Climatic Discussion Relating to Wetlands and Landscape Condition in southern South Australia

December 2014

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INTRODUCTION

Significant rainfall events promote wetland vigour and expand waterfowl habitat, but most importantly, they stimulate breeding. The Eastern Aerial Waterbird Survey (EAWS) has shown over a succession of years that there is a strong positive correlation between waterfowl abundance, wetland condition and rainfall. Waterfowl have the ability to anticipate climatic changes before their effects are felt, often migrating under the cover of darkness to areas where water is expected. This behaviour is triggered by the need to find productive feeding habitat but also by their instinct to breed if water levels and habitat condition permit.

Waterfowl lead a tenuous existence; their distribution and abundance is controlled by the availability of shallow wetland habitats, often in the interior, which are spatially and temporally highly variable. They must also compete with humankind for water resources that are becoming increasingly regulated and less commonly allocated as environmental flows.

Climatic conditions regulate waterfowl population sizes in an unforgiving and often ruthless manner. Functionally, 'boom and bust' changes in waterfowl abundance correlate with climatic extremes. Were it not for their opportunistic ability to breed, in some cases instantaneously, waterfowl populations would not be able to benefit from the short duration but high productivity of many of Australia’s ephemeral wetland systems.

To appreciate changes to waterfowl population dynamics we must be aware of the likely effects of climate on their activity cycle. This paper examines recent rainfall statistics, discusses similarities between rainfall and wetland condition and compares it with Normalised Difference Vegetation Index (NDVI) satellite images and landscape models which show the density and vigour of green vegetation growth across the Australian continent and more closely within regional South Australia (SA).

Quail lead a nomadic existence; their movements are thought to be dictated by the availability of food resources and ground cover. Anthropogenic activities such as cropping play some role in determining the suitability of habitat for quail. However, true abundance is thought to be regulated by climatic influences and landscape condition.

Quail are difficult subjects to monitor and their behavioural response to dry climatic conditions is not completely understood - other than the vague notion that population densities decrease. This paper uses the Aussie Grass Pasture Model (CSIRO) and crop yield data to explain the condition of natural and anthropogenic landscapes in South Australia.
1. AUSTRALIA - RAINFALL 12 MONTHS TO SEPTEMBER 2014

There has been a mix of rainfall conditions across the Australian continent during the past 12 months. Some western parts of SA received rainfall that was very much above average, with the north-east and south-east of the state receiving very much below average rainfall (Figure 1). With some exceptions, the eastern two thirds of the continent, including the majority of the Murray Darling Basin has experienced average or below average rainfall during the past 12 months.

Figure 1. Australian Rainfall Deciles November 2013-October 2014.

The interannual rainfall anomaly for 2013/14 compared with 2012/13 shows areas of higher rainfall in central and northern Australia and lower rainfall along the eastern and western coastal regions, including the Murray-Darling Basin. In SA, most of the region is +100 or down to -100 mm difference apart from Kangaroo Island and parts of the South East which are -200 mm (Figure 2).
The Murray-Darling Basin (Figures 3, 4, and 5) is a region supporting many aquatic ecosystems and is an important region for waterfowl recruitment. The Murray-Darling Basin experienced widespread dry conditions with some areas in north-eastern NSW, southern QLD, southern Victoria, the South East, Adelaide and Mt Lofty Ranges, and north-eastern parts of SA declared to be in drought or partial drought conditions for several months. The rainfall history in the Murray-Darling Basin over the past 12 months shows below average rainfall across the basin (Figures 3, 4, and 5).
Figure 3. Murray-Darling Rainfall Deciles (November 2013-October 2014).

Murray-Darling Rainfall Deciles 1 November 2013 to 31 October 2014
Distribution Based on Gridded Data
Australian Bureau of Meteorology

Figure 4. Murray-Darling Basin Annual Rainfall Anomaly.

Rainfall Anomalies (mm) 1 November 2013 to 31 October 2014
Australian Bureau of Meteorology
Figure 5. Murray-Darling Basin Rainfall Deficiencies November 2013 to October 2014.

Murray-Darling Rainfall Deficiencies 1 November 2013 to 31 October 2014

Distribution Based on Gridded Data
Australian Bureau of Meteorology

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Issued: 21/11/2014
2. SOUTH AUSTRALIA - Rainfall November 2013 to October 2014.

