2	*Ctenotus euclae*	0.18	2.00
2	*Nephrurus levis*	0.04	1.99
2	*Morethia adelaidensis*	0.14	1.96
	Group 2 total	5.42	100

Reptile Association with soil texture

Similarities in reptile assemblages within each soil texture class were investigated using cluster analyses. In the 2012 survey there was 1 group of soil texture classes detected (Figure 22). The species that contributed the greatest difference are described in table 27. (Note: reptile associations are not analysed with a separation of climate zones because there was no difference in assemblages based on climate, see ANOSIM analyses).

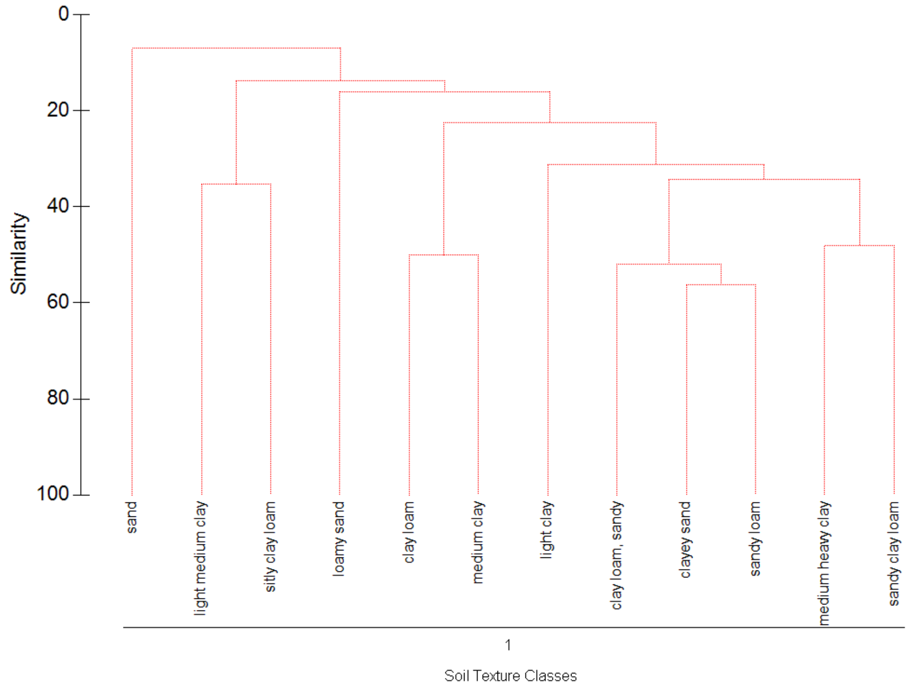

Figure 22 Bray-Curtis similarity dendrogram of reptile-soil groups in 2012. There were no significant differences between the reptile species and abundances recorded in each soil texture classes, therefore all classes formed 1 group. The measure of similarity ranging from 0 to 100 is shown on the y-axis. On the x-axis are the soil texture classes that were compared.

Table 27 The reptile species were dominant in group 1 in 2012, based on SIMPROF analyses of the species and the proportion of relative abundance. The amount that each species contributed to the difference is SIMPER%.

Group	Reptile species	Sum of standardised abundance per group	SIMPER %
1	*Ctenotus schomburgkii*	82.0	39.0
1	*Ctenophorus pictus*	39.3	22.6
1	*Tympanocryptis houstoni*	22.0	9.9
1	*Nephrurus milii*	32.4	9.7
1	*Diplodactylus calcicolus*	29.4	8.2
1	*Menetia greyii*	31.6	5.9
1	*Ctenotus orientalis*	13.4	4.5
	total	250.06	100

We also classified soil into three categories based on dominant texture. There were no significant reptile associations based on these classifications ($R < 0.456$, $p > 0.125$).

DISCUSSION

The key aims of this project were to detect trends in the cover of plants, and the abundance of mammals, birds and reptiles, on the basis of a comparison of an historical survey from 1984 with a current survey from 2012, and to investigate the link between temporal and spatial changes in rainfall and temperature with changes in the Nullarbor biota.

The results detected a significant relationship between the composition of plants, bird and mammals, and dominant temperature and rainfall gradients. There was a significant change between 1984 and 2012 within the COLD/WET zone in cover of plants and the abundance of birds, and small mammals that are typical in the HOT/DRY zone, but there was no change detected in the abundance and cover of species that are typical for the COLD/WET zone. Similar analyses of reptiles could not be done because the assemblage of reptile species in 1984 did not change with respect to the climate gradient. The assemblage of reptiles was not related to vegetation structural communities or soil texture either, but some changes between 1984 and 2012 were detected regardless. The results of this report demonstrate change, but cannot be used unequivocally to link changes in the ecology of a landscape with causes, such as rainfall or temperature.

Overall, some differences were observed between 1984 and 2012, but the ability to detect the causes of differences are difficult because arid lands are variable environments. Change, in itself, is not as informative as the link between change and explicit drivers. Short-term rainfall events, monitoring design, data storage, and natural fire regimes confound the interpretation of changes in the environment as being linked solely to climate change. Given the time lapse, natural fluctuations of any natural system and perceived changes due to monitoring design, the changes detected in the Nullarbor survey cannot be directly linked to climate change (Eyre, 2011) but the differences between 1984 and 2012 provide an indication of potential changes. We recommend future monitoring be undertaken long-term and focused on detecting changes that are directly associated with assets and threats in the Nullarbor, and on testing the effectiveness of management interventions applied to manage the assets of interest.

Describing trends over 18 years from two data points is difficult, particularly in landscapes with highly variable inter-year climate patterns. For example: Nullarbor rainfall in the years leading up to the 1984 survey was between 189mm and 241mm (Mean=210mm annual rainfall), while in the years leading up to the 2012 survey rainfall ranged from 205 to 376mm (mean=272mm), with the highest rainfall being in the year immediately prior to the 2012 survey. Any increases in plant cover or animal abundance could more easily be explained by this 'boom' period in the boom-bust cycle of these systems (Smyth & James, 2004), rather than any consistent trending changes in the ecological measures (Pickup & Stafford-Smith, 1993). If the 2012 survey had been done in 2009 (at the end of a drought, before the break of weather) we may have detected the opposite patterns. Our results therefore reflect changes in the environment, that cannot be directly associated with long-term trends.

The 1984 and 2012 surveys had some differences in design and data collection. The comparison of vegetation in this report might have been influenced by changes to the location of sampling quadrats between 1984 and 2012. To reduce the effect of these potential biases changes to plant species and cover were compared between sites. Bird survey methods were refined in 2012 because of a lack of clarity in the 1984 survey (McKenzie & Robinson, 1987). Location of bird surveys remained the same between years but effort differed somewhat. Therefore, for birds and plants it is difficult to infer that variation in bird abundance and plant cover is a response to changing climate, because the effect of sampling design can not be separated from other effects. Furthermore, there are potential biases introduced because of data capture and storage. For example, the transformation of cover/abundance data could reduce the accuracy of some results. The differences between cover/abundance might reflect biologically meaningful patterns or resource availability or growth conditions (Gotelli & Colwell, 2001) and it is therefore important to discuss differences, but further long-term monitoring is needed to identify confidently, the causes underlying any changes observed.

Readers should note the 1984 bird data might not be an accurate reflection of what was actually recorded due to changes made to the Biological Database of South Australia between 1984 and 2012. As a result, the comparison between 1984 and 2012 bird results should be interpreted with caution.

Species richness can be a simple and effective way to describe community diversity but it is influenced by sampling biases (Gotelli & Colwell, 2001). Fundamental to species richness is the notion that as more individuals are captured, the more taxa will be recorded (Bunge & Fitzpatrick, 1993). When survey effort is not equal, as in the case of the bird surveys, it is possible to describe false differences. Cover and abundance measures that are standardised are likely to be a stronger biodiversity metric (Albright *et al.*, 2010). Therefore, changes in species richness are supplemented with changes in abundance or cover in this report.

The study hypothesised there would be a relative reduction of plant cover and animal abundance of those species that characterised the COLD/WET coastal fringe as the environmental conditions became less favourable, due to temporal and spatial changes to rainfall and temperature. It was expected that some plants and animals might have been on the edge of their natural ranges, and changes in the climate would decrease the range of their habitats further, but the results did not detect evidence to support this hypothesis. The results might be linked to the relatively high rainfall preceding the 2012 survey (refer to Figure 3 in the introduction). Therefore, changes (or the lack of changes) to bird and plant communities are more likely to be related to this ‘boom’ period as opposed to long term changes in rainfall and temperature. Our results did not detect significant changes to the distribution and cover/abundance of species that characterised the COLD/WET zone but this might occur as the impacts of a change in long-term rainfall and temperature are increased.

In the COLD/WET coastal zone we expected to find an increase in the cover and abundance of the plants and animals that characterised the HOT/DRY zone as the arid zone encroaches south (Bryne *et al.,* 2008). A review of phylogeographic patterns in the Australian arid zone show that past biota demonstrate geographical movement to refuges in times of global climate change (Bryne, 2007). The coastal fringe of the Nullarbor is likely to act as a refuge due to the buffering effect of the ocean on temperature as well as the relatively high humidity and rainfall in the area (Bryne,2007). Studies such as these demonstrate how the distribution of plants and animals can be altered because of climate change.

We detected a significant change in the bird species that characterised the HOT/DRY zone between 1984 and 2012, with *Malurus leucopterus* (white-winged fairy-wren) and *Gavicalis virescens* (singing honeyeater) both significantly increasing in abundance. Importantly, a number of species that were expected to increase were recorded as decreasing in abundance, for example *Anthus australis* (Australasian pipit). While distribution models demonstrate community-wide expectations, there are likely to be many species that do not migrate as expected for a number of complex factors, for example habitat limitations, or associations with other plants or animals.

The results also detected a significant change in the cover of plants that characterise the HOT/DRY zone that were observed in the COLD/WET zone, with some plants increasing as expected, and others decreasing contrary to the hypothesised change. Current ecological theories predict that many species are expected to shift their ranges to higher altitudes and from the tropics to the poles in response to changes to global climate (Hickling *et al.*, 2006; Wilson *et al.*, 2005), whereas other species will retract and potentially face extinction (Thomas *et al.*, 2004). These global scale, generalised predictions do not necessarily provide a good account of what is occurring on the Nullarbor. The movement of species is probably buffered on the Nullarbor by above average rainfall in recent decades, and possibly by the positive effects of additional carbon dioxide in the air (Steffen *et al.*, 2009). In contrast to our predictions it is not surprising, therefore, to detect a decrease in some plant species that defined the HOT/DRY zone. Our results provide a snapshot of current biodiversity, but further monitoring is needed to determine long-term trends in cover and abundance.