South Australia has experienced widespread below average rainfall for the 12 months to September 2014 (Figure 6). The inter-annual difference between 2013/14 and 2012/13 (Figure 7) reveals a decline in total rainfall across Kangaroo Island and the south-east of the state which also experienced drought conditions.

Figure 6. South Australia Rainfall Anomalies

Rainfall Anomalies (mm) 1 November 2013 to 31 October 2014
Australian Bureau of Meteorology
2.1 Rainfall within the Four Southern Districts of South Australia

Table 1. Rainfall summary of the four southern districts used in the annual South Australian waterfowl survey (from November 2013 to October 2014).

<table>
<thead>
<tr>
<th>District</th>
<th>Rainfall total (mm)</th>
<th>Rainfall anomaly (mm above average)</th>
<th>Rainfall % (% of mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleurieu</td>
<td>300 to 600</td>
<td>-200 to 0</td>
<td>60 to 100</td>
</tr>
<tr>
<td>Murraylands</td>
<td>50 to 400</td>
<td>-200 to 0</td>
<td>20 to 80</td>
</tr>
<tr>
<td>Coorong</td>
<td>300 to 400</td>
<td>-200 to 0</td>
<td>60 to 100</td>
</tr>
<tr>
<td>Southeast</td>
<td>200 to 600</td>
<td>-400 to -100</td>
<td>40 to 80</td>
</tr>
</tbody>
</table>

FLEURIEU
The Fleurieu Peninsula supports a mosaic of small water storages, farm dams and spring fed wetlands across a highly fragmented landscape. Some storages are artificially maintained at high capacity and others are surcharged from the River Murray. Overall, the district was below average for the 12 months to October 2014 relative to the long-term average for the region (see Table 1; Figure 7).
MURRAYLANDS
Rainfall conditions varied over the past 12 months in sections of the region (see Table 1; Figure 7). Wetland status has improved with local inflows contributing to improved cross-border River Murray inflows and environmental watering over the past two years.

COORONG
The Coorong region contains a significant number of large and small mostly shallow wetlands and watercourses that become seasonally inundated each winter. Some of the wetlands are dependent on discharges associated with the drainage scheme throughout the region. Rainfall during 2014 was close to average conditions in some areas, with approximately half of the region below average (see Table 1; Figure 7).

SOUTH EAST
Just over half of the South-East experienced below average rainfall conditions during 2014.
3. VICTORIA

Victoria’s conditions are closely linked to SA for influence regarding landscape and waterfowl abundance and habitat. In 2014 Victoria has had mainly lower than average rainfall across most of the State (0-400 mm below mean). Some coastal areas received above average rainfall conditions (100-200 mm above mean) (Figure 8, 9).

**Figure 8. Victoria Rainfall Anomalies**
Rainfall Anomalies (mm)  1 November 2013 to 31 October 2014
Australian Bureau of Meteorology

**Figure 9. Victoria Rainfall Annual Variation**
Australian Bureau of Meteorology
4. BUREAU OF METEOROLOGY 2014 SUMMARIES

4.1 South Australia in winter 2014: below average rainfall

RAINFALL
Winter 2014 rainfall was generally below average across much of the state, apart from the far north. Rainfall varied throughout June and July between the Pastoral and Agricultural districts. Minimal rainfall was recorded throughout August with dry conditions extending across the Agricultural districts, but a widespread single rainfall event saw almost all the state achieve their highest rainfall for the season which was slightly above average.

PASTORAL DISTRICTS
Rainfall totals for the season were generally below average. Rainfall continued through July for northeast Pastoral areas but a widespread rainfall event over the northeast saw some Pastoral districts receive their most significant rainfall for the season in August.

AGRICULTURAL DISTRICTS
Agricultural areas experienced average to above average June rainfall, with rainfall totals ranging from around 80 mm in the Riverland, 50 to 200 mm in the Western Agricultural and Upper North districts, 100 to 250 mm in the South East, and ranging up to 400 mm in the Mount Lofty ranges. The wettest location overall in the agricultural districts was at Uraidla in the Mount Lofty ranges with a winter rainfall total of 525.4 mm. Cowell received its lowest winter rainfall in 21 years with 43.8 mm.

4.2 2014 – Latest ENSO Summary (Bureau of Meteorology)
Issued on Tuesday 18 November 2014 (Bureau of Meteorology, 2014)

The Pacific Ocean has shown some renewed signs of El Niño development in recent weeks. Above-average temperatures in the tropical Pacific Ocean have warmed further in the past fortnight, while the Southern Oscillation Index (SOI) has generally been in excess of El Niño thresholds for the past three months. Climate models suggest current conditions will either persist or strengthen. These factors indicate at least a 70% chance of El Niño occurring.

Regardless of whether or not El Niño fully develops, warmer-than-average tropical Pacific Ocean temperatures, combined with cooler waters currently to the north of Australia increase the chance of some El Niño-like impacts. For many parts of Australia, this suggests below average rainfall and above average temperatures in the months ahead.

While ENSO is the dominant natural driver of Australia’s climate, a neutral period does not guarantee a benign or normal season. However, more localised weather extremes can and do occur during neutral ENSO phases as secondary or local factors come into play. For instance, warmer-than-average sea surface temperatures around parts of the Australian coastline may currently be influencing
regional climate producing below-average rainfall over the majority of Australia for the rest of 2014.

The Indian Ocean Dipole (IOD) is currently neutral after remaining negative since June. It is expected to remain in neutral for the remainder of 2014. It typically has little influence on Australian climate during the months from December to April.

5 BUREAU OF METEOROLOGY 2014

South Australia in summer 2013-14: Extreme temperatures throughout the season
Issued on 3 March 2014 (Bureau of Meteorology, 2014)
- Record summer daily rainfall totals for several locations around the State
- Sixth warmest summer on record for South Australia as a whole
- Adelaide has a record 13 days reaching 40°C or more, 11 of which reached 42°C or higher
- Adelaide has its wettest day in 45 years and 6th wettest day on record, in mid-February

South Australia in autumn 2014: A warm and wet season across the state
Issued 2 June 2014 (Bureau of Meteorology, 2014)
- Fourth-warmest autumn mean temperatures on record, with daytime and nighttime temperatures together being +1.6°C warmer than average
- Warmest autumn nights on record with nights +1.9°C warmer than average
- Rainfall above average across the state as a whole, the wettest since 2011
- Several locations have their wettest autumn on record for at least 20 years

South Australia in winter 2014: Below average rainfall with cold nights and frosts
Issued September 2014 (Bureau of Meteorology, 2014)
- Wetter than average across much of the State, tending towards drier than average across the north.
- Record highest winter rainfall in some locations across the centre of the State, and on Kangaroo Island.
- Warmer than average winter temperatures, with record warmest winter nights at some locations.
- Second warmest winter for the State as whole.

South Australia in spring 2014: Record warmth across the state
Issued 1 December 2014 (Bureau of Meteorology, 2014)
- Very dry across agricultural districts, with record lowest spring rainfall at several locations.
- Driest October on record for South Australia.
- Warmest spring on record for South Australia.
- 14th driest spring on record for South Australia.
A drier than normal summer is more likely over northern, eastern and central Australia.

For December, a drier than normal month is more likely over the northern half of Australia, with the chances of a wetter or drier December roughly equal over most of the south.

The summer temperature outlooks indicate a warmer than normal season for both days and nights across most of the Australian mainland, except parts of the west and southeast.

Climate influences include El Niño-like conditions in the tropical Pacific Ocean, and average to cooler than average waters surrounding northern Australia.

The chances of exceeding the median rainfall during December 2014 to February 2015 are 25 to 40% over most of Queensland, most of the NT and WA (Figure 10). In other words, the chances of below average rainfall are 60 to 75% over these areas. SA and Victoria are showing a 30 to 45% chance of exceeding the median rainfall during December 2014 to February 2015 (Figure 10).

**CLIMATE INFLUENCES**

The tropical Pacific has remained ENSO-neutral since mid-2012. However, dynamical models surveyed by the Bureau suggest El Niño remains possible during the last quarter of 2014.
The IOD is neutral, and is expected to remain so for the remainder of 2014. Beyond that time, the effect of the IOD on Australian climate from December through to April is limited, and is therefore not an influence in the outlooks during this period. With the main climate influences likely to remain neutral (and hence have lesser impact upon Australia), secondary influences, such as warmer-than-normal sea surface temperatures around Australia are tending to drive the Australian climate patterns.