Mus musculus (house mice) was the dominant species captured in the small mammal survey and therefore dominated the analyses and results in this area. There was a significant increase in the abundance of house mice in the COLD/WET zone. This result might support the hypotheses that species characterising the HOT/DRY zone will move south to the coastal refuges, but house mice are generalists and are known to retreat to more favourable areas during dry times. Likewise, mice extend their distribution and increase in abundance in 'boom' periods, therefore the relative increase in mice in the COLD/WET zone might indicate a response to short-term pulses of rainfall rather than long-term temporal and spatial changes in rainfall and temperature.

No change was detected between 1984 and 2012 in the abundance of *Notomys mitchellii,* the species that defined the COLD/WET zone. Studies in the arid zone have demonstrated that rodents respond to pulses of precipitation by increasing abundance and extent. In contrast, Dasyurids are not limited by water, but by other factors such as vegetation cover and life history (Dickman *et al.*, 1999). In Australia's arid zone house mice are thought to pose a mild threat to the natural biodiversity. When house mice are in plague numbers, they support high numbers of feral cats and foxes, which then prey on native species (Norris & Low, 2005). The vulnerable bird species, *Pedionomus torquatu*s (plains wanderer) is likely to be preyed on in this event (Garnett & Crowley, 2000). In contrast, house mice are recognised as an important food source for native animals, for example the black-shouldered kite, nankeen kestrel, kookaburras and brown snakes (Norris & Low, 2005). Studies of barn owls in the rangelands found that house mice constitute as much as 97% of their diet (Morton & Martin, 1979). Our study detected an increase in the number of house mice in the

COLD/WET zone in the Nullarbor, but given the low threat to biodiversity in the landscape, it is not necessary to change the region's management of feral rodents.

We expected that assemblages of reptiles would be different between the HOT/DRY and COLD/WET sites. This was not supported by the survey results. Therefore, the hypothesis that the reptile species that characterised the HOT/DRY zone would increase in the coastal COLD/WET zone could not be analysed because no indicator species could be selected by SIMPER. Likewise, the reduction of reptiles that characterised COLD/WET between 1984 and 2012 could not be tested either.

Reptiles have low metabolic rates and low energy needs and can further reduce their need for food and water by remaining inactive and maintaining relative low body temperatures. It is therefore likely that reptiles are not subjected to population fluctuation in response to rainfall variability (Read, 1992). A similar study of herpetofauna in Kakadu National Park showed that reptile distribution and abundance is more related to the moisture substrate gradient than to vegetation structure. The study also noted a number of exceptions that were distributed landscape-wide and not related to either factor (Woinarski & Gambold, 1992). This study may offer some explanation as to why our study did not detect a relationship between reptile composition and broad climate gradients or soil texture.

The vegetation photopoint survey indicated the cover, recruitment and density of plants in the study area has been stable over time. There were 40 sites in total, where low shrubs, trees and tall shrubs, grass and herbs, *Acacia aneura* and *Maireana sedifolia* were assessed according to detect changes in density, cover and recruitment over time. On average these sites were 'stable', although only one assessment of *A. aneura* was possible, and this recorded a decreasing condition.

The warming and drying of the Nullarbor region might lead to increased frequency and intensity of fires and a reduction in patches of fire-sensitive mulga, *A. aneura*, in grassland communities (Myers *et al.*, 2004). Camels and rabbits selectively feed on mulga further increasing the threats to survival and recruitment in arid Australia (Edwards *et al.*, 2010). Additional photopoints have been installed and surveys are currently underway to measure trends in the condition of mulga stands in the Nullarbor landscape. The results from these extra photopoints will be presented in a separate report along with assessments of shrubland, grass/herb land, and woodland communities throughout the Nullarbor.

Camels have a preference for feeding on *Acacia aneura*, *Alectryon oleifolius ssp*., *Amyema ssp.*, *Casuarina pauper, Eremophila longifolia, Exocarpos aphyllus, Lysiana spp., Myoporum platycarpum var., Pittosporum angustifolium, Santalum acuminatum, Santalum spicatum,* and *Santalum lanceolatum* (Edwards *et al.* 2010; Brandle, pers. comms. 2012). These palatable plants occur across the Nullarbor landscape but are more common in tall shrubland, low open woodland, low woodland, low open shrubland and low shrubland communities within the HOT/DRY zone. In the COLD/WET zone, the plants are more common in mallee, open low mallee, open mallee, very low open woodland, very low woodland, low open woodland, and low woodland communities.

Our results showed no difference in the abundance of camels between these vegetation structural communities. Given the increase in rainfall in recent years, it is possible that increased water and resource availability meant that camels did not aggregate in any particular location. Even if camel numbers remain stable in the Nullarbor, the negative impacts are likely to be concentrated at particular points under climate change scenarios, rather than be dispersed. Remote settlements and natural water accumulation points will become important refuges and are susceptible to increases in camel visitation. Water scarcity and increased droughts will amplify water pollution, vegetation browsing and trampling, and competition caused by camels.

Strategies for conservation management should focus of the region's priorities and assets and aim to build resilience in the system to climate change through habitat restoration, and continued management of other stressors, such as pest management and fire management (Bardsley & Wiseman, 2012). Management of feral plants and animals, including camels, has been occurring Australia-wide. The National Feral Camel Action Project (NFCAP) could be adopted for the Nullarbor region (Vertebrate Pest Committee, 2010). The NFCAP would crucially begin with the identification of assets in AW and then sets target required to protect these assets. Monitoring is essential to inform the effectiveness of management and to inform the need for adaptive management.

Biological surveys such as this one can help to identify assemblages in landscapes and provide snapshots in species abundance and cover. According to the recommendations in the report by Bardsley & Wiseman (2012) key actions for the AW region regarding conservation management should include investigation of the relationship between biodiversity and climate and the resampling of a biological survey. This report has achieved some of the outcomes recommended for these actions for the Nullarbor region. The results of our study can be used to inform the AW of the biodiversity condition, changes in species abundance and cover relative to 1984 and provides information on the selection of environmental assets and the monitoring that is required to track the condition of these assets.

The key objective of this project was to assess the response of biodiversity to climate change. Revisiting existing biological survey sites has allowed for landscape wide changes in biodiversity to be investigated but the analysis of the results from this study has highlighted a number of limitations in the monitoring design that prevented detection of a clear links between changes in biodiversity and changes in climate over the timeframe of interest. The most fundamental limits are that there are only two samples over the time period, it was difficult to be sure that the study was repeated accurately because the methods for the oldest survey were not always clear, and the study provides a relatively small sample from a very large landscape.

Future monitoring in the Nullarbor, needs to focus on assets that are expected to be impacted by climate change. Many of these assets are current priorities for management in the AW region, for example the coastal ecosystems contributing to the Yalata Coast, Bunda Cliffs and Merdayerrah Sandpatch, the endemic biota that exist in the limestone caves across the Nullarbor landscape (AW NRM, 2011) or water points that occur throughout the rangelands (Steffen *et al.,* 2009). It is likely that a warmer, drier environment will further impact these assets (Steffen *et al.,* 2009). For example, our results indicated that the distribution of *Maireana sedifolia, Sclerolaena obliquicuspis, Lycium australe, Rhagodia spinescens, Enchylaena tomentosa var. tomentosa, Pittosporum angustifolium, Anthus australis, Pomatostomus superciliosus, Malurus leucopterus, Gavicalis virescens, Psephotus varius, Artamus cinereus, Aphelocephala leucopsis, Cinclosoma cinnamomeum alisteri, Falco berigora, Colluricincla harmonica,* and *Melanodryas cucullata* may have changed over the last 28 years. While our study did not link these changes to climate change, these species may be assessed as potential sentinels of climate change. These potential sentinels should not be considered the exhaustive list of the species that may change their distribution in the future.

The identification of priority species and regional assets is important to conservation planning because it assists in clearly articulating monitoring questions and allows these questions to be adequately answered. The priority species for the AW NRM should be based on: endemism, threats, abundance, potential climate change impacts, existing monitoring data, and species of high profile. An example is *Acanthiza iredalei iredalei* (slender-billed thornbill) which is common across the Nullarbor landscape and a notable priority because of its conservation status under the *EPBC Act 1999*.

Threats to the region have been identified, including: buffel grass, fire regimes and large herbivores (Biosecurity SA, 2012; Myers *et al.,* 2004; Vertebrate Pest Committee, 2010), thus monitoring the impacts these threats have on regional biodiversity assets would help to better inform management actions. This work could be linked to national and state-wide strategic plans, for example South Australia Buffel Grass Strategic Plan 2012-2017, and the National Feral Camel Action Project. Monitoring the condition and trends of assets that are likely to be impacted by climate change will increase the knowledge needed to make informed management decisions, in turn maximising the opportunities to build resilience in arid ecosystems.

An adaptive management approach should be used to improve environmental management outcomes, while at the same time increase understanding of the consequences of incomplete knowledge (Sabine *et al.,* 2004). There is extensive literature on adaptive management that can be used to design effective monitoring programs. Lindenmayer and Likens (2009) provide an accessible review that discusses the links between long-term research and monitoring in an adaptive management context.

In conclusion, the study found little support for the hypotheses that species have moved south toward coastal refuges in response to changes in rainfall and temperature, and no evidence to indicate a relative decline in species that characterised the coastal zone. Increased rainfall in the year preceding the 2012 survey, compared with the rainfall immediately preceding the 1984 survey, is a possible explanation for this. The results provide a snapshot of current levels of abundance of animals and cover of plants. Improved and enhanced monitoring can be used to inform the AW of changes in biodiversity in the Nullarbor region, and we recommend this monitoring has a stronger focus toward the long-term monitoring of assets determined by priorities set by the AW NRM.