7 THE SOUTHERN OSCILLATION INDEX (SOI)

The Southern Oscillation Index (SOI) (Figure 11) is calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin.

Sustained positive values of the SOI (above +8) may indicate a La Niña event, while sustained negative values (below −8) may indicate an El Niño event. Positive values are associated with stronger pacific trade winds and warmer sea temperatures to the north of Australia and above normal rainfall across large parts of Australia, most notably eastern and northern regions. Negative values are usually accompanied by sustained warming of the central and eastern tropical Pacific Ocean, a decrease in the strength of the Pacific Trade Winds, and a reduction in rainfall over eastern and northern Australia. Values of between about +8 and −8 generally indicate neutral conditions.

Table 2. Comparison SOI values between 2013 and 2014

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>-1.1</td>
<td>-3.6</td>
<td>11.1</td>
<td>0.3</td>
<td>8.4</td>
<td>13.9</td>
<td>8.1</td>
<td>-0.5</td>
<td>3.9</td>
<td>-1.9</td>
<td>9.2</td>
<td>0.6</td>
</tr>
<tr>
<td>2014</td>
<td>12.2</td>
<td>-1.3</td>
<td>-13.3</td>
<td>8.6</td>
<td>4.4</td>
<td>-1.5</td>
<td>-3.0</td>
<td>-11.4</td>
<td>-7.5</td>
<td>-8.0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 11. Southern Oscillation Index (January 2007 to November 2014). Southern Oscillation Index (SOI)
8. VEGETATION MONITORING PRODUCTS DERIVED FROM NOAA SATELLITE DATA

Normalised Difference Vegetation Index (NDVI) products are produced by the Bureau of Meteorology for the Australian region using measurements from the Advanced Very High Resolution Radiometer (AVHRR) on board the USA’s NOAA polar orbiting meteorological satellites.

The differential reflectances in these bands provide a means of monitoring density and vigour of green vegetation growth using the spectral reflectivity of solar radiation. Green leaves commonly have larger reflectances in the near infrared than in the visible range. As the leaves come under water stress, become diseased or die back, they become more yellow and reflect significantly less in the near infrared range. Clouds, water, and snow have larger reflectances in the visible than in the near infrared while the difference is almost zero for rock and bare soil. Vegetation NDVI typically ranges from 0.1 up to 0.6, with higher values associated with greater density and greenness of the plant canopy. Surrounding soil and rock values are close to zero while the differential for water bodies such as rivers and dams have the opposite trend to vegetation and the index is negative.

Figure 12 illustrates a significant decrease in the abundance of vegetation over much of Australia with a slight increase in south-western Australian and parts of the Murray-Darling Basin in 2014 since 2013 (Figure 13), when compared with 2011 and 2012 which were years of higher rainfall (Figures 14 and 15).

**Figure 12. Normalised Difference Vegetation Index (NDVI) at a continental scale in 2014**
Figure 13. Normalised Difference Vegetation Index (NDVI) at a continental scale in 2013

Figure 14. Normalised Difference Vegetation Index (NDVI) at a continental scale in 2012
9. LANDSCAPE MODELLING

The Australian Government operate a National Agricultural Monitoring Service (NAMS) that contains a range of climatic and production information, initially for dry-land/broad-acre industries, for over 600 regions throughout Australia. Landscape models are widely used to infer condition based on a range of data sources. Importantly, the interpretation of these models requires an understanding that the values are relative not absolute. They are indicative spatial interpretations.

9.1 AussieGRASS – Spatial

This model shows relative growth percentiles across South Australia, averaged over 12 months. The data is sourced from the AussieGRASS pasture model; it considers the effects of pasture communities, climate, tree density, soil-attributes, stock and other herbivore numbers on growth. The legend defines relative growth percentiles. The spatial distribution of the actual growth percentiles is compared to the historical median, based on 115 years of modelled data. Some model inputs, such as plant available water capacity, are estimated from other data.