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APPENDIX A

Table 28 Disturbance history of the Nullarbor Plains after European introduction in 1801

Time period	People in charge	Location of disturbance	Details of disturbance
1800 to 1840	Whalers	Fowlers Bay	Local timber clearing for Fuel for rendering pots
			Introduction of cats
1841 to 1842	Eyre	Trans-Nullarbor	Pack horse
			Overlanding stock to the west not possible
1858	Swan and Barr Smith	Fowlers Bay	First Pastoral Leases
1858 to 1859		Colona, Nundroo, Penong	Pastoral Settlement
1860	P Warburton	Nullarbor Plain	"neither man nor stock could live upon (Nullarbor Plain)"
1861		Fowlers Bay	Pastoral development begins
1863 to 1865	Far West Coast	Early Settlers	Severe Drought
			Agricultural settlers sell out to Swan and B-Smith
1865		Head of Bight	Stock being grazed; White Well Outstation established
			White Well and soaks at Peenalubie Ilgamba are main waters
		Yalata Station	20,000 Sheep
			5,000 driven to Adelaide due to drought
1865 to 1866	A Delisser	Nullarbor Plain	Pack horses
			Coastal Survey Lines
1867		Head of Bight	W Gray/C Schilling purchase leases
1870 to 1871	J Forrest	Nullarbor Plain	Exploration with horses
			"vast plains of grass and saltbush"
1871		Fowlers Bay	Swan, Barr Smith and Armstrong control all grazing land around Fowlers Bay
1871		Mundrabilla Station	Station established
1873	Muir Bros	Moopina Station	Station established
1875	E Giles	Nullarbor E and N Fringes	Exploration with Camels
1876		Madura Station	Station established
1876 to 1877			Telegraph Line constructed
			Use of horses
1877 to 1879			Leases west of Nullarbor taken up but not stocked
1878	Faerie & Woolley	Nullarbor Plain	Fatal Expedition; using horses
1879	R Tate	Nullarbor Plain	Exploration with Camels
1880	J Jones	Nullarbor Plain	Exploration with Camels
1880		Albala-Karoo	First Bore

Table 27 continues on the next page

Table 28 continued

Time period	People in charge	Location of disturbance	Details of disturbance
1880		Yalata Station	100,000 sheep
1880		Balladonia Station	Station established
1880 to 1889	W Ifould	Lake Ifould	Takes up leases around Lake Ifould
1886 to 1887		Nullarbor Station	Roberts Well bored
			Station established
1885?	HYL Brown		Camels on Geol Survey
1886 to 1889	Afghans	Nullarbor Plain	260 - 500 camels used as carriers across Nullarbor, to WA Goldfields
1890	W Ifould	Ooldea	Grazing sheep at Ooldea
			First Well at Ooldea
1894	A Heath	Nullarbor Plain	Drives ~50 camels across Nullarbor to Goldfields
1894 to 1898		Nullarbor Plain	Rabbits cross plain from Head of Bight to Coolgardie
1896	Mason & Yonge	Nullarbor Plain	Camel Expedition
			Investigation of rabbit movements
1896 to 1897		Eucla	Rabbit plagues; Cat introduction
			Sandhill drifts induced
			1000 Rabbits slaughtered in a day with no evident impact
1900		Nullarbor Plain	500 camels driven from Marree to Kalgoorlie
1901	J Muir	Nullarbor Plain	Survey of WA part of Transcontinental Rail
			Uses Camels
1906		Nullarbor Plain	Overland track across Nullarbor recognised
			WA Goldfields developing
1912 to 1917		Nullarbor Plain	Construction of Transcontinental Railway
1917			Transcontinental Railway begins
1941	R&C Gurney	Koonalda Station	Take up Pastoral Lease
1941 to 1942	Commonwealth Defence Forces	Nullarbor Plain Coast	Overland Track converted to serviceable Road
1954			Myxomatosis spread reduces rabbit populations
1954 to 1961	A&C Beatty	Nullarbor Station	Run 3,000 to 5,000 sheep
1959		Nullarbor Station	Drought - 1700 sheep kept; water carted to them
1960 to 1969		Nullarbor Plain Coast	Eyre Highway becomes all-weather road
1964	M&D Thomas	Nullarbor Station	Nullarbor Roadhouse complex established
1976	NPWS	Nullarbor Station	Purchase and Proclamation of Nullarbor NP

APPENDIX B

Survey records from 1984 and 2012:

- Plants observed in 2012, cover has been standardised by site and climate zone, table 29
- Plants observed in 1984, cover has been standardised by site and climate zone, table 30
- Birds observed in 2012 table 31
- Birds observed in 1984 table 32
- Small observed mammals in 2012 table 33
- Small observed mammals in 1984 table 34
- Reptiles observed in 2012 table 35
- Reptiles observed in 1984 table 36

Plants species tables list all plants as present (1). No number indicates absence.

Bird, mammal, and reptile tables describe the number of individuals observed at each camp, and the total number of individuals that were opportunistic observations.

NB All exotic species are identified with an asterisk, for example **Mus musculus*.

Table 29 Plant species recorded in the 2012 survey with the total percent cover in each camp

Plant Species	common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Abutilon leucopetalum	desert lantern-bush	perennial							2.5	
Abutilon otocarpum	desert lantern-bush	perennial							2	
Acacia aneura var.		perennial							2.5	
Acacia aneura var. intermedia	broad-leaf mulga	perennial							54.5	
Acacia ayersiana	blue mulga	perennial							1	
Acacia erinacea	prickly wattle	perennial						3.5		
Acacia kempeana	witchetty bush	perennial							5	
Acacia ligulata	umbrella bush	perennial							64	
Acacia oswaldii	umbrella wattle	perennial	1	1	1	6.5	3		4.5	23
Acacia papyrocarpa	western myall	perennial			112.5	30	97.5	45		1
Acacia ramulosa var. linophylla	horse mulga	perennial							22	
Acacia ramulosa var. ramulosa	horse mulga	perennial							0.5	
Acacia tetragonophylla	dead finish	perennial		0.5					9	
Alectryon oleifolius ssp. canescens	bullock bush	perennial			0.5					
Amyema melaleucae	tea-tree mistletoe	perennial						2		
Amyema quandang var. quandang	grey mistletoe	perennial			1		13			
Angianthus conocephalus		annual	6.5	5					2.5	
Angianthus sp.		annual	0.5							
Arabidella trisecta	shrubby cress	perennial			1					
Aristida anthoxanthoides	yellow three-awn	annual							0.5	
Aristida contorta	curly wire-grass	perennial							11	
Aristida holathera var. holathera	tall kerosene grass	perennial							41	
Atriplex acutibractea ssp.	pointed saltbush	perennial		0.5						
Atriplex acutibractea ssp. acutibractea	pointed saltbush	perennial	2.5	3.5					3	
Atriplex acutibractea ssp. karoniensis	pointed saltbush	perennial						3		
Atriplex cryptocarpa		perennial		76						
Atriplex nummularia ssp. spathulata	old-man saltbush	perennial						41.5		
Atriplex stipitata	bitter saltbush	perennial								30
Atriplex vesicaria	bladder saltbush	perennial	124.5	180	315	183.5	152	32.5		181
Austrodanthonia caespitosa	common wallaby-grass	perennial		12.5		18			16	35
Austrodanthonia eriantha	hill wallaby-grass	perennial				1				
Austrodanthonia sp.		perennial	200	6	5	35.5	41	78		15
Austrostipa acrociliata	graceful spear-grass	perennial						6.5		5
Austrostipa acrociliata group	branched spear-grass	perennial								0.5
Austrostipa drummondii	cottony spear-grass	perennial					3.5			32.5
Austrostipa elegantissima	feather spear-grass	perennial				5				
Austrostipa eremophila/puberula		perennial	0.5	15.5		40.5		57.5	0.5	30
Austrostipa nitida	Balcarra spear-grass	perennial	8	16.5	40	75.5	90.5	19	7	
Austrostipa platychaeta	flat-awn spear-grass	perennial	3			1.5	2.5			5.5
Austrostipa puberula	fine-hairy spear-grass	perennial		3.5		37.5				
Austrostipa sp.	spear-grass	perennial	2.5							
Austrostipa velutina		perennial				18				
Boerhavia dominii	tar-vine	perennial							1	
Brachyscome ciliaris var. ciliaris	variable daisy	perennial				0.5				
Brachyscome tatei	Nullarbor daisy	perennial				2				
Calotis breviradiata		perennial		1						
Calotis cymbacantha	showy burr-daisy	annual								2.5
Carpobrotus rossii	native pigface	perennial								4.5
Cassytha melantha	coarse dodder-laurel	perennial				1.5		8.5		

Table 29 continued

Plant Species	common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Casuarina pauper	black oak	perennial							1	
Chenopodium curvispicatum	cottony goosefoot	perennial						3		
Chenopodium desertorum ssp. desertorum	frosted goosefoot	perennial							2.5	
Chenopodium gaudichaudianum	scrambling goosefoot	perennial							21.5	
Comesperma volubile	love creeper	perennial						2.5		
Compositae sp.	daisy family	annual	0.5	4.5	0.5		0.5			
Convolvulus angustissimus ssp. angustissimus	Australian bindweed	perennial					1.5			
Convolvulus remotus	grassy bindweed	perennial		0.5						
Convolvulus sp.	bindweed	perennial		4.5						
Crassula colorata var. acuminata	dense crassula	annual	0.5				1.5			
Crassula sp.	crassula/stonecrop	annual					0.5			18.5
Cratystylis conocephala	bluebush daisy	perennial			1	40	90	21		123
Cullen sp.	scurf-pea	perennial		1						
Dianella revoluta var. divaricata	broad-leaf flax-lily	perennial						5		1
Dicrastylis beveridgei var. lanata	woolly sand-sage	perennial							15	
Disphyma crassifolium ssp. clavellatum	round-leaf pigface	perennial				0.5	3.5			2.5
Dissocarpus biflorus var. biflorus	two-horn saltbush	perennial	22				0.5			
Dodonaea stenozyga	desert hop-bush	perennial				1		3		
Dodonaea viscosa ssp. angustissima	narrow-leaf hop-bush	perennial							55.5	
Enchylaena tomentosa var. tomentosa	ruby saltbush	perennial	2.5	6.5	4.5	9	6	9.5	8.5	7.5
Enneapogon avenaceus	common bottle-washers	perennial		1	3				35	
Enneapogon caerulescens	blue bottle-washers	perennial			3.5				7.5	
Enneapogon cylindricus	jointed bottle-washers	perennial			2.5				30.5	
Enneapogon polyphyllus	leafy bottle-washers	perennial							31.5	
Enneapogon sp.	bottle-washers/nineawn	perennial							2.5	
Eragrostis dielsii var. dielsii	mulka	perennial		4						
Eragrostis eriopoda	woollybutt	perennial							6	
Eremophila alternifolia	narrow-leaf emubush	perennial							1.5	
Eremophila decipiens ssp. decipiens	long-stalk tar-bush	perennial						2.5		
Eremophila deserti	turkey-bush	perennial					1			
Eremophila glabra ssp. glabra	tar bush	perennial						19.5		26.5
Eremophila latrobei ssp. glabra	crimson emubush	perennial							3	
Eremophila longifolia	weeping emubush	perennial		2						
Eremophila maculata ssp. maculata	spotted emubush	perennial		31						
Eremophila parvifolia ssp. parvifolia	small-leaf emubush	perennial				1				
Eremophila scoparia	broom emubush	perennial			16		2			4.5
Eremophila weldii	purple emubush	perennial						110		
Eremophila willsii ssp. willsii	sandhill emubush	perennial							15	
Eriochiton sclerolaenoides	woolly-fruit bluebush	perennial	3.5	4.5	5		2.5		10	
Erodiophyllum elderi	Koonamore daisy	perennial							15	
Eucalyptus brachycalyx	gilja	perennial								105
Eucalyptus calcareana	nundroo mallee	perennial						107		150
Eucalyptus gracilis	yorrell	perennial				1		64		53.5
Eucalyptus oleosa ssp. ampliata	red mallee	perennial			16	2.5	30	3		17.5
Eucalyptus socialis ssp. victoriensis	beaked red mallee	perennial				2.5		30		2
Eucalyptus yalatensis	Yalata mallee	perennial				31		60		
Eucalyptus youngiana	Ooldea mallee	perennial							0.5	
Euphorbia drummondii		perennial	1	3.5	2		1		1.5	3
Euphorbia tannensis ssp. eremophila	desert spurge	perennial			2				0.5	
Exocarpos aphyllus	leafless cherry	perennial				1.5	1	9		6

Table 29 continued

Plant Species	common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Frankenia serpyllifolia	thyme sea-heath	perennial			15					50
Frankenia sessilis	small-leaf sea-heath	perennial				3				31
Galium sp.	bedstraw	perennial	0.5							
Geijera linearifolia	sheep bush	perennial				55	1.5	77		9.5
Gnephosis tenuissima	dwarf golden-tip	annual							1	
Goodenia pinnatifida	cut-leaf goodenia	perennial					2			
Gramineae sp.	grass family	perennial					2.5			
Gunniopsis calcarea		perennial	3							
Hemichroa diandra	mallee hemichroa	perennial				2.5				0.5
Lawrencia squamata	thorny lawrencia	perennial	2.5			110.5	3			1
Lepidium phlebopetalum	veined peppercress	annual			2.5				5.5	
Lepidium sp.	peppercress	annual			0.5					
Leucochrysum fitzgibbonii	Fitzgibbon’s daisy	annual							9.5	
Lomandra collina	sand mat-rush	perennial								1
Lomandra effusa	scented mat-rush	perennial					30			5
Lycium australe	Australian boxthorn	perennial	8	4.5	1	27.5	1	3	0.5	
Lysiana exocarpi ssp. exocarpi	harlequin mistletoe	perennial		2			3			
Lysiana murrayi	mulga mistletoe	perennial							4	
Maireana appressa	pale-fruit bluebush	perennial					2.5			
Maireana erioclada	rosy bluebush	perennial	4.5		3	17	5	11.5	5	
Maireana erioclada/pentatropis		perennial			2		11			30
Maireana georgei/turbinata	satiny bluebush	perennial	2							
Maireana integra	entire-wing bluebush	perennial			6.5				2.5	
Maireana lobiflora	lobed bluebush	perennial					2			
Maireana oppositifolia	salt bluebush	perennial					2.5			10
Maireana pentatropis	erect mallee bluebush	perennial			2.5		2.5			28.5
Maireana radiata	radiate bluebush	perennial			0.5					2
Maireana rohrlachii	rohrlach's bluebush	perennial					0.5			
Maireana sedifolia	bluebush	perennial	96	30	235.5	3	2	34	15	
Maireana trichoptera	hairy-fruit bluebush	perennial			3		4.5			
Maireana turbinata	top-fruit bluebush	perennial		5.5			0.5			
Malvastrum americanum var. americanum	malvastrum	perennial							1.5	
Marsdenia australis	native pear	perennial							2.5	
Melaleuca lanceolata	dryland tea-tree	perennial				37.5		46.5		63.5
Melaleuca pauperiflora ssp. mutica	boree	perennial				37.5		17		6.5
Melaleuca quadrifaria	limestone honey-myrtle	perennial						52.5		
Microcybe multiflora ssp. baccharoides	scale-leaf microcybe	perennial						1		
Monachather paradoxus	bandicoot grass	perennial							5	
Myoporum platycarpum ssp.	false sandalwood	perennial								31
Myoporum platycarpum ssp. platycarpum	false sandalwood	perennial			30	5	6.5	5.5		64.5
Nicotiana goodspeedii	small-flower tobacco	annual	0.5			3				2
Nicotiana sp.	tobacco	annual				0.5			1	
Nitraria billardierei	nitre-bush	perennial	3			42.5				3
Olearia exiguifolia	lobed-leaf daisy-bush	perennial				2		3		
Olearia magniflora	splendid daisy-bush	perennial					1			1.5
Olearia muelleri	mueller's daisy-bush	perennial				5		41		38.5
Omphalolappula concava	burr stickseed	annual					0.5			
Osteocarpum salsuginosum	inland bonefruit	perennial	1							
Osteocarpum sp.	bonefruit	perennial	0.5							
Paractaenum refractum	bristle-brush grass	annual							1.5	

Table 29 continued

Plant Species	common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Pimelea microcephala ssp. microcephala	shrubby riceflower	perennial							1	
Pimelea serpyllifolia ssp. serpyllifolia	thyme riceflower	perennial						2.5		
Pittosporum angustifolium	native apricot	perennial		7.5			4		22.5	37
Plantago drummondii	dark plantain	annual	0.5							
Plantago sp.	plantain	annual	0.5							
Podolepis canescens	grey copper-wire daisy	annual					6			30
Podolepis capillaris	wiry podolepis	annual							12.5	
Pomaderris forrestiana		perennial						21		
Pomax umbellata	pomax	perennial							1	
Ptilotus obovatus		perennial					2		27.5	5
Ptilotus polystachyus	long-tails	perennial							4.5	
Rhagodia candolleana ssp. argentea	silver sea-berry saltbush	perennial			0.5					
Rhagodia crassifolia	fleshy saltbush	perennial				18	9	42.5		49
Rhagodia preissii ssp. preissii	mallee saltbush	perennial							2.5	
Rhagodia spinescens	spiny saltbush	perennial		4.5	4.5		4.5			
Rhodanthe floribunda	white everlasting	annual		1						
Rhodanthe sp.	everlasting	annual				0.5				
Salsola tragus	buckbush	annual	6.5	4	8	6.5	9	1	4	3
Santalum acuminatum	quandong	perennial			30.5	0.5	4.5			5.5
Santalum spicatum	sandalwood	perennial			0.5			3	1	
Scaevola spinescens	spiny fanflower	perennial			15		1	17.5		5
Sclerolaena brevifolia	small-leaf bindyi	perennial				2	0.5			17.5
Sclerolaena diacantha	grey bindyi	perennial			30.5				55.5	15
Sclerolaena obliquicuspis	oblique-spined bindyi	perennial	9	7.5	66.5	0.5	3.5	4.5	2.5	
Sclerolaena patenticuspis	spear-fruit bindyi	perennial	26	11.5	37.5	3	1	2	24	
Sclerolaena sp.	bindyi	perennial					11.5			
Sclerolaena uniflora	small-spine bindyi	perennial	1		0.5	5	10.5	12		65.5
Senecio pinnatifolius group		perennial	0.5			1.5				10.5
Senecio sp.	groundsel	annual	0.5							1
Senna artemisioides ssp. filifolia	fine-leaf desert senna	perennial							6.5	
Senna artemisioides ssp. petiolaris		perennial			1					
Senna artemisioides ssp. X coriacea	broad-leaf desert senna	perennial			1			1		
Senna artemisioides ssp. X sturtii	grey senna	perennial			1					1
Senna cardiosperma ssp. gawlerensis	gawler ranges senna	perennial			2					
Setaria constricta	knotty-butt paspalidium	perennial							1.5	
Sida calyxhymenia	tall sida	perennial							2.5	
Sida corrugata var.	corrugated sida	perennial							4	2.5
Sida fibulifera	pin sida	perennial							1	
Sida intricata	twiggy sida	perennial							4	
Sida sp.	sida	perennial		1						
Sida sp. Rabbit Flat (R.B.Major 158)		perennial							1.5	
Sida spodochroma		perennial							7.5	
Solanum coactiliferum	tomato-bush	perennial							2.5	
Solanum hystrix	afghan thistle	perennial								5
Solanum orbiculatum ssp.		perennial							1	
Tecticornia disarticulata		perennial	106			11	77	7.5		30
Templetonia battii	spiny templetonia	perennial								1
Templetonia retusa	cockies tongue	perennial						2		2
Tetragonia implexicoma	bower spinach	perennial				0.5				1.5
Threlkeldia diffusa	coast bonefruit	perennial				3	4	6		31.5

Table 29 continued

Plant Species	common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Trachymene glaucifolia	blue parsnip	annual							2	
Trichanthodium skirrophorum	woolly yellow-heads	annual				17.5	3.5		0.5	
Triraphis mollis	purple plume grass	perennial							2.5	
Vittadinia australasica var. australasica	sticky New Holland daisy	annual					1.5			17.5
Vittadinia cervicularis var. cervicularis	waisted New Holland daisy	annual			0.5				0.5	
Vittadinia gracilis	woolly New Holland daisy	perennial			5					
Vittadinia sp.	New Holland daisy	annual							2	
Westringia rigida	stiff westringia	perennial				2.5		135		9
Xerochrysum bracteatum	golden everlasting	annual							0.5	
Zygophyllum apiculatum	pointed twinleaf	annual						1		
Zygophyllum aurantiacum ssp.		perennial								1.5
Zygophyllum aurantiacum ssp. aurantiacum	shrubby twinleaf	perennial			2.5		2.5			
Zygophyllum aurantiacum/eremaeum	shrubby twinleaf	perennial					5			3.5
Zygophyllum billardierei	coast twinleaf	perennial				1				
Zygophyllum eremaeum		perennial							4	
Zygophyllum ovatum	dwarf twinleaf	annual							0.5	
Zygophyllum sp.	twinleaf	perennial		2.5		2				
**Carrichtera annua*	ward's weed	annual	4	10	0.5	1	12		2.5	
**Eragrostis barrelieri*	pitted love-grass	annual							4	
**Medicago minima var. minima*	little medic	annual					0.5			
**Mesembryanthemum nodiflorum*	slender iceplant	annual					0.5			
**Reichardia tingitana*	false sowthistle	annual								1
**Sisymbrium sp.*	wild mustard	annual							4	
**Sonchus oleraceus*	common sow-thistle	annual		0.5					0.5	

Table 30 Plant species recorded in the 1984 survey with the total percent cover in each camp