Figure 16 shows a range of extremely low to average pasture growth in 2014, below average rainfall levels, particularly in the north-west of the State. There are some areas of well above average pasture growth in the Coorong and South East regions reflecting patchy areas of average rainfall. Figure 17 shows the continued abundance of biomass attributed to the high rainfall between November 2010 and October 2011. When comparing current biomass (Figure 17) with that of recent years (Figures 18–21) a trend of decreasing amounts of pasture biomass throughout agricultural regions of South Australia has continued since the high levels of 2011.
Pasture Growth Relative to Historical Records from 1957, October 2014

TSDM Relative to Historical Records from 1957, October 2014
Figure 18. SA Pasture Biomass Relative to Historical Records from 1957, October 2013

Figure 19. SA Pasture Biomass Relative to Historical Records from 1957, October 2012
Figure 20. SA Pasture Biomass Relative to Historical Records from 1957, October 2011.

Figure 21. SA Pasture Biomass Relative to Historical Records from 1957, October 2010.
9.2. Pasture Growth Rate

The Pastures from Space program is a joint venture between the Department of Agriculture of Western Australia, Department of Land Information Western Australia, and the CSIRO. The program combines pasture biomass and feed on offer estimates obtained from satellite data, with climate and soil information to produce an estimate of Pasture Growth Rate (PGR) that can be used for regional agricultural monitoring. The satellite imagery is converted into a normalised difference vegetation index (NDVI), a measure of greenness of the pastures. This is then combined with climate information and soil data to give estimates of PGR. PGR is calculated and provided weekly and is provided as kg/ha/day rather than as a relative index of greenness and is of immediate value for on-farm decision making. By following the line in the graph, it is possible to determine the amount of pasture growth rate for that particular period compared to the median. The median is represented by the grey line.

Figures 22-26 show an estimate of PGR for three areas in southern South Australia (Adelaide Hills, Mid Murray and Orroroo/Carrieton) based upon satellite data from 2010 to 2014.

It should be noted that PGR outputs are not absolute values of pasture production. Some model inputs, such as plant available water capacity, are estimated from other data, and therefore the model output should be viewed only as an indication of pasture production. PGR has been extensively validated for Western Australia; however, there has been little validation work completed for the eastern states.

Figure 22. Pasture Growth Rates, calculated monthly for the Adelaide Hills, Mid Murray and Orroroo districts in 2014

<table>
<thead>
<tr>
<th>Shire PGR Comparisons - 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mid Murray (DC)</strong></td>
</tr>
<tr>
<td>J</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>kg/ha/day</td>
</tr>
</tbody>
</table>
Figure 23. Pasture Growth Rates, calculated monthly for the Adelaide Hills, Mid Murray and Orroroo districts in 2013

**Shire PGR Comparisons – 2013**

![Graph showing pasture growth rates for Adelaide Hills, Mid Murray, and Orroroo districts in 2013.](image)

Figure 24. Pasture Growth Rates, calculated monthly for the Adelaide Hills, Mid Murray and Orroroo districts in 2012

**Shire PGR Comparisons – 2012**

![Graph showing pasture growth rates for Adelaide Hills, Mid Murray, and Orroroo districts in 2012.](image)

Figure 25. Pasture Growth Rates, calculated monthly for the Adelaide Hills, Mid Murray and Orroroo districts in 2011

**Shire PGR Comparisons – 2011**

![Graph showing pasture growth rates for Adelaide Hills, Mid Murray, and Orroroo districts in 2011.](image)
10. CROP AND PASTURE, CONDITIONS AND PERFORMANCE

Rainfall for spring was below to well below average across the state. Some areas on Lower Eyre Peninsula, Upper North and Northern Murray Mallee received their lowest October rainfall totals on record. Maximum temperatures were average to very much above average for the season. The mean maximum temperatures were very much above average (2 to 5°C) during September and October, with areas of Eyre Peninsula, Kangaroo Island and southern Yorke Peninsula observing their highest maximum mean October temperatures on record.

Crop yields are estimated to be near or above the long term average, mainly due to the stored soil moisture from above average rainfall earlier in the season despite some areas were significantly damaged by severe frost throughout the winter (Figure 27). Wheat yields are likely to be variable across the State with some above average yields on upper Eyre Peninsula and the northern part of the Upper North but conditions are average to below average in other districts. The crop biomass is generally good, however some grazed crops and grain legume stubbles will have reduced biomass and ground cover going into summer-autumn. Some failed crops have been grazed rather than harvested.

Pastures dried off quickly during September and October with the warm and dry conditions experienced. Most of the State has adequate supplies of dry pasture feed but the Central Hills and Kangaroo Island only have marginal levels and the South East has had poor pasture growth.
10.1. Crop and Pasture Conditions, and Performance within the Four Southern Districts of South Australia.

**FLEURIEU AND CENTRAL HILLS**

The Fleurieu and Central Hills districts experienced well below average rainfall in September and very much below average in October. The maximum temperatures were very much above average for both September and October.

The crops sown in late April and May on sandy loam soils are likely to achieve average yields. Later-sown crops or crops on heavy soils, sands or shallow soils are suffering from moisture stress and will be below average in yield. There were areas of minor frost damage and some isolated pockets were severely affected. The yield impacts will not be known until harvest.

Pasture quality and availability is declining rapidly in the region. This loss of pasture is resulting large numbers of livestock are being sold as producers reduce stock numbers. Market prices have flattened because of the increase in supply.

**MURRAYLANDS**

The total monthly rainfall for the area was below average in September and very much below average in October. Mean maximum temperatures were above average to very much above average during September and October. There were some frosts and days of strong winds.

The cereal crops are expected to yield above average despite the poor finish to the season, particularly on soils where stored early-season rainfall can be used. Canola crops have been windrowed or desiccated and yields are expected to be below average due to virus and frost. While frost has been severe in specific areas with
pea crops the worst affected, the overall yield reduction across the district is likely to be less than 10%.

The hay yields were above average this season and generally of very good quality. Current pasture growth is deteriorating and while livestock are in good condition, the lack of spring rain and poor pasture growth means farmers will move stock onto stubbles as soon as they become available.

**COORONG/UPPER SOUTH EAST**

Rainfall in the region was very much below average for September and October with the growing Season Rainfall (April – Oct) well below average. The daily maximum temperature was very much above average for September and October.

Harvest commenced in the last few days of October with yields likely to be well below average with the early sown crops having the best yield potential. The crops have held up exceptionally well considering the season. This is due to use of mid-season maturing varieties, no till systems and overall better management.

Cattle producers have cut crops for hay to ensure sufficient feed to get their cattle through the summer/autumn period. Some grassy crops were cut for hay. Dry-land pasture hay yields have been down by 50% with many pasture paddocks that were planned to be cut for hay being grazed due to poor pasture growth. Much of the pasture hay has been cut from irrigated areas.

**LOWER SOUTH EAST**

Rainfall for September and October was below average to very much below average, with the growing season rainfall (April-October) was well below average. Mean maximum daily temperatures were very much above average during September and October.

Crops and pastures on shallow soils are suffering moisture stress with the soil moisture levels depleted in most soils. Some growers have cut some crops on shallow soils for hay as they are likely to have high levels of screenings and hay will be needed to feed their livestock. Crops and pastures on deeper soils still have average yield potential if reasonable rainfall is received.

The hay and silage yields have been below average but quality has been good with most of the hay and silage cut being from crops and not pastures, due to poor pasture growth. Most crops that were cut for hay were cereal crops with 20-25% of these crops cut for hay instead of being taken through to grain. The remaining pasture growth is very slow on heavy soils because of the dry conditions.
11. LANDSCAPE CONDITION AND QUAIL

Quail are difficult to monitor and their responses to climatic conditions are inferred from an analysis of their preferred habitat of agricultural areas and plains, open and lightly wooded grasslands, samphire flats and heathlands. Pasture growth models, greenness index and wheat yield data indicate that there are variable landscape conditions throughout the State with generally below average rainfall conditions and reduced landscape conditions.

These mainly below to very much below average climate and landscape conditions indicate less favourable habitat conditions for quail than recent seasons. Quail are nomadic and are still expected to be reasonably distributed around regions that have experienced higher rainfall with average levels of abundance. Limited breeding activity is likely to continue into late summer in some areas. Birds are understood to actively breed during a phase of optimal habitat quality and food resources.
12. REFERENCES