Plant species	Common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Abutilon sp.	lantern-bush	perennial							3.5	
Acacia aneura var. intermedia	mulga	perennial		1					61.5	
Acacia burkittii	pin-bush wattle	perennial							3	
Acacia erinacea	prickly wattle	perennial						2		
Acacia hakeoides	hakea wattle	perennial						0.5		0.5
Acacia kempeana	witchetty bush	perennial							16	
Acacia ligulata	umbrella bush	perennial							18	
Acacia nyssophylla	spine bush	perennial			1					
Acacia oswaldii	umbrella wattle	perennial	31	2.5	1	35.5	2.5	4.5	1	3
Acacia papyrocarpa	western myall	perennial	1		33	3	85.5	17		2
Acacia ramulosa (NC)	horse mulga	perennial							48	
Acacia tetragonophylla	dead finish	perennial		2.5					47.5	
Acrotriche patula	prickly ground-berry	perennial						0.5		
Actinobole uliginosum	flannel cudweed	annual	0.5							
Alectryon oleifolius ssp. canescens	bullock bush	perennial		2.5	1				0.5	
Amyema maidenii ssp. maidenii	pale-leaf mistletoe	perennial								2.5
Amyema melaleucae	tea-tree mistletoe	perennial						5		
Amyema preissii	wire-leaf mistletoe	perennial	0.5							
Amyema quandang var. quandang	grey mistletoe	perennial			7.5		13.5			
Angianthus conocephalus		annual	95.5	0.5		21				
Angianthus disarticulata (NC)		annual	2.5							
Angianthus sp.		annual					15			
Angianthus tomentosus	hairy angianthus	annual								2.5
Arabidella filifolia	thread-leaf cress	perennial			0.5					
Aristida contorta	curly wire-grass	perennial							32.5	
Aristida holathera var. holathera	tall kerosene grass	perennial							17.5	
Atriplex acutibractea ssp. acutibractea	pointed saltbush	perennial		37.5	0.5					
Atriplex cinerea	coast saltbush	perennial								1.5
Atriplex cryptocarpa		perennial		37.5						
Atriplex eardleyae	Eardley's saltbush	perennial	3	2.5		1.5		1		
Atriplex nummularia ssp. spathulata	old-man saltbush	perennial						12.5		
Atriplex sp.	saltbush	perennial		15						
Atriplex stipitata	bitter saltbush	perennial			2					
Atriplex vesicaria		perennial	196	37.5	76.5	83	102	48		191.5
Austrodanthonia caespitosa	common wallaby-grass	perennial			0.5			2.5		
Austrodanthonia setacea	small-flower wallaby-grass	perennial								0.5
Austrodanthonia sp.	wallaby-grass	perennial	58	3.5		29.5	5	0.5		15
Austrostipa acrociliata	graceful spear-grass	perennial	31			1.5				4
Austrostipa drummondii	cottony spear-grass	perennial				30				5.5
Austrostipa nitida	Balcarra spear-grass	perennial		2.5	2.5					
Austrostipa platychaeta	flat-awn spear-grass	perennial	0.5				0.5	0.5		
Austrostipa sp.	spear-grass	perennial	11	4.5		93	60.5	8	15	55
Beyeria lechenaultii	pale turpentine bush	perennial								1
Brachyscome ciliaris var. ciliaris	variable daisy	perennial			0.5					
Brachyscome sp.	native daisy	perennial					15			
Brachyscome tatei	Nullarbor daisy	perennial				0.5				
Bromus arenarius	sand brome	annual	0.5							
Bromus sp.	brome	annual					2.5			
Bulbine sp.	bulbine-lily	annual					0.5			
Calotis breviradiata		perennial		2.5						
Calotis hispidula	hairy burr-daisy	annual			0.5					
Carpobrotus rossii	native pigface	perennial								2
Cassia sturtii (NC)	grey cassia	perennial			2					
Cassytha melantha	coarse dodder-laurel	perennial				1		31		0.5

Table 30 continued

Plant species	Common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Casuarina pauper	black oak	perennial							1	1
Cephalipterum drummondii	pompom head	annual			0.5					
Chenopodium sp.	goosefoot	perennial							1	
Comesperma volubile	love creeper	perennial							0.5	
Compositae sp.	daisy family	annual	22		0.5	22	15	0.5		
Convolvulus angustissimus ssp. angustissimus	Australian bindweed	perennial		3					2.5	
Crassula sp.	crassula/stonecrop	annual				3	2.5			6
Cratystylis conocephala	bluebush daisy	perennial				1	105	18		11.5
Cullen sp.	spreading scurf-pea	perennial		2.5						
Dianella revoluta var. divaricata		perennial						2		
Dicrastylis beveridgei var. lanata	woolly sand-sage	perennial							0.5	
Disphyma crassifolium ssp. clavellatum	round-leaf pigface	perennial				0.5	0.5	3		30
Dodonaea stenozyga	desert hop-bush	perennial				2		4.5		0.5
Dodonaea viscosa ssp. angustissima	narrow-leaf hop-bush	perennial							2.5	
Dysphania cristata	crested goosefoot	annual							2.5	
Enchylaena tomentosa var. tomentosa	ruby saltbush	perennial	3.5	37.5	3.5	17	2	7	4	8.5
Enneapogon avenaceus	common bottle-washers	perennial							0.5	
Enneapogon caerulescens	blue bottle-washers	perennial							2.5	
Enneapogon cylindricus	jointed bottle-washers	perennial							52.5	
Enneapogon polyphyllus	leafy bottle-washers	perennial							18	
Enneapogon robustissimus	Cleland's nineawn	perennial							15	
Enneapogon sp.	bottle-washers/nineawn	perennial								18.5
Eragrostis lanipes	woollybutt	perennial							15	
Eremophila alternifolia	narrow-leaf emubush	perennial				0.5			0.5	
Eremophila glabra ssp. glabra	tar bush	perennial		37.5				18		2
Eremophila longifolia	weeping emubush	perennial		1					15	
Eremophila maculata ssp. maculata	spotted emubush	perennial		16						
Eremophila parvifolia ssp. parvifolia	small-leaf emubush	perennial								1
Eremophila scoparia	broom emubush	perennial			0.5					1
Eremophila weldii	purple emubush	perennial						46		
Eremophila willsii ssp. willsii	wills' emubush	perennial							0.5	
Eriochiton sclerolaenoides	woolly-fruit bluebush	perennial			0.5		2.5			
Erodium sp.	heron's-bill/crowfoot	annual	14		0.5		2.5			
Eucalyptus brachycalyx	gilja	perennial						1		
Eucalyptus calcareana	Nundroo mallee	perennial						2		49
Eucalyptus diversifolia ssp. diversifolia	coastal white mallee	perennial						3		
Eucalyptus gracilis	yorrell	perennial				1		32		49
Eucalyptus oleosa ssp. ampliata	red mallee	perennial			1	4	52.5			34
Eucalyptus socialis ssp. victoriensis	beaked red mallee	perennial						34		35
Eucalyptus yalatensis	Yalata mallee	perennial						3		1
Eucalyptus youngiana	Ooldea mallee	perennial							1	
Euphorbia drummondii	caustic weed	annual			0.5					
Euphorbia sp.	spurge	perennial					2.5			
Euphorbia tannensis ssp. eremophila	desert spurge	perennial			0.5				2.5	
Eutaxia microphylla	common eutaxia	perennial								1
Exocarpos aphyllus	leafless cherry	perennial				1	2	7		6
Frankenia serpyllifolia	thyme sea-heath	perennial	15							66
Frankenia sp.	sea-heath	perennial			1					
Geijera linearifolia	sheep bush	perennial	1			18	2	5.5		7.5
Gonocarpus sp.	raspwort	perennial							2.5	
Goodenia sp.	goodenia	perennial		0.5						
Goodenia varia	sticky goodenia	perennial				2.5		15.5		
Gramineae sp.	grass family	perennial			2.5	0.5	15	0.5		
Gunniopsis calcarea		perennial	3					3.5		
Hemichroa diandra	mallee hemichroa	perennial				1				16
Lawrencia squamata	thorny lawrencia	perennial	1			3.5		16		15.5

Table 30 continued

Plant species	Common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Lepidium phlebopetalum	veined peppercress	annual			0.5				2.5	
Lepidium sp.	peppercress	annual					0.5			
Leucochrysum fitzgibbonii	Fitzgibbon's daisy	annual			0.5				20	
Leucophyta brownii	coast cushion bush	perennial								15
Lomandra effusa	scented mat-rush	perennial								0.5
Lycium australe	Australian boxthorn	perennial	51.5	38		1			2	1
Lysiana exocarpi ssp. exocarpi	harlequin mistletoe	perennial	0.5	1		7.5	2.5		0.5	2.5
Lysiana murrayi	mulga mistletoe	perennial							6	
Maireana erioclada	rosy bluebush	perennial	16		1					
Maireana oppositifolia	salt bluebush	perennial				1				49
Maireana pentatropis	erect mallee bluebush	perennial	1		3.5	6	23	4	5	19
Maireana sedifolia	bluebush	perennial	78	1	57	4.5		18	2.5	
Maireana sp.	bluebush/fissure-plant	perennial	5	15	16			2		1
Maireana turbinata	top-fruit bluebush	perennial			1					
Malva preissiana	Australian hollyhock	perennial	2.5							
Melaleuca lanceolata	dryland tea-tree	perennial								37.5
Melaleuca pauperiflora ssp. mutica	boree	perennial				20		49.5		
Melaleuca quadrifaria	limestone honey-myrtle	perennial						1		
Myoporum insulare	common boobialla	perennial								2.5
Myoporum platycarpum ssp. platycarpum	false sandalwood	perennial	4		1		1			7
Nicotiana goodspeedii	small-flower tobacco	annual	5			3		0.5	2.5	0.5
Nicotiana velutina	velvet tobacco	annual							2.5	
Nitraria billardierei	nitre-bush	perennial	2.5			2		4		19
Olearia exiguifolia	lobed-leaf daisy-bush	perennial				1.5		16		
Olearia muelleri	Mueller's daisy-bush	perennial				1		2		17
Omphalolappula concava	burr stickseed	annual	2.5		0.5					
Osteocarpum salsuginosum	inland bonefruit	perennial	5.5					1		
Oxalis perennans	native sorrel	perennial	0.5					1		
Paractaenum refractum	bristle-brush grass	annual							2.5	
Parietaria debilis (NC)	smooth-nettle	annual	2.5							
Pelargonium sp.	storks-bill	perennial						0.5		
Pittosporum angustifolium	native apricot	perennial	1.5	3.5	1	0.5	6.5	4	30	6
Plantago drummondii	dark plantain	annual			0.5					
Podolepis canescens	grey copper-wire daisy	annual						0.5		2.5
Podolepis capillaris	wiry podolepis	annual							1	
Pomaderris forrestiana		perennial						16.5		
Ptilotus obovatus		perennial						0.5	16	17
Pultenaea elachista	limestone bush-pea	perennial						0.5		
Rhagodia crassifolia	fleshy saltbush	perennial		0.5		1.5	5.5	36		19.5
Rhagodia preissii ssp. preissii	mallee saltbush	perennial							1	
Rhagodia spinescens	spiny saltbush	perennial	0.5	38	18	1	21		15	0.5
Rhagodia ulicina	intricate saltbush	perennial	2					17		
Rhodanthe floribunda	white everlasting	annual		2.5						
Rhodanthe haigii	Haig's everlasting	annual			0.5					
Sagina maritima	sea pearlwort	annual	2.5							
Salsola tragus	buckbush	annual	3.5	8	4	18.5		2	23	4.5
Santalum acuminatum	quandong	perennial			3	6	3	4.5		
Santalum lanceolatum	plumbush	perennial							15	
Santalum spicatum	sandalwood	perennial					1		15	
Sarcozona praecox	sarcozona	perennial						0.5		
Scaevola spinescens	spiny fanflower	perennial		0.5	1			16.5		2
Sclerolaena brevifolia	small-leaf bindyi	perennial	2							
Sclerolaena diacantha	grey bindyi	perennial				0.5		4	18	92.5
Sclerolaena obliquicuspis	oblique-spined bindyi	perennial	6.5	25.5	21		20	0.5		5
Sclerolaena patenticuspis	spear-fruit bindyi	perennial				18.5		37.5		1
Sclerolaena uniflora	small-spine bindyi	perennial						1	17.5	

Table 30 continued

Plant species	Common name	Life Span	CA	HU	IF	KD	KO	ME	MU	YA
Senecio glossanthus (NC)	annual groundsel	annual						2.5		
Senecio pinnatifolius group	variable groundsel	annual			0.5	2.5	2.5	2.5		7.5
Senna artemisioides ssp. filifolia	fine-leaf desert senna	perennial						1		
Senna artemisioides ssp. X coriacea	broad-leaf desert senna	perennial	1							1
Setaria constricta	knotty-butt paspalidium	perennial							2.5	
Sida sp.	sida	perennial							5	
Sida spodochroma		perennial							3.5	
Solanum coactiliferum	tomato-bush	perennial							1	
Solanum ellipticum	velvet potato-bush	perennial							3.5	
Sonchus sp.	sow-thistle	annual					2.5			
Stenopetalum lineare	narrow thread-petal	annual			0.5					
Swainsona oliveri		annual			0.5					
Swainsona oroboides complex	variable swainson-pea	annual		0.5						
Tecticornia disarticulata		perennial	111			17	83.5	15		
Tecticornia sp.	samphire	perennial	1							15.5
Templetonia retusa	cockies tongue	perennial						4		0.5
Tetragonia eremaea	desert spinach	annual			0.5			2.5		
Tetragonia implexicoma	bower spinach	perennial				2		2		4
Threlkeldia diffusa	coast bonefruit	perennial				4	17.5			39.5
Threlkeldia sp.	bonefruit	perennial	44			40				
Trichanthodium skirrophorum	woolly yellow-heads	annual			3	19	3.5			
Trichodesma zeylanicum var. zeylanicum	camel bush	perennial							2.5	
Triodia irritans	spinifex	perennial								15
Velleia sp.	Velleia	annual			0.5					
Vittadinia nullarborensis	Nullarbor New Holland daisy	annual		0.5						
Vittadinia sp.	New Holland daisy	annual			0.5					
Westringia rigida	stiff westringia	perennial				1.5		18		17
Zygophyllum compressum	rabbit-ears twinleaf	annual								15
Zygophyllum sp.	twinleaf	perennial			2		3	0.5	7.5	2.5
**Anagallis arvensis*	pimpernel	annual						0.5		
**Arctotheca populifolia*	beach daisy	perennial								1
**Brassica tournefortii*	wild turnip	annual			0.5					
**Carrichtera annua*	ward's weed	annual	1	10	5	75.5				2.5
**Centaurea melitensis*	Malta thistle	annual	3							1.5
**Erodium moschatum*	musky herons-bill	annual			0.5					
**Lagurus ovatus*	hare's tail grass	annual	0.5							
**Lycium ferocissimum*	African boxthorn	perennial								0.5
**Mesembryanthemum crystallinum*	common iceplant	annual								0.5
**Plantago lanceolata var. lanceolata*	ribwort	perennial	14							1
**Rostraria pumila*	tiny bristle-grass	annual			0.5					
**Schismus barbatus*	Arabian grass	annual								10
**Sisymbrium erysimoides*	smooth mustard	annual		2.5						
**Sisymbrium sp.*	wild mustard	annual	0.5			0.5	2.5			7.5
**Solanum nigrum*	black nightshade	perennial	2.5					0.5		
**Sonchus oleraceus*	common sow-thistle	annual	2.5		0.5			1		1
**Vulpia bromoides*	squirrel-tail fescue	annual								0.5

Government of South Australia
Department of Environment, Water and Natural Resources

Table 31 2012 species list of birds, with the number of individuals recorded at each camp – incl. total opportunistic records (OPP. RECORD)

BIRD TAXA	COMMON NAME	CA	HU	IF	KD	KO	ME	MU	YA	OPP.RECORD	Total per taxa
Acanthagenys rufogularis	spiny-cheeked honeyeater			11	20	123	110		5	41	310
Acanthiza apicalis	inland thornbill			18	23	10	81	9	17	1	159
Acanthiza chrysorrhoa	yellow-rumped thornbill	2		23	176	17		6	24	9	257
Acanthiza iredalei	slender-billed thornbill	60	20	51			67	7		22	227
Acanthiza iredalei iredalei	slender-billed thornbill (western sp)									1	1
Acanthiza sp.						2					2
Acanthiza uropygialis	chestnut-rumped thornbill			29		7	3	90	4	18	151
Aegotheles cristatus	Australian owlet-nightjar					2				2	4
Amytornis textilis	thick-billed grasswren		2								2
Anthochaera carunculata	red wattlebird						44		41	43	128
Anthochaera chrysoptera	little wattlebird								8		8
Anthus australis	Australian pipit	30	49	1	141	14	26	3	38	31	333
Aphelocephala leucopsis	southern whiteface	52		24	14	25	39	142		19	315
Aphelocephala sp.							2				2
Aquila audax	wedge-tailed eagle		1		2		1	2		16	22
Ardeotis australis	Australian bustard									2	2
Artamus cinereus	black-faced woodswallow	12	46	44	10	14	30	32		24	212
Artamus cyanopterus	dusky woodswallow			1		28			67	37	133
Barnardius zonarius	Australian ringneck			3	10	23	12		41	21	110
Cacatua leadbeateri	major Mitchell's cockatoo						2			113	115
Cacomantis flabelliformis	fan-tailed cuckoo									1	1
Cacomantis pallidus	pallid cuckoo				1						1
Calamanthus campestris	rufous fieldwren	99	30	17	11	1	15		9	59	241
Calamanthus cautus	shy heathwren								13	4	17
Charadrius australis	inland dotterel		3		3						6
Cheramoeca leucosterna	white-backed swallow									2	2
Cinclosoma castaneothorax	chestnut-breasted quailthrush								2		2
Cinclosoma castanotum	chestnut quailthrush						2	15	5	3	25
Cinclosoma cinnamomeum	cinnamon quailthrush						2				2
Cinclosoma cinnamomeum alisteri	Nullarbor quail-thrush	75	14	6	4		5	9		42	155
Circus approximans	swamp harrier								2		2
Circus assimilis	spotted harrier							1		1	2
Climacteris rufus	rufous treecreeper								8		8
Colluricincla harmonica	grey shrikethrush			5	14	14	10	3	11	18	75
Coracina maxima	ground cuckooshrike									11	11
Coracina novaehollandiae	black-faced cuckooshrike							1			1
Corvus bennetti	little crow					1		1		7	9
Corvus coronoides	Australian raven	7			29	4	35		4	52	131
Corvus sp.						2				4	6
Coturnix pectoralis	stubble quail		1		6				1	1	9
Coturnix ypsilophora	brown quail		1								1
Cracticus torquatus	grey butcherbird			5	14	8	15	8	25	48	123
Daphoenositta chrysoptera	varied sittella			11		25		22	44	9	111
Dicaeum hirundinaceum	mistletoebird					2				1	3
Elanus axillaris	black-shouldered kite									1	1
Elanus sp.									3		3
Eolophus roseicapilla	galah				4	8				14	26
Falco berigora	brown falcon	4	7	4	6	3	3	8	6	10	51
Falco cenchroides	nankeen kestrel	4	6	1	4	2	1			26	44
Falco peregrinus	peregrine falcon						1				1
Gavicalis virescens	singing honeyeater	1	15	45	28	153	96	32	15	69	454

Table 31 continued

BIRD TAXA	COMMON NAME	CA	HU	IF	KD	KO	ME	MU	YA	OPP.RECORD	Total per taxa
Glossopsitta porphyrocephala	purple-crowned lorikeet								27	12	39
Gymnorhina tibicen	Australian magpie	2		1	10		7	2	23	41	86
Hirundo neoxena	welcome swallow	9		8	66	3	15		33	8	142
Lichenostomus cratitius	purple-gaped honeyeater				1						1
Lichmera indistincta	brown honeyeater						2				2
Malurus lamberti	variegated fairywren		1	10	9	4		38		9	71
Malurus leucopterus	white-winged fairywren	116	95	63	33	8	28		8	81	432
Malurus pulcherrimus	blue-breasted fairywren						18		10		28
Malurus sp.						21	24			1	46
Malurus splendens	splendid fairywren			8				37			45
Manorina flavigula	yellow-throated miner			224	124	82	276	37	124	82	949
Melanodryas cucullata	hooded robin			16		51		44		3	114
Melanodryas vittata	dusky robin							14			14
Melithreptus brevirostris	brown-headed honeyeater					11			6	1	18
Microeca fascinans	jacky winter			7		1		7	2	2	19
Myiagra inquieta	restless flycatcher					6			1	3	10
Nesoptilotis leucotis	white-eared honeyeater			1		1	3			1	6
Ninox boobook	southern boobook									2	2
Ninox sp.										1	1
Northiella haematogaster	bluebonnet				13	4	5	8		2	32
Oreoica gutturalis	crested bellbird			5	4	6		9		4	28
Pachycephala inornata	Gilbert's whistler					6					6
Pardalotus punctatus	spotted pardalote						3		1	2	6
Pardalotus striatus	striated pardalote			3			27		21	2	53
Pedionomus torquatus	plains-wanderer	1									1
Petrochelidon nigricans	tree martin			16	1	84			18	8	127
Petroica goodenovii	red-capped robin		1	10	1	1				1	14
Phaps chalcoptera	common bronzewing							1		1	2
Phaps elegans	brush bronzewing						1				1
Podargus strigoides	tawny frogmouth						1		2		3
Pomatostomus superciliosus	white-browed babbler			55	209	58	35	162	69	38	626
Psephotus varius	mulga parrot	1	38	21	2	16	11	44	11	8	152
Ptilotula ornata	yellow-plumed honeyeater			21		46			138	8	213
Purnella albifrons	white-fronted honeyeater			4	2	38	134		3	17	198
Pyrrholaemus brunneus	redthroat						34				34
Rhipidura albiscapa	grey fantail		1								1
Rhipidura leucophrys	willie wagtail	12	6	11	6	8	18	18	14	26	119
Sericornis frontalis	white-browed scrubwren				83	2	89		27	8	209
Sericornis sp.							4				4
Smicrornis brevirostris	weebill			58		4	9		20	5	96
Strepera versicolor	grey currawong						1		10	12	23
Zosterops lateralis	silvereye				36		65		15	31	147
Zosterops sp.							47			17	64
	Total per Camp	**487**	**337**	**841**	**1120**	**949**	**1459**	**812**	**976**	**1220**	**8201**

Table 32 1984 species list of birds, with the number of individuals recorded at each camp – incl. total opportunistic records (OPP. RECORD)

SPECIES	COMNAME1	CA	HU	IF	KD	KO	ME	MU	YA	OPP.RECORD	Grand Total
Acanthagenys rufogularis	spiny-cheeked honeyeater				32	14	20	2	56	12	136
Acanthiza apicalis	inland thornbill				16	16	212		28	16	288
Acanthiza chrysorrhoa	yellow-rumped thornbill	6		4	16	22			44	6	98
Acanthiza iredalei	slender-billed thornbill			12		2					14
Acanthiza iredalei iredalei	slender-billed thornbill (western ssp)	145	6							8	159
Acanthiza sp.									4		4
Acanthiza uropygialis	chestnut-rumped thornbill					2		12		12	26
Accipiter fasciatus	brown goshawk		2		2				2		6
Aegotheles cristatus	Australian owlet-nightjar									6	6
Anthochaera carunculata	red wattlebird				4				70	20	94
Anthus australis	Australian pipit	69	40	31	26	2	8	18	32	34	260
Aphelocephala leucopsis	southern whiteface	45		8		24		30		12	119
Aquila audax	wedge-tailed eagle	2	8	1	4			20	9		44
Artamus cinereus	black-faced woodswallow	51	18	10	16	4		70		6	175
Artamus cyanopterus	dusky woodswallow								92	6	98
Artamus minor	little woodswallow					4					4
Barnardius zonarius	Australian ringneck					10			10	14	34
Cacatua galerita	sulphur-crested cockatoo									2	2
Cacatua leadbeateri	major mitchell's cockatoo					14			60	2	76
Cacomantis flabelliformis	fan-tailed cuckoo									2	2
Cacomantis pallidus	pallid cuckoo			6				20		14	40
Calamanthus campestris	rufous fieldwren	6			2					38	46
Calamanthus cautus	shy heathwren								4		4
Calamanthus sp.										1	1
Chalcites osculans	black-eared cuckoo								2	2	4
Cheramoeca leucosterna	white-backed swallow			4	4			10		4	22
Cinclosoma castanotum	chestnut quailthrush						6	4	2		12
Cinclosoma cinnamomeum alisteri	Nullarbor quail-thrush	2	4								6
Circus assimilis	spotted harrier									1	1
Climacteris rufus	rufous treecreeper								6		6
Colluricincla harmonica	grey shrikethrush			4	6	8	10	12	30	16	86
Coracina novaehollandiae	black-faced cuckooshrike	2							12		14
Corvus bennetti	little crow	6	4					24		19	53
Corvus coronoides	Australian raven		12				4		4	15	35
Corvus sp.		14	36	2	20	6	12		14	12	116
Coturnix pectoralis	stubble quail								2		2
Cracticus torquatus	grey butcherbird	2			6	8	22	6	32	44	120
Daphoenositta chrysoptera	varied sittella			12		2			20	2	36
Dromaius novaehollandiae	emu									4	4
Eolophus roseicapilla	galah							80			80
Epthianura albifrons	white-fronted chat					2			4		6
Epthianura aurifrons	orange chat		6								6
Falco berigora	brown falcon	2		1		2		10		4	19
Falco cenchroides	nankeen kestrel		8	2	2	2	2	4	2	2	24
Gavicalis virescens	singing honeyeater		16		24	32	24	12	18	17	143
Gymnorhina tibicen	Australian magpie							4	22	4	30
Hieraaetus morphnoides	little eagle		2								2
Hirundo neoxena	welcome swallow	19		10	20	2	6			2	59
Malurus lamberti	variegated fairywren						12			14	26
Malurus leucopterus	white-winged fairywren	46	62	3						2	113
Malurus pulcherrimus	blue-breasted fairywren				16						16
Manorina flavigula	yellow-throated miner	2		12	122	4	90	28	226	38	522

Table 32 continued

BIRD TAXA	COMMON NAME	CA	HU	IF	KD	KO	ME	MU	YA	OPP.RECORD	Total per taxa
Melanodryas cucullata	hooded robin					22		20			42
Microeca fascinans	jacky winter								14	4	18
Nesoptilotis leucotis	white-eared honeyeater								24		24
Ninox boobook	southern boobook								2		2
Northiella haematogaster	bluebonnet									6	6
Oreoica gutturalis	crested bellbird			2	4	12		6		12	36
Pachycephala pectoralis	golden whistler								14	4	18
Pachycephala rufiventris	rufous whistler									4	4
Pardalotus punctatus	spotted pardalote								40	42	82
Pardalotus striatus	striated pardalote			4		2			80	4	90
Petrochelidon nigricans	tree martin					76			14	20	110
Petroica goodenovii	red-capped robin	1	2	2		8		2	4	6	25
Phaps chalcoptera	common bronzewing					2					2
Podargus strigoides	tawny frogmouth					6			12		18
Pomatostomus superciliosus	white-browed babbler	14			12	74	56	38	28	58	280
Psephotus varius	mulga parrot			14		28	32	44	14	30	162
Ptilotula ornata	yellow-plumed honeyeater					2			68		70
Ptilotula plumula	grey-fronted honeyeater							2			2
Purnella albifrons	white-fronted honeyeater				6	4	6		70	6	92
Pyrrholaemus brunneus	redthroat				4		190			24	218
Rhipidura leucophrys	willie wagtail	3			4	10		14	10	6	47
Sericornis frontalis	white-browed scrubwren				22		58		66	24	170
Smicrornis brevirostris	weebill					26	52		80	54	212
Stiltia isabella	Australian pratincole		8								8
Strepera versicolor	grey currawong								2	20	22
Taeniopygia guttata	zebra finch									4	4
Zosterops lateralis	silvereye				8		28		30	2	68
	Total per camp	**437**	**234**	**144**	**398**	**454**	**850**	**492**	**1379**	**743**	**5131**

Table 33 2012 species list of mammals, with the number of individuals recorded at each camp – incl. total opportunistic records (OPP. RECORD)

MAMMAL TAXA	COMMON NAME	CA	HU	IF	KD	KO	ME	MU	YA	OPP.RECORD	total per taxa
**Camelus dromedarius*	one-humped camel									72	72
**Canis lupus*	feral dog, dingo									5	5
**Canis lupus dingo*	dingo									34	34
**Canis lupus familiaris*	feral dog									13	13
**Canis sp.*										2	2
Cercartetus concinnus	western pygmy-possum			2			8		8		18
Cercartetus sp.							1				1
Chalinolobus morio	chocolate wattled bat									2	2
**Felis catus*	cat (feral cat)									14	14
Lasiorhinus latifrons	southern hairy-nosed wombat									37	37
Macropus fuliginosus	western grey kangaroo									2	2
Macropus sp.										55	55
**Mus musculus*	house mouse	133	407	100	153	131	33	153	74	8	1192
Notomys alexis	spinifex hopping-mouse							58		5	63
Notomys mitchellii	Mitchell's hopping-mouse			1			2				3
Notomys sp.										1	1
Nyctophilus geoffroyi	lesser long-eared bat									2	2
**Oryctolagus cuniculus*	rabbit (European rabbit)									169	169
Pseudomys hermannsburgensis	sandy inland mouse			3	1	1	1	29	1	5	41
Sminthopsis crassicaudata	fat-tailed dunnart		2	1		2					5
Sminthopsis dolichura	little long-tailed dunnart						1		2		3
Sminthopsis ooldea	Ooldea dunnart							20		1	21
Tachyglossus aculeatus	short-beaked echidna									3	3
Tadarida australis	white-striped freetail-bat									1	1
Vespadelus baverstocki	inland forest bat									1	1
**Vulpes vulpes*	fox (red fox)									23	23
	total per camp	**133**	**409**	**107**	**154**	**134**	**46**	**260**	**85**	**455**	**1783**

Table 34 1984 species list of mammals, with the number of individuals recorded at each camp – incl. total opportunistic records (OPP. RECORD)

Mammal taxa	Common name	CA	HU	IF	KD	KO	ME	MU	YA	opp. record	total per taxa
**Camelus dromedarius*	one-humped camel									10	10
**Canis lupus dingo*	dingo									17	17
Chalinolobus gouldii	Gould’s wattled bat									3	3
Chalinolobus morio	chocolate wattled bat									4	4
**Felis catus*	cat (feral cat)									9	9
Lasiorhinus latifrons	southern hairy-nosed wombat									18	18
Leporillus sp.										1	1
Macropus fuliginosus	western grey kangaroo									33	33
Macropus rufus	red kangaroo									30	30
Macropus sp.										11	11
**Mus musculus*	house mouse	2	13	12	19	34	4	35	28	3	150
Notomys mitchellii	Mitchell’s hopping-mouse						5				5
Nyctophilus geoffroyi	lesser long-eared bat									1	1
Nyctophilus major	central long-eared bat									2	2
**Oryctolagus cuniculus*	rabbit (European rabbit)									51	51
Pseudomys hermannsburgensis	sandy inland mouse							1			1
Sminthopsis crassicaudata	fat-tailed dunnart		1	2		1	1				5
Sminthopsis dolichura	little long-tailed dunnart			2			1				3
Tachyglossus aculeatus	short-beaked echidna									2	2
Tadarida australis	white-striped freetail-bat									4	4
Vespadelus regulus	southern forest bat									7	7
**Vulpes vulpes*	fox (red fox)									16	16
	total per camp	**2**	**14**	**16**	**19**	**35**	**11**	**36**	**28**	**222**	**383**

Table 35 2012 species list of reptiles, with the number of individuals recorded at each camp – incl. total opportunistic records (OPP. RECORD)

Reptile taxa	Common name	CA	HU	IF	KD	KO	ME	MU	YA	opp. record	total per taxa
Amphibolurus norrisi	mallee tree-dragon						1			1	2
Aprasia sp.										1	1
Christinus alexanderi	Nullarbor marbled gecko				2					1	3
Christinus marmoratus	marbled gecko	1			1					3	5
Cryptoblepharus australis	desert wall skink								2	1	3
Ctenophorus chapmani	prickly dragon								2		2
Ctenophorus cristatus	crested dragon									4	4
Ctenophorus maculatus	spotted dragon						3			1	4
Ctenophorus mckenziei	McKenzie's dragon					3					3
Ctenophorus pictus	painted dragon	9		5	21	7	1		8	16	67
Ctenotus euclae	bight coast ctenotus								9		9
Ctenotus orientalis	spotted ctenotus	6		2	5	4				2	19
Ctenotus regius	eastern desert ctenotus			2				19		1	22
Ctenotus schomburgkii	sandplain ctenotus		27	29		11	5	11		11	94
Delma australis	barred snake-lizard								1		1
Delma sp.										1	1
Diplodactylus calcicolus	south coast gecko	5	4		5	3	2		4	2	25
Drysdalia mastersii	master's snake				1				3		4
Eremiascincus fasciolatus	narrow-banded sandswimmer							1			1
Gehyra lazelli	southern rock dtella					1					1
Gehyra variegata	tree dtella									1	1
Hemiergis initialis	western earless skink									3	3
Heteronotia binoei	Bynoe's gecko								2	1	3
Lerista baynesi	speckled slider									1	1
Lerista dorsalis	southern four-toed slider	2		1	4		1			7	15
Lerista edwardsae	myall slider					1			3	5	9
Lerista labialis	eastern two-toed slider							3			3
Lerista terdigitata	southern three-toed slider									1	1
Lerista timida	dwarf three-toed slider			1						1	2
Liopholis inornata	desert skink							1			1
Liopholis multiscutata	bull skink						1			1	2
Lucasium damaeum	beaded gecko			7						1	8
Menetia greyii	dwarf skink	1	6	2	4		4	9	1	7	34
Morethia adelaidensis	Adelaide snake-eye	1		1	1	4			1		8
Morethia obscura	mallee snake-eye				6	1	3		1	6	17
Nephrurus levis	smooth knob-tailed gecko							1			1
Nephrurus milii	barking gecko	12	6	1	12			1	2	1	35
Parasuta spectabilis	mallee black-headed snake	1							1		2
Pogona minor	dwarf bearded dragon									1	1
Pogona nullarbor	Nullarbor bearded dragon		1							1	2
Pseudechis australis	mulga snake									2	2
Pseudonaja affinis	dugite									3	3
Pseudonaja inframacula	peninsula brown snake	1									1
Pseudonaja modesta	five-ringed snake									1	1
Pseudonaja sp.										1	1
Pygopus lepidopodus	common scaly-foot						1				1
Simoselaps bertholdi	desert banded snake					1					1
Tiliqua occipitalis	western bluetongue	1	1								2
Tiliqua rugosa	sleepy lizard		2						2	13	17
Tympanocryptis houstoni	Nullarbor earless dragon	9	3	2	3	3				2	22
Varanus gouldii	sand goanna									3	3
	total per camp	**49**	**50**	**53**	**65**	**39**	**22**	**46**	**42**	**108**	**474**

Table 36 1984 species list of reptiles, with the number of individuals recorded at each camp – incl. total opportunistic records (OPP. RECORD)

Reptile taxa	Common name	CA	HU	IF	KD	KO	ME	MU	YA	opp. record	total per taxa
Amphibolurus norrisi	mallee tree-dragon									4	4
Christinus marmoratus	marbled gecko									2	2
Ctenophorus chapmani	prickly dragon						2		1	1	4
Ctenophorus fordi	mallee dragon							12		4	16
Ctenophorus mckenziei	McKenzie's dragon					2					2
Ctenophorus nuchalis	central netted dragon									2	2
Ctenophorus pictus	painted dragon				4	10			8	12	34
Ctenophorus reticulatus	western netted dragon							4			4
Ctenotus euclae	bight coast ctenotus								1	1	2
Ctenotus orientalis	spotted ctenotus									4	4
Ctenotus regius	eastern desert ctenotus							12		2	14
Ctenotus schomburgkii	sandplain ctenotus			2		18		4		2	26
Ctenotus sp.							2			2	4
Diplodactylus calcicolus	south coast gecko			2						12	14
Diplodactylus pulcher	patchwork gecko							2			2
Diplodactylus vittatus complex (NC)	stone geckos					4				2	6
Drysdalia mastersii	master's snake						2			2	4
Eremiascincus richardsonii	broad-banded sandswimmer							2			2
Gehyra lazelli	southern rock dtella									2	2
Gehyra variegata	tree dtella					6		22		16	44
Hemiergis initialis	western earless skink									4	4
Heteronotia binoei	Bynoe's gecko					2		4	2		8
Lerista arenicola	beach slider									2	2
Lerista baynesi	speckled slider						2				2
Lerista dorsalis	southern four-toed slider				2					2	4
Lerista edwardsae	myall slider									1	1
Lerista labialis	eastern two-toed slider							6			6
Liopholis inornata	desert skink							2			2
Lucasium damaeum	beaded gecko			12				2		2	16
Menetia greyii	dwarf skink	2				6	2	8	1	10	29
Morethia adelaidensis	Adelaide snake-eye	4		2		14			2	10	32
Morethia obscura	mallee snake-eye									11	11
Nephrurus laevissimus	pale knob-tailed gecko							6		24	30
Nephrurus levis	smooth knob-tailed gecko							2		4	6
Nephrurus milii	barking gecko	2	8		6	12	4	8	2	19	61
Nephrurus stellatus	starred knob-tailed gecko			2					8		10
Pogona minor	dwarf bearded dragon					2		4	4	2	12
Pogona nullarbor	Nullarbor bearded dragon									2	2
Pseudonaja inframacula	peninsula brown snake									4	4
Pseudonaja sp.		2								2	4
Pygopus lepidopodus	common scaly-foot								3		3
rhynchoedura ornata	beaked gecko							6			6
Strophurus intermedius	southern spiny-tailed gecko									2	2
Tiliqua occipitalis	western bluetongue							2		2	4
Tiliqua rugosa	sleepy lizard	2				12	2		1	52	69
Tympanocryptis houstoni	Nullarbor earless dragon	2			4		2			8	16
Varanus gilleni	pygmy mulga goanna									4	4
Varanus gouldii	sand goanna							2		12	14
Varanus sp.	goanna									2	2
	total per camp	**14**	**8**	**20**	**16**	**88**	**18**	**110**	**33**	**251**	**558**

APPENDIX C

Table 37 Photopoint survey results for

Site	Trend Period	Trend Summary
CA00101	Apr 84 to Nov 01	Maintenance of saltbush and samphire populations with fluctuations in bush size Thinning crowns of trees at rear
CA00201	Apr 84 to Nov 01	Maintenance of Bluebush population/cover Decline of Dark green low shrub Decline of crown in trees at rear
CA00301	Apr 84 to Nov 01	Maintenance of saltbush and samphire populations with fluctuations in bush size
CA00401	Apr 84 to Nov 01	Maintenance of saltbush and samphire populations with fluctuations in bush size
CA00501	Apr 84 to Nov 01	Increasing bladder saltbush presence on annuals dominated plain
KO00101	Apr 84 to Oct 87	Stable Myall over saltbush and samphire
KO00201	Apr 84 to Oct 87	Decreasing saltbush abundance Tree crowns stable
KO00301	Apr 84 to Oct 87	Stable Eucalypt/Cratystylis community
KO00401	Apr 84 to Oct 87	Stable Myall/Cratystylis/Saltbush Saltbush population turnover since 1984 Thinning western myall crowns
KO00501	Apr 84 to Oct 87	Stable Mallee/Cratystylis/Saltbush system
HU00101	Apr 84 to May 02	Increased Atriplex vesicaria since Jul 1985, from a few plants only
HU00201	Apr 84 to May 02	Stable saltbush low open shrubland with increase in saltbush abundance (size,cover)
HU00301	Apr 84 to May 02	Growth of Eremophila longifolia Increased abundance of ?Chenopodium nitrariaecum?
HU00401	Apr 84 to May 02	Herbland annual grassland maintained
HU00501	Apr 84 to May 02	Maintained Erem longifolia grove in Herbland/Annual Grassland Plain; some fluctuation in E longifolia crown density
IF00101	Apr 84 to Nov 01	Stable Chenopod Shrubland Apr84 to Jul85
IF00201	Apr 84 to Nov 01	Stable Bluebush shrubland Apr84 to Jul85
IF00301	Apr 84 to Jul 85	Myall/Bluebush
IF00401	Apr 84 to Jul 85	Mallee: Shrub growth
IF00501	Apr 84 to Jul 85	Myall/?Declining saltbush?
KD00101	Apr 84 to Nov 01	Stable shrubland
KD00201	Apr 84 to Nov 01	Stable low mallee/Cratystylis; Craty smaller, mallee larger in 2001; rear Craty more evident in 2001
KD00301	Apr 84 to Nov 01	Stable low mallee/saltbush; saltbush may be increasing in density; fluctuation in crown density
KD00401	Apr 84 to Nov 01	Stable Chenopod Shrubland; possible abundance increase to M. pyr.
KD00501	Apr 84 to Aug 85	Stable
ME00101	Apr 84 to Nov 01	Stable; some taller shrub decline
ME00201	Apr 84 to Nov 01	Stable; some perennial groundcover increase
ME00301	Apr 84 to Nov 01	Stable? But much growth/decline of shrubs since 1985
ME00401	Apr 84 to Nov 01	Stable with thickening of tall shrub and low shrub cover through size increase
ME00501	Apr 84 to Nov 01	Stable Bluebush; Tree profile at rear has altered markedly
MU00101	Apr 84 to May 02	Stable Mulga/Bluebush; Mulga crowns thinned
MU00201	Apr 84 to May 02	Mulga declining especially, crown foliage density, but marked increase in tall shrub growth (Ac ligulata?)
MU00301	Apr 84 to May 02	Stable Mulga/Ptilotus
MU00401	Apr 84 to May 02	Stable Mulga/Ptilotus
MU00501	Apr 84 to Jul 85	Stable Mallee/Tall shrubs (Dods?) with size increase of tall shrubs
YA00101	Apr 84 to Jul 85	Stable Mallee/Cratystylis
YA00201	Apr 84 to Jul 85	Stable Mallee/Saltbush
YA00301	Apr 84 to Jul 85	Stable Myoporum/Saltbush; some mid-shrub growth
YA00401	Apr 84 to Jul 85	Stable Mallee/Melaleuca/Saltbush
YA00501	Apr 84 to Jul 85	Stable dune shrubs

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